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BRONCHOSCOPY AND ESOPHAGOSCOPY

A Manual of Peroral Endoscopy and Laryngeal Surgery

by

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With 114 Illustrations and Four Color Plates

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TO MY MOTHER TO WHOSE INTEREST IN MEDICAL SCIENCE THE AUTHOR OWES HIS INCENTIVE, AND TO MY FATHER WHOSE CONSTANT ADVICE TO "EDUCATE THE EYE AND THE FINGERS" SPURRED THE AUTHOR TO CONTINUAL EFFORT, THIS BOOK IS AFFECTIONATELY DEDICATED.

PREFACE

This book is based on an abstract of the author's larger work, Peroral Endoscopy and Laryngeal Surgery. The abstract was prepared under the author's direction by a reader, in order to get a reader's point of view on the presentation of the subject in the earlier book. With this abstract as a starting point, the author has endeavored, so far as lay within his limited abilities, to accomplish the difficult task of presenting by written word the various purely manual endoscopic procedures. The large number of corrections and revisions found necessary has confirmed the wisdom of the plan of getting the reader's point of view; and these revisions, together with numerous additions, have brought the treatment of the subject up to date so far as is possible within the limits of a working manual. Acknowledgment is due the personnel of the W. B. Saunders Company for kindly help.

CHEVALIER JACKSON. OCTOBER, 1922. II

CONTENTS PAGE

[17] CHAPTER I—INSTRUMENTARIUM

Direct laryngoscopy, bronchoscopy, esophagoscopy and gastroscopy are procedures in which the lower air and food passages are inspected and treated by the aid of electrically lighted tubes which serve as specula to manipulate obstructing tissues out of the way and to bring others into the line of direct vision. Illumination is supplied by a small tungsten-filamented, electric, "cold" lamp situated at the distal extremity of the instrument in a special groove which protects it from any possible injury during the introduction of instruments through the tube. The bronchi and the esophagus will not allow dilatation beyond their normal caliber; therefore, it is necessary to have tubes of the sizes to fit these passages at various developmental ages. Rupture or even over-distention of a bronchus or of the thoracic esophagus is almost invariably fatal. The armamentarium of the endoscopist must be complete, for it is rarely possible to substitute, or to improvise makeshifts, while the bronchoscope is in situ. Furthermore, the instruments must be of the proper model and well made; otherwise difficulties and dangers will attend attempts to see them.

Laryngoscopes.—The regular type of laryngoscope shown in Fig. I (A, B, C) is made in adult's, child's, and infant's sizes. The instruments have a removable slide on the top of the tubular portion of the speculum to allow the removal of the laryngoscope after the insertion of the bronchoscope through it. The infant size is made in two forms, one with, the other without a removable slide; with either form the larynx of an infant can be exposed in but a few seconds and a definite diagnosis made, without anesthesia, general or local; a thing possible by no other method. For operative work on the larynx of adults, such as the removal of benign growths, particularly when these are situated in the anterior portion of the larynx, a special tubular laryngoscope having a heart-shaped lumen and a beveled tip is used. With this instrument the anterior commissure is readily exposed, and because of this it is named the anterior commissure laryngoscope (Fig. 1, D). The tip of the anterior commissure laryngoscope can

be used to expose either ventricle of the larynx by lifting the ventricular band, or it may be passed through the adult glottis for work in the subglottic region. This instrument may also be used as an esophageal speculum and as a pleuroscope. A side-slide laryngoscope, used with or without the slide, is occasionally useful.

Bronchoscopes.—The regular bronchoscope is a hollow brass tube slanted at its distal end, and having a handle at its proximal or ocular extremity. An auxiliary canal on its under surface contains the light carrier, the electric bulb of which is situated in a recess in the beveled distal end of the tube. Numerous perforations in the distal part of the tube allow air to enter from other bronchi when the tube-mouth is inserted into one whose aerating function may be impaired. The accessory tube on the upper surface of the bronchoscope ends within the lumen of the bronchoscope, and is used for the insufflation of oxygen or anesthetics, (Fig. 2, A, B, C, D).

For certain work such as drainage of pulmonary abscesses, the lavage treatment of bronchiectasis and for foreign-body or other cases with abundant secretions, a drainage-bronchoscope is useful The drainage canal may be on top, or on the under surface next to the light-carrier canal. For ordinary work, however, secretion in the bronchus is best removed by sponge-pumping (Q.V.) which at the same time cleans the lamp. The drainage bronchoscope may be used in any case in which the very slightly-greater area of cross section is no disadvantage; but in children the added bulk is usually objectionable, and in cases of recent foreign-body, secretions are not troublesome.

As before mentioned, the lower air passages will not tolerate dilatation; therefore, it is necessary never to use tubes larger than the size of the passages to be examined. Four sizes are sufficient for any possible case, from a newborn infant to the largest adult. For infants under one year, the proper tube is the 4 mm. by 30 cm.; the child's size, 5 mm. by 30 cm., is used for children aged from one to five years. For children six years or over, the 7 mm. by 40 cm. bronchoscope (the adolescent size) can be used unless the smaller bronchi are to be explored. The adult bronchoscope measures 9 mm. by 40 cm.

The author occasionally uses special sizes, 5 mm. x 45 cm., 6 mm. x 35 cm., 8 mm. x 40 cm.

Esophagoscopes.-The esophagoscope, like the bronchoscope, is a hollow brass tube with beveled distal end containing a small electric light. It differs from the bronchoscope in that it has no perforations, and has a drainage canal on its upper surface, or next to the light-carrier canal which opens within the distal end of the tube. The exact size, position, and shape of the drainage outlets is important on bronchoscopes, and to an even greater degree on esophagoscopes. If the proximal edge of the drainage outlet is too near the distal end of the endoscopic tube, the mucosa will be drawn into the outlet, not only obstructing it, but, most important, traumatizing the mucosa. If, for instance, the esophagoscope were to be pushed upon with a fold thus anchored in the distal end, the esophageal wall could easily be torn. To admit the largest sizes of esophagoscopic bougies (Fig. 40), special esophagoscopes (Fig. 5) are made with both light canal and drainage canal outside the lumen of the tube, leaving the full area of luminal cross-section unencroached upon. They can, of course, be used for all purposes, but the slightly greater circumference is at times a disadvantage. The esophageal and stomach secretions are much thinner than bronchial secretions, and, if free from food, are readily aspirated through a comparatively small canal. If the canal becomes obstructed during esophagoscopy, the positive pressure tube of the aspirator is used to blow out the obstruction. Two sizes of esophagoscopes are all that are required—7 mm. X 45 cm. for children, and 10 mm. X 53 cm. for adults (Fig. 3, A and B); but various other sizes and lengths are used by the author for special purposes.* Large esophagoscopes cause dangerous dyspnea in children. If, it is desired to balloon the esophagus with air, the window plug shown in Fig. 6, is inserted into the proximal end of the esophagoscope, and air insufflated by means of the hand aspirator or with a hand bulb. The window can be replaced by a rubber diaphragm with a perforation for forceps if desired. It will be noted that none of the endoscopic tubes are fitted with mandrins. They are to be introduced under the direct guidance of the eye only. Mandrins are obtainable, but their use is objectionable for a number of reasons, chief of which is the danger of overriding a foreign body or a lesion, or of perforating a lesion, or even the normal esophageal wall. The slanted end on the esophagoscope obviates the necessity of a mandrin for introduction. The longer the slant, with consequent acuting of the angle, the more the introduction is facilitated; but too acute an angle increases the risk of perforating the esophageal wall, and necessitates the utmost caution. In some foreign-body cases an acute angle giving a long slant is useful, in others a short slant is better, and in a few cases the squarely cut-off distal end is best. To have all of these different slants on hand would require too many tubes. Therefore the author has settled upon a moderate angle for the end of both esophagoscopes and bronchoscopes that is easy to insert, and serves all purposes in the version and other manipulations required by the various mechanical problems of foreign-body extraction. He has, however, retained all the experimental models, for occasional use in such cases as he falls heir to because of a problem of extraordinary difficulty.

* A 9 mm. X 45 cm. esophagoscope will reach the stomach of almost all adults and is somewhat easier

to introduce than the 10 mm. X 53 cm., which may be omitted from the set if economy must be practiced.

[FIG. I.—Author's laryngoscopes. These are the standard sizes and fulfill all requirements. Many other forms have been devised by the author, but have been omitted from the list as unnecessary. The infant diagnostic laryngoscope (C) is not for introducing bronchoscopes, and is not absolutely necessary, as the larynx of any infant can be inspected with the child's size laryngoscope (B).

A Adult's size; B, child's size; C, infant's diagnostic size; D, anterior commissure laryngoscope; E, with drainage canal; 17, intubating laryngoscope, large lumen. All the laryngoscopes are preferred without drainage canals.]

[FIG. 2.—The author's bronchoscopes of the sizes regularly used. Various other lengths and diameters are on hand for occasional use for special purposes. With the exception of a 6 mm. X 35 cm. size for older children, these special bronchoscopes are very rarely used and none of them can be regarded as necessary. For special purposes, however, special shapes of tube-mouth are useful, as, for instance, the oval end to facilitate the getting of both points of a staple into the tube-mouth The illustrated instruments are as follows:

A, Infant's size, 4 mm. X 30 cm.; B, child's size, 5 mm. X 30 cm.;
C, adolescent's size, 7 mm. X 40 cm.; D, adult's size, 9 mm. X 40 cm.;
E, aspirating bronchoscope made in all the foregoing sizes, and in a
special size, 5 mm. X 45 cm.]

[FIG. 3.—The author's esophagoscopes of the sizes he has standardized for all ordinary requirements. He uses various other lengths and sizes for special purposes, but none of them are really necessary. A gastroscope, 10 mm. X 70 cm., is useful for adults, especially in cases of gastroptosis. Drainage canals are placed at the top or at the side of the tube, next to the light-carrier canal.

A, Adult's size, 10 mm. X 53 cm.; B, child's size, 7 mm. X 45 cm.; C and D, full lumen, with both light canal and drainage canal outside the wall of the tube, to be used for passing very large bougies. This instrument is made in adult, child, and adolescent (8 mm. by 45 cm.) sizes. Gastroscopes and esophagoscopes of the sizes given above (A) and (B), can be used also as gastroscopes. A small form of C, 5 mm. X 30 cm. is used in infants, and also as a retrograde esophagoscope in patients of any age. E, window plug for ballooning gastroscope, F.]

[FIG. 4.—Author's short esophagoscopes and esophageal specula A, Esophageal speculum and hypopharyngoscope, adult's size; B, esophageal speculum and hypopharyngoscope, child's size; C, heavy handled short esophagoscope; D, heavy handled short esophagoscope with drainage.]

[FIG. 5.—Cross section of full-lumen esophagoscope for the use of largest bourgies. The canals for the light carrier and for drainage are so constructed that they do not encroach upon the lumen of the tube.]

[25] The special sized esophagoscopes most often useful are the 8 mm. X 30 cm., the 8 mm. X 45 cm., and the 5 mm. X 45 cm. These are made with the drainage canal in various positions.

For operations on the upper end of the esophagus, and particularly for foreign body work, the esophageal speculum shown at A and B, in Fig. 4, is of the greatest service. With it, the anterior wall of the post-cricoidal pharynx is lifted forward, and the upper esophageal orifice exposed. It can then be inserted deeper, and the upper third of the esophagus can be explored. Two sizes are made, the adult's and the child's size. These instruments serve, very efficiently as pleuroscopes. They are made with and without drainage canals, the latter being the more useful form.

[FIG. 6.—Window-plug with glass cap interchangeable with a cap having a rubber diaphragm with a perforation so that forceps may be used without allowing air to escape. Valves on the canals (E, F, Fig. 3) are preferable.]

Gastroscopes.—The gastroscope is of the same construction as the esophagoscope, with the exception that it is made longer, in order to reach all parts of the stomach. In ordinary cases, the regular esophagoscopes for adults and children respectively will afford a good view of the stomach, but there are cases which require longer tubes, and for these a gastroscope 10 mm. X 70 cm. is made, and also one 10 mm. X 80 cm., though the latter has never been needed but once.

[26] *Pleuroscopes*.—As mentioned above the anterior commissure laryngoscope and the esophageal specula make very efficient pleuroscopes; but three different forms of pleuroscopes have been devised by the author for pleuroscopy. The retrograde esophagoscope serves very well for work through small fistulae.

Measuring Rule (Fig. 7).—It is customary to locate esophageal lesions by denoting their distance from the incisor teeth. This is readily done by measuring the distance from the proximal end of the esophagoscope to the upper incisor teeth, or in their absence, to the upper alveolar process, and subtracting this measurement from the known length of the tube. Thus, if an esophagoscope 45 cm. long be introduced and we find that the distance from the incisor teeth to the ocular end of the esophagoscope as measured by the rule is 20 cm., we subtract this 20 cm. from the total length of the esophagoscope (45 cm.) and then know that the distal end of the tube is 25 cm. from the incisor teeth. Graduation marks on the tube have been used, but are objectionable.

[FIG. 7.—Measuring rule for gauging in centimeters the depth of any location by subtraction of the length of the uninserted portion of the esophagoscope or bronchoscope. This is preferable to graduations marked on the tubes, though the tubes can be marked with a scale if desired.]

Batteries.—The simplest, best, and safest source of current is a double dry battery arranged in three groups of two cells each, connected in series (Fig. 8). Each set should have two binding posts and a rheostat. The binding posts should have double holes for two additional cords, to be kept in reserve for use in case a cord becomes defective.* The commercial current reduced through a rheostat should never be used, because there is always the possibility of "grounding" the circuit through the patient; a highly dangerous accident when we consider that the tube makes a long moist contact in tissues close to the course of both the vagi and the heart. The endoscopist should never depend upon a pocket battery as a source of illumination, for it is almost certain to fail during the endoscopy. The wires connecting the battery and endoscopic instrument are covered with rubber, so that they may be cleansed and superficially sterilized with alcohol. They may be totally immersed in alcohol for any length of time without injury.

* When this is done care is necessary to avoid attempting to use simultaneously the two cords from one pair of posts.

[FIG 8.—The author's endoscopic battery, heavily built for reliability.

It contains 6 dry cells, series-connected in 3 groups of 2 cells each.
Each group has its own rheostat and pair of binding posts.]

Aspirating Tubes.—Independent aspirating tubes involve delay in their use as compared to aspirating canals in the wall of the endoscopic tube; but there are special cases in which an independent tube is invaluable. Three forms are used by the author. The "velvet eye" cannot traumatize the mucosa (Fig. 9). To hold a foreign body by suction, a squarely cut off end is necessary. For use through the tracheotomic wound without a bronchoscope a malleable tube (Fig. 10) is better.

[FIG. 9.—The author's protected-aperture endoscopic aspirating tube for aspiration of pharyngeal secretions during direct laryngoscopy and endotracheobronchial secretions at bronchoscopy, also for draining retropharyngeal abscesses. The laryngoscopes are obtainable with drainage canals, but for most purposes the independent aspirating tube shown above is more satisfactory. The tubes are made in 20 30, 40, and 60 cm. lengths. An aperture on both sides prevents drawing in the mucosa. It can be used for insufflation of ether if desired. An aspirating tube of the same design, but having a squarely cut off end, is sometimes useful for removing secretions lying close to a foreign body; for removing papillomata; and even for withdrawing foreign bodies of a soft surface consistency. It is not often that the foreign bodies can be thus withdrawn through the glottis, but closely fitting foreign bodies can at least be withdrawn to a higher level at which ample forceps spaces will permit application of forceps. Such aspirating tubes, however, are not so safe to use as the protected, double aperture tubes.]

[FIG. 10.—The author's malleable tracheotomic aspirating tube for removal of secretions, exudates, crusts, etc., from the tracheobronchial tree through the tracheotomic wound without a bronchoscope. The tube is made of copper so that it can be bent to any curve, and the copper wire stylet prevents kinking. The stylet is removed before using the tube for aspiration.]

[28] *Aspirators*.—The various electric aspirators so universally used in throat operations should be utilized to withdraw secretions in the tubes fitted with drainage canals. They, however, have the disadvantages of not being easily transported, and of occasionally being out of order. The hand aspirator shown in Fig. 11 is, therefore, a necessary part of the instrumental equipment. It never fails to work, is portable, and affords both positive and negative pressures. The positive pressure is sometimes useful in clearing the drainage canal of any particles of food, tissue, clots, or secretion which may obstruct it; and it also serves to fill the stomach or esophagus with air when the ballooning procedure is used. The mechanical aspirator (Fig. 12) is highly efficient and is the one used in the Bronchoscopic Clinic. The positive pressure will quickly clear obstructed drainage canals, and may be used while the esophagoscope is in situ, by simply detaching the minus pressure tube and attaching the plus pressure. In the lungs, however, high plus pressures are so dangerous that the pressure valve

must be lowered.

[Fig. 11—Portable aspirator for endoscopy with additional tube connected with the plus pressure side for use in case of occlusion of the drainage canal. This aspirator has the advantage of great power with portability. Where portability is not required the electrically operated aspirator is better.]

[FIG. 12.—Robinson mechanical aspirator adapted for bronchoscopic and esophagoscopic aspiration by the author. The positive pressure is used for clearing obstructed drainage canals and tubes.]

[FIG. 13.—Apparatus for insufflation of ether or chloroform during bronchoscopy, for those who may desire to use general anesthesia. The mechanical methods of intratracheal insufflation anesthesia subsequently developed by Meltzer and Auer, Elsberg, Geo. P. Muller and others have rightly superseded this apparatus for all general surgical purposes.]

Sponge-pumping.—While the usually thin, watery esophageal and gastric secretions, if free from food, are readily aspirated through a drainage canal, the secretions of the bronchi are often thick and mucilaginous and aspirated with difficulty. Further-more, bronchial secretions as a rule are not collected in pools, but are distributed over the walls of the larger bronchi and continuously well up from smaller bronchi during cough. The aspirating bronchoscopes should be used whenever their very slight additional area of cross-section is unobjectionable. In most cases, however, the most advantageous way to remove bronchial secretion has been found to be by introducing a gauze swab on a long sponge carrier (Fig. 14), so that the sponge extends beyond the distal end of the bronchoscope, causing cough. Then withdrawal of the sponge carrier will remove all of the secretion in the tube just as the plunger in a pump will lift all of the water above it. By this maneuver the walls of the bronchus are wiped free from secretions, and the lamp itself is cleansed.

[FIG. 14.—Sponge carrier with long collar for carrying the small sponges shown in Fig. 15. The collar screws down as in the Coolidge cotton carrier. About a dozen of these are needed and they should all be small enough to go through the 4 mm. (diameter) bronchoscope and long enough to reach through the 53 cm. (length) esophagoscope, so that one set will do for all tubes. The schema shows method of sponging. The carrier C, armed with the sponge, S, when rotated as shown by the dart, D, wipes the field, P, at the same time wiping the lamp, L. The lamp does not need ever to be withdrawn for cleaning during bronchoscopy. It is protected in a recess so that it does not catch in the sponges.]

[FIG 15.—Exact size to which the bandage-gauze is cut to make endoscopic sponges. Each rectangle is the size for the tubal diameter given. The dimensions of the respective rectangles are not given because it is easier for the nurse or any one to cut a cardboard pattern of each size directly from this drawing. The gauze rectangles are folded up endwise as shown at A, then once in the middle as at B, then strung one dozen on a safety pin. In America gauze bandages run about 16 threads to the centimeter. Different material might require a slightly different size and the pattern could be made to suit.]

[32] The gauze sponges are made by the instrument nurse as directed in Fig. 15, and are strung on safety pins, wrapped in paper, the size indicated by a figure on the wrapper, and then sterilized in an autoclave. The sterile packages are opened only as needed. These "bronchoscopic sponges" are also made by Johnston and Johnston, of New Brunswick, N. J. and are sold in the shops.

Mouth-gag.—Wide gagging prevents proper exposure of the larynx by forcing the mandible down on the hyoid bone. The mouth should be gently opened and a bite block (Fig. 16) inserted between the teeth on the left side of the patient's mouth, to prevent closing of the jaws on the delicate bronchoscope or esophagoscope.

[FIG. 16.—Bite block to be inserted between the teeth to prevent closure of the jaws on the endoscopic tube. This is the McKee-McCready modification of the Boyce thimble with the omission of the etherizing tube, which is no longer needed. The block has been improved by Dr. W. F. Moore of the Bronchoscopic Clinic.]

Forceps.—Delicacy of touch and manipulation are an absolute necessity if the endoscopist is to avoid mortality; therefore, heavily built and spring-opposed forceps are dangerous as well as useless. For foreign-body work in the larynx, and for the removal of benign laryngeal growths, the alligator forceps with roughened jaws shown in Fig. 17 serve every purpose.

[FIG. 17.—Laryngeal grasping forceps designed by Mosher. For my own use I have taken off the ratchet-locking device for all general work, to be reapplied on the rare occasions when it is required.]

Bronchoscopic and esophagoscopic grasping forceps are of the tubular type, that is, a stylet carrying the jaws works in a slender tube so that traction on the stylet draws the V of the open jaws into the lumen of the tube, thus causing the blades to approximate. They are very delicate and light, yet have

great grasping power and will sustain any degree of traction that it is safe to exert. They permit of the delicacy of touch of a violin bow. The two types of jaws most frequently used, are those with the forward-grasping blades shown in Fig. 18, and those having side-grasping blades shown in Fig. 19. The side-curved forceps are perhaps the most generally useful of all the endoscopic forceps; the side projection of the jaws makes them readily visible during their closure on an object; their broader grasp is also an advantage., The projection of the blades in the side-curved grasping forceps should always be directed toward the left. If it is desired that they open in another direction this should be accomplished by turning the handle and not by adjusting the blade itself. If this rule be followed it will always be possible to tell by the position of the handle exactly where the blades are situated; whereas, if the jaws themselves are turned, confusion is sure to result. The forward-grasping forceps are always so adjusted that the jaws open in an up-and-down direction. On rare occasions it may be deemed desirable to turn the stylet of either forceps in some other direction relative to the handle.

[FIG. 18.—The author's forward grasping tube forceps. The handle mechanism is so simple and delicate that the most exquisite delicacy of touch is possible. Two locknuts and a thumbscrew take up all lost motion yet afford perfect adjustability and easy separation for cleansing. At A is shown a small clip for keeping the jaws together to prevent injurious bending in the sterilizer, or carrying case. At the left is shown a handle-clamp for locking the forceps on a foreign body in the solution of certain rarely encountered mechanical problems. The jaws are serrated and cupped.]

[FIG. 19.—Jaws of the author's side-curved endoscopic forceps. These work as shown in the preceding illustration, each forceps having its own handle and tube. Originally the end of the cannula and stylet were squared to prevent rotation of the jaws in the cannula. This was found to be unnecessary with properly shaped jaws, which wedge tightly.]

Rotation Forceps.—It is sometimes desired to make traction on an irregularly shaped foreign body, and yet to allow the object to turn into the line of least resistance while traction is being made. This can be accomplished by the use of the rotation forceps (Fig. 20), which have for blades two pointed hooks that meet at their points and do not overlap. Rotation forceps made on the model of the laryngeal grasping forceps, but having opposing points at the end of the blades, are sometimes very useful for the removal of irregular foreign bodies in the larynx, or when used through the esophageal speculum they are of great service in the extraction of such objects as bones, pin-buttons, and tooth-plates, from the upper esophagus. These forceps are termed laryngeal rotation forceps (Fig. 31). All the various forms of forceps are made in a very delicate size often called the "mosquito" or "extra light" forceps, 40 cm. in length, for use in the 4 mm. and the 5 mm. bronchoscopes. For the 5 mm. bronchoscopes heavier forceps of the 40 cm. length are made. For the larger tubes the forceps are made in 45 cm., 50 cm., and 60 cm. lengths. A square-cannula forceps to prevent turning of the jaws was at one time used by the author but it has since been found that round cannula pattern serves all purposes.

[FIG. 20.—The author's rotation forceps. Useful to allow turning of an irregular foreign body to a safer relation for withdrawal and for the esophagoscopic removal of safety pins by the method of pushing them into the stomach, turning and withdrawal, spring up.]

Upper-lobe-bronchus Forceps.—Foreign bodies rarely lodge in an upper-lobe bronchus, yet with such a problem it is necessary to have forceps that will reach around a corner. The upper-lobe-bronchus forceps shown in Fig. 27 have curved jaws so made as to straighten out while passing through the bronchoscope and to spring back into their original shape on up from the lower jaw emerging from the distal end of the bronchoscopic tube, the radius of curvature being regulated by the extent of emergence permitted. They are made in extra-light pattern, 40 cm. long, and the regular model 45 cm. long. The full-curved model, giving 180 degrees and reaching up into the ascending branches, is made in both light and heavy patterns. Forceps with less curve, and without the spiral, are used when it is desired to reach only a short distance "around the corner" anywhere in the bronchi. These are also useful, as suggested by Willis F. Manges, in dealing with safety pins in the esophagus or tracheobronchial tree.

[FIG. 21.—Tucker jaws for the author's forceps. The tiny lip projecting down from the upper, and up from the lower jaw prevents sidewise escape of the shaft of a pin, tack, nail or needle. The shaft is automatically thrown parallel to the bronchoscopic axis. Drawing about four times actual size.]

[36] *Tucker Forceps*—Gabriel Tucker modified the regular side-curved forceps by adding a lip (Fig. 21) to the left hand side of both upper and lower jaws. This prevents the shaft of a tack, nail, or pin, from springing out of the grasp of the jaws, and is so efficient that it has brought certainty of grasp never before obtainable. With it the solution of the safety-pin problem devised by the author many years ago has a facility and certainty of execution that makes it the method of choice in safety-pin extraction.

[FIG. 22.—The author's down-jaw esophageal forceps. The dropping jaw is useful for reaching

backward below the cricopharyngeal fold when using the esophageal speculum in the removal of foreign bodies. Posterior forceps-spaces are often scanty in cases of foreign bodies lodged just below the cricopharyngeus.]

[FIG. 23.—Expansile forceps for the endoscopic removal of hollow foreign bodies such as intubation tubes, tracheal cannulae, caps, and cartridge shells.]

Screw forceps.—For the secure grasp of screws the jaws devised by Dr. Tucker for tacks and pins are excellent (Fig. 21).

Expanding Forceps.—Hollow objects may require expanding forceps as shown in Fig. 23. In using them it is necessary to be certain that the jaws are inside the hollow body before expanding them and making traction. Otherwise severe, even fatal, trauma may be inflicted.

[FIG. 24.—The author's fenestrated peanut forceps. The delicate construction with long, springy and fenestrated jaws give in gentle hands a maximum security with a minimum of crushing tendency.]

[FIG. 25—The author's bronchial dilators, useful for dilating strictures above foreign bodies. The smaller size, shown at the right is also useful as an expanding forceps for removing intubation tubes, and other hollow objects. The larger size will go over the shaft of a tack.]

[FIG. 26.—The author's self-expanding bronchial dilator. The extent of expansion can be limited by the sense of touch or by an adjustable checking mechanism on the handle. The author frequently used smooth forceps for this purpose, and found them so efficient that this dilator was devised. The edges of forceps jaws are likely to scratch the epithelium. Occasionally the instrument is useful in the esophagus; but it is not very safe, unless used with the utmost caution.]

Tissue Forceps.—With the forceps illustrated in Fig. 28 specimens of tissue may be removed for biopsy from the lower air and food passages with ease and certainty. They have a cross in the outer blade which holds the specimen removed. The action is very delicate, there being no springs, and the sense of touch imparted is often of great aid in the diagnosis.

[FIG. 27.—The author's upper-lobe bronchus forceps. At A is shown the full-curved form, for reaching into the ascending branches of the upper-lobe bronchus A number of different forms of jaws are made in this kind of forceps. Only 2 are shown.]

[FIG 28—The author's endoscopic tissue forceps. The laryngeal length is 30 cm. For esophageal use they are made 50 and 60 cm. long. These are the best forceps for cutting out small specimens of tissue for biopsy.]

The large basket punch forceps shown in Fig. 33 are useful in removing larger growths or specimens of tissue from the pharynx or larynx. A portion or the whole of the epiglottis may be easily and quickly removed with these forceps, the laryngoscope introduced along the dorsum of the tongue into the glossoepiglottic recess, bringing the whole epiglottis into view. The forceps may be introduced through the laryngoscope or alongside the tube. In the latter method a greater lateral action of the forceps is obtainable, the tube being used for vision only. These forceps are 30 cm. long and are made in two sizes; one with the punch of the largest size that can be passed through the adult laryngoscope, and a smaller one for use through the anterior-commissure laryngoscope and the child's size laryngoscope.

[FIG. 29.—The author's papilloma forceps. The broad blunt nose will scalp off the growths without any injury to the normal basal tissues. Voice-destroying and stenosing trauma are thus easily avoided.]

[FIG. 30.—The author's short mechanical spoon (30 cm. long).]

Papilloma Forceps.—Papillomata do not infiltrate; but superficial repullulations in many cases require repeated removals. If the basal tissues are traumatized, an impaired or ruined voice will result. The author designed these forceps (Fig. 29) to scalp off the growths without injury to the normal tissues.

[FIG. 31.—The author's laryngeal rotation forceps.]

[FIG. 32.—Enlarged view of the jaws of the author's vocal-nodule forceps. Larger cups are made for other purposes but these tiny cups permit of that extreme delicacy required in the excision of the nodules from the vocal cords of singers and other voice users.]

[FIG 33.-Extra large laryngeal tissue forceps. 30 cm. long, for removing entire growths or large specimens of tissue. A smaller size is made.]

Bronchial Dilators.—It is not uncommon to find a stricture of the bronchus superjacent to a foreign body that has been in situ for a period of months. In order to remove the foreign body, this stricture

must be dilated, and for this the bronchial dilator shown in Fig. 25 was devised. The channel in each blade allows the closed dilator to be pushed down over the presenting point of such bodies as tacks, after which the blades are opened and the stricture stretched. A small and a large size are made. For enlarging the bronchial narrowing associated with pulmonary abscess and sometimes found above a bronchiectatic or foreign body cavity, the expanding dilator shown in Fig. 26 is perhaps less apt to cause injury than ordinary forceps used in the same way. The stretching is here produced by the spring of the blades of the forceps and not by manual force. The closed blades are to be inserted through the strictured area, opened, and then slowly withdrawn. For cicatricial stenoses of the trachea the metallic bougies, Fig. 40, are useful. For the larynx, those shown in Fig. 41 are needed.

[FIG. 34.—A, Mosher's laryngeal curette; B, author's flat blade cautery electrode; C, pointed cautery electrode; D, laryngeal knife. The electrodes are insulated with hard-rubber vulcanized onto the conducting wires.]

[FIG. 35.—Retrograde esophageal bougies in graduated sizes devised by Dr. Gabriel Tucker and the author for dilatation of cicatricial esophageal stenosis. They are drawn upward by an endless swallowed string, and are therefore only to be used in gastrostomized cases.]

[FIG. 36.—Author's bronchoscopic and esophagoscopic mechanical spoon, made in 40, 50 and 60 cm. lengths.]

[FIG. 37.—Schema illustrating the author's method of endoscopic closure of open safety pins lodged point upward The closer is passed down under ocular control until the ring, R, is below the pin. The ring is then erected to the position shown dotted at M, by moving the handle, H, downward to L and locking it there with the latch, Z. The fork, A, is then inserted and, engaging the pin at the spring loop, K, the pin is pushed into the ring, thus closing the pin. Slight rotation of the pin with the forceps may be necessary to get the point into the keeper. The upper instrument is sometimes useful as a mechanical spoon for removing large, smooth foreign bodies from the esophagus.]

Esophageal Dilators.—The dilatation of cicatricial stenosis of the esophagus can be done safely only by endoscopic methods. Blind esophageal bouginage is highly dangerous, for the lumen of the stricture is usually eccentric and the bougie is therefore apt to perforate the wall rather than find the small opening. Often there is present a pouching of the esophagus above a stricture, in which the bougie may lodge and perforate. Bougies should be introduced under visual guidance through the esophagoscope, which is so placed that the lumen of the stricture is in the center of the endoscopic field. The author's endoscopic bougies (Fig. 40) are made with a flexible silk-woven tip securely fastened to a steel shaft. This shaft lends rigidity to the instrument sufficient to permit its accurate placement, and its small size permits the eye to keep the silk-woven tip in view. These endoscopic bougies are made in sizes from 8 to 40, French scale. The larger sizes are used especially for the dilatation of laryngeal and tracheal stenoses. For the latter work it is essential that the bougies be inspected carefully before they are used, for should a defective tip come off while in the lower air passages a difficult foreign body problem would be created. Soft-rubber retrograde dilators to be drawn upward from the stomach by a swallowed string are useful in gastrostomized cases (Fig. 35).

[FIG 38.—Half curved hook, 45 cm. and 60 cm. Full curved patterns are made but caution is necessary to avoid them becoming anchored in the bronchi. Spiral forms avoid this. The author makes for himself steel probe-pointed rods out of which he bends hooks of any desired shape. The rod is held in a pin-vise to facilitate bending of the point, after heating in an alcohol or bunsen flame.]

Hooks.—No hook greater than a right angle should be used through endoscopic tubes; for should it become caught in some of the smaller bronchi its extraction might result in serious trauma. The half curved hook shown in Fig. 38 is the safest type; better still, a spiral twist to the hook will add to its uses, and by reversing the turning motion it may be "unscrewed" out if it becomes caught. Hooks may easily be made from rods of malleable steel by heating the end in a spirit lamp and shaping the curve as desired by means of a pin-vise and pliers. About 2 cm. of the proximal end of the rod should be bent in exactly the opposite direction from that of the hook so as to form a handle which will tell the position of the hook by touch as well as by sight. Coil-spring hooks for the upper-lobe-bronchus (Fig. 39) will reach around the corner into the ascending bronchus of the upper-lobe-bronchus, but the utmost skill and care are required to make their use justifiable.

[FIG. 39.—Author's coil-spring hook for the upper-lobe, bronchus]

Safety-pin Closer.—There are a number of methods for the endoscopic removal of open safety-pins when the point is up, one of which is by closing the pin with the instrument shown in Fig. 37 in the following manner. The oval ring is passed through the endoscope until it is beyond the spring of the safety-pin, the ring is then turned upward by depressing the handle, and by the aid of the prong the pin is pushed into the ring, which action approximates the point of the pin and the keeper and closes the

pin. Removal is then less difficult and without danger. This instrument may also be used as a mechanical spoon, in which case it may be passed to the side of a difficultly grasped foreign body, such as a pebble, the ring elevated and the object withdrawn. Elsewhere will be found a description of the various safety-pin closers devised by various endoscopists. The author has used Arrowsmith's closer with much satisfaction.

Mechanical Spoon.—When soft, friable substances, such as a bolus of meat, become impacted in the upper esophagus, the short mechanical spoon (Fig. 30) used through the esophageal speculum is of great aid in their removal. The blade in this instrument, as the name suggests, is a spoon and is not fenestrated as is the safety-pin closer, which if used for friable substances would allow them to slip through the fenestration. A longer form for use through bronchoscopes and esophagoscopes is shown in Fig. 36.

A laryngeal curette, cautery electrodes, cautery handle, and laryngeal knife are illustrated in Fig. 34. The cautery is to be used with a transformer, or a storage battery.

Spectacles.—If the operator has no refractive error he will need two pairs of plane protective spectacles with very large "eyes." If ametropic, corrective lenses are necessary, and duplicate spectacles must be in charge of a nurse. For presbyopia two pairs of spectacles for 40 cm. distance and 65 cm. distance must be at hand. Hook temple frames should be used so that they can be easily changed and adjusted by the nurse when the lenses become spattered. The spectacle nurse has ready at all times the extra spectacles, cleaned and warmed in a pan of heated water so that they will not be fogged by the patient's breath, and she changes them without delay as often as they become soiled. The operator should work with both eyes open and with his right eye at the tube mouth. The operating room should be somewhat darkened so as to facilitate the ignoring of the image in the left eye; any lighting should be at the operator's back, and should be insufficient to cause reflections from the inner surface of his glasses.

[FIG. 40.—The author's endoscopic bougies. The end consists of a flexible silk woven tip attached securely to a steel shank. Sizes 8 to 30 French catheter scale. A metallic form of this bougie is useful in the trachea; but is not so safe for esophageal use.]

[FIG. 41.—The author's laryngeal bougie for the dilatation of cicatricial laryngeal stenosis. Made in 10 sizes. The shaded triangle shows the cross-section at the widest part.]

[FIG. 42.—The author's bronchoscopic and esophagoscopic table.]

[46] *Endoscopic Table*.—Any operating table may be used, but the work is facilitated if a special table can be had which allows the placing of the patient in all required positions. The table illustrated in fig. 42 is so arranged that when the false top is drawn forward on the railroad, the head piece drops and the patient is placed in the correct (Boyce) position for esophagoscopy or bronchoscopy, i.e., with the head and shoulders extending over the end of the table. By means of the wheel the plane of the table may be altered to any desired angle of inclination or height of head.

Operating Room.—All endoscopic procedures should be performed in a somewhat darkened operating room where all the desired materials are at hand. An endoscopic team consists of three persons: the operator, the assistant who holds the head, and the instrument assistant. Another person is required to hold the patient's arms and still another for the changing of the operator's glasses when they become spattered. The endoscopic team of three maintain surgical asepsis in the matter of hands and gowns, etc. The battery, on a small table of its own, is placed at the left hand of the operator. Beyond it is the table for the mechanical aspirator, if one is used. All extra instruments are placed on a sterile table, within reach, but not in the way, while those instruments for use in the particular operation are placed on a small instrument table back of the endoscopist. Only those instruments likely to be wanted should be placed on the working table, so that there shall be no confusion in their selection by the instrument nurse when called for. Each moment of time should be utilized when the endoscopic procedure has been started, no time should be lost in the hunting or separating of instruments. To have the respective tables always in the same position relative to the operator prevents confusion and avoids delay.

[FIG 43.—The author's retrograde esophagoscope.]

Oxygen Tank and Tracheotomy Instruments.—Respiratory arrest may occur from shifting of a foreign body, pressure of the esophagoscope, tumor, or diverticulum full of food. Rare as these contingencies are, it is essential that means for resuscitation be at hand. No endoscopic procedure should be undertaken without a set of tracheotomy instruments on the sterile table within instant reach. In respiratory arrest from the above mentioned causes, respiratory efforts are not apt to return unless oxygen and amyl nitrite are blown into the trachea either through a tracheotomy opening or better still by means of a bronchoscope introduced through the larynx. The limpness of the patient renders

bronchoscopy so easy that the well-drilled bronchoscopist should have no difficulty in inserting a bronchoscope in 10 or 15 seconds, if proper preparedness has been observed. It is perhaps relatively rarely that such accidents occur, yet if preparations are made for such a contingency, a life may be saved which would otherwise be inevitably lost. The oxygen tank covered with a sterile muslin cover should stand to the left of the operating table.

Asepsis.—Strict aseptic technic must be observed in all endoscopic procedures. The operator, first assistant, and instrument nurse must use the same precautions as to hand sterilization and sterile gowns as would be exercised in any surgical operation. The operator and first assistant should wear masks and sterile gloves. The patient is instructed to cleanse the mouth thoroughly with the tooth brush and a 20 per cent alcohol mouth wash. Any dental defects should, if time permit, as in a course of repeated treatments, be remedied by the dental surgeon. When placed on the table with neck bare and the shoulders unhampered by clothing, the patient is covered with a sterile sheet and the head is enfolded in a sterile towel. The face is wiped with 70 per cent alcohol.

It is to be remembered that while the patient is relatively immune to the bacteria he himself harbors, the implantation of different strains of perhaps the same type of organisms may prove virulent to him. Furthermore the transference of lues, tuberculosis, diphtheria, pneumonia, erysipelas and other infective diseases would be inevitable if sterile precautions were not taken.

All of the tubes and forceps are sterilized by boiling. The light-carriers and lamps may be sterilized by immersion in 95 per cent alcohol or by prolonged exposure to formaldehyde gas. Continuous sterilization by keeping them put away in a metal box with formalin pastilles or other source of formaldehyde gas is an ideal method. Knives and scissors are immersed in 95 per cent alcohol, and the rubber covered conducting cords are wiped with the same solution.

List of Instruments.—The following list has been compiled as a convenient basis for equipment, to which such special instruments as may be needed for special cases can be added from time to time. The instruments listed are of the author's design.

1 adult's laryngoscope.
1 child's laryngoscope.
1 infant's diagnostic laryngoscope.
1 anterior commissure laryngoscope.
1 bronchoscope, 4 mm. X 30 cm.
1 bronchoscope, 5 mm. X 30 cm.
1 bronchoscope, 7 mm. X 40 cm.
1 bronchoscope, 9 mm. X 40 cm.
1 esophagoscope, 7 mm. X 45 cm.
1 esophagoscope, 10 mm. X 53 cm.
1 esophagoscope, full lumen, 7 mm. X 45 cm.
1 esophagoscope, full lumen, 9 mm. X 45 cm.
1 esophageal speculum, adult.
1 esophageal speculum, child.
1 forward-grasping forceps, delicate, 40 cm.
1 forward-grasping forceps, regular, 50 cm.
1 forward-grasping forceps, regular, 60 cm.
1 side-grasping forceps, delicate, 40 cm.
1 side-grasping forceps, regular, 50 cm.
1 side-grasping forceps, regular, 60 cm.
1 rotation forceps, delicate, 40 cm.
1 rotation forceps, regular, 50 cm.
1 rotation forceps, regular, 60 cm.
1 laryngeal alligator forceps.
1 laryngeal papilloma forceps.
10 esophageal bougies, Nos. 8 to 17 French (larger sizes to No. 36 may be added).
1 special measuring rule.
6 light sponge carriers.
1 aspirator with double tube for minus and plus pressure.
2 endoscopic aspirating tubes 30 and 50 cm.
1 half curved hook, 60 cm.
1 triple circuit bronchoscopy battery.
6 rubber covered conducting cords for battery.
1 box bronchoscopic sponges, size 4.

1 box bronchoscopic sponges, size 5.
1 box bronchoscopic sponges, size 7.
1 box bronchoscopic sponges, size 10.
1 bite block, 1 adult.
1 bite block, child.
2 dozen extra lamps for lighted instruments.
1 extra light carrier for each instrument.*
4 yards of pipe-cleaning, worsted-covered wire.

[* Messrs. George P. Pilling and Sons who are now making these instruments supply an extra light carrier and 2 extra lamps with each instrument.]

Care of Instruments.—The endoscopist must either personally care for his instruments, or have an instrument nurse in his own employ, for if they are intrusted to the general operating room routine he will find that small parts will be lost; blades of forceps bent, broken, or rusted; tubes dinged; drainage canals choked with blood or secretions which have been coagulated by boiling, and electric attachments rendered unstable or unservicable, by boiling, etc. The tubes should be cleansed by forcing cold water through the drainage canals with the aspirating syringe, then dried by forcing pipe-cleaning worsted-covered wire through the light and drainage canals. Gauze on a sponge carrier is used to clean the main canal. Forceps stylets should be removed from their cannulae, and the cannulae cleansed with cold water, then dried and oiled with the pipe-cleaning material. The stylet should have any rough places smoothed with fine emery cloth and its blades carefully inspected; the parts are then oiled and reassembled. Nickle plating on the tubes is apt to peel and these scales have sharp, cutting edges which may injure the mucosa. All tubes, therefore, should be unplated. Rough places on the tubes should be smoothed with the finest emery cloth, or, better, on a buffing wheel. The dry cells in the battery should be renewed about every 4 months whether used or not. Lamps, light carriers, and cords, after cleansing, are wiped with 95 per cent alcohol, and the light-carriers with the lamps in place are kept in a continuous sterilization box containing formaldehyde pastilles. It is of the utmost importance that instruments be always put away in perfect order. Not only are cleaning and oiling imperative, but any needed repairs should be attended to at once. Otherwise it will be inevitable that when gotten out in an emergency they will fail. In general surgery, a spoon will serve for a retractor and good work can be done with makeshifts; but in endoscopy, especially in the small, delicate, natural passages of children, the handicap of a defective or insufficient armamentarium may make all the difference between a success and a fatal failure. A bronchoscopic clinic should at all times be in the same state of preparedness for emergency as is everywhere required of a fire-engine house.

[PLATE I—A WORKING SET OF THE AUTHOR'S ENDOSCOPIC TUBES FOR LARYNGOSCOPY, BRONCHOSCOPY, ESOPHAGOSCOPY, AND GASTROSCOPY: A, Adult's laryngoscope; B, child's laryngoscope; C, anterior commissure laryngoscope; D, esophageal speculum, child's size; E, esophageal speculum, adult's size; F, bronchoscope, infant's size, 4 mm. X 30 cm.; G, bronchoscope, child's size, 5 mm. X 30 cm.; H, aspirating bronchoscope for adults, 7 mm. X 40 cm.; I, bronchoscope, adolescent's size, 7 mm. x 40 cm., used also for the deeper bronchi of adults; J, bronchoscope, adult size, g mm. x 40 cm.; K, child's size esophagoscope, 7 mm. X 45 cm.; L, adult's size esophagoscope, full lumen construction, 9 mm. x 45 cm.; M, adult's size gastroscope. C, I, and E are also hypopharyngoscopes. C is an excellent esophageal speculum for children, and a longer model is made for adults. If the utmost economy must be practised D, E, and M may be omitted. The balance of the instruments are indispensable if adults and children are to be dealt with. The instruments are made by Charles J. Pilling & Sons, Philadelphia.]

[52] CHAPTER II—ANATOMY OF LARYNX, TRACHEA, BRONCHI AND ESOPHAGUS, ENDOSCOPICALLY CONSIDERED

The *larynx* is a cartilaginous box, triangular in cross-section, with the apex of the triangle directed anteriorly. It is readily felt in the neck and is a landmark for the operation of tracheotomy. We are concerned endoscopically with four of its cartilaginous structures: the epiglottis, the two arytenoid cartilages, and the cricoid cartilage. The *epiglottis*, the first landmark in direct laryngoscopy, is a leaf-like projection springing from the anterointernal surface of the larynx and having for its function the directing of the bolus of food into the pyriform sinuses. It does not close the larynx in the trap-door manner formerly taught; a fact easily demonstrated by the simple insertion of the direct laryngoscope and further demonstrated by the absence of dysphagia when the epiglottis is surgically removed, or is destroyed by ulceration. Closure of the larynx is accomplished by the approximation of the ventricular bands, arytenoids and aryepiglottic folds, the latter having a sphincter-like action, and by the raising and tilting of the larynx. The *arytenoids* form the upper posterior boundary of the larynx and our particular interest in them is directed toward their motility, for the rotation of the arytenoids at the

cricoarytenoid articulations determines the movements of the cords and the production of voice. Approximation of the arytenoids is a part of the mechanism of closure of the larynx.

The *cricoid cartilage* was regarded by esophagoscopists as the chief obstruction encountered on the introduction of the esophagoscope. As shown by the author, it is the cricopharyngeal fold, and the inconceivably powerful pull of the cricopharyngeal muscle on the cricoid cartilage, that causes the difficulty. The cricoid is pulled so powerfully back against the cervical spine, that it is hard to believe that this muscles is inserted into the median raphe and not into the spine itself (Fig. 68).

The *ventricular bands* or false vocal cords vicariously phonate in the absence of the true cords, and assist in the protective function of the larynx. They form the floor of the *ventricles* of the larynx, which are recesses on either side, between the false and true cords, and contain numerous mucous glands the secretion from which lubricates the cords. The ventricles are not visible by mirror laryngoscopy, but are readily exposed in their depths by lifting the respective ventricular bands with the tip of the laryngoscope. The *vocal cords*, which appear white, flat, and ribbon-like in the mirror, when viewed directly assume a reddish color, and reveal their true shelf-like formation. In the subglottic area the tissues are vascular, and, in children especially, they are prone to swell when traumatized, a fact which should be always in mind to emphasize the importance of gentleness in bronchoscopy, and furthermore, the necessity of avoiding this region in tracheotomy because of the danger of producing chronic laryngeal stenosis by the reaction of these tissues to the presence of the tracheotomic cannula.

The *trachea* just below its entrance into the thorax deviates slightly to the right, to allow room for the aorta. At the level of the second costal cartilage, the third in children, it bifurcates into the right and left main bronchi. Posteriorly the bifurcation corresponds to about the fourth or fifth thoracic vertebra, the trachea being elastic, and displaced by various movements. The endoscopic appearance of the trachea is that of a tube flattened on its posterior wall. In two locations it normally often assumes a more or less oval outline; in the cervical region, due to pressure of the thyroid gland; and in the intrathoracic portion just above the bifurcation where it is crossed by the aorta. This latter flattening is rhythmically increased with each pulsation. Under pathological conditions, the tracheal outline may be variously altered, even to obliteration of the lumen. The mucosa of the trachea and bronchi is moist and glistening, whitish in circular ridges corresponding to the cartilaginous rings, and reddish in the intervening grooves.

The right bronchus is shorter, wider, and more nearly vertical than its fellow of the opposite side, and is practically the continuation of the trachea, while the left bronchus might be considered as a branch. The deviation of the right main bronchus is about 25 degrees, and its length unbranched in the adult is about 2.5 cm. The deviation of the left main bronchus is about 75 degrees and its adult length is about 5 cm. The right bronchus considered as a stem, may be said to give off three branches, the epiarterial, upper- or superior-lobe bronchus; the middle-lobe bronchus; and the continuation downward, called the lower- or inferior-lobe bronchus, which gives off dorsal, ventral and lateral branches. The left main bronchus gives off first the upper-or superior-lobe bronchus, the continuation being the lower-or inferior-lobe bronchus, consisting of a stem with dorsal, ventral and lateral branches.

[FIG. 44.—Tracheo-bronchial tree. LM, Left main bronchus; SL, superior lobe bronchus; ML, middle lobe bronchus; IL, inferior lobe bronchus.]

The septum between the right and left main bronchi, termed the carina, is situated to the left of the midtracheal line. It is recognized endoscopically as a short, shining ridge running sagitally, or, as the patient lies in the recumbent position, we speak of it as being vertical. On either side are seen the openings of the right and left main bronchi. In Fig. 44, it will be seen that the lower border of the carina is on a level with the upper portion of the orifice of the right superior-lobe bronchus; with the carina as a landmark and by displacing with the bronchoscope the lateral wall of the right main bronchus, a second, smaller, vertical spur appears, and a view of the orifice of the right upper-lobe bronchus is obtained, though a lumen image cannot be presented. On passing down the right stem bronchus (patient recumbent) a horizontal partition or spur is found with the lumen of the middle-lobe bronchus extending toward the ventral surface of the body. All below this opening of the right middle-lobe bronchus constitutes the lower-lobe bronchus and its branches.

[FIG. 45.—Bronchoscopic views. S; Superior lobe bronchus; SL, superior lobe bronchus; I, inferior lobe bronchus; M, middle lobe bronchus.]

[56] Coming back to the carina and passing down the left bronchus, the relatively great distance from the carina to the upper-lobe bronchus is noted. The spur dividing the orifices of the left upper- and lower-lobe bronchi is oblique in direction, and it is possible to see more of the lumen of the left upper-lobe bronchus than of its homologue on the right. Below this are seen the lower-lobe bronchus and its divisions (Fig. 45).

Dimensions of the Trachea and Bronchi.—It will be noted that the bronchi divide monopodially, not dichotomously. While the lumina of the individual bronchi diminish as the bronchi divide, the sum of the areas shows a progressive increase in total tubular area of cross-section. Thus, the sum of the areas of cross-section of the two main bronchi, right and left, is greater than the area of cross section of the trachea. This follows the well known dynamic law. The relative increase in surface as the tubes branch and diminish in size increases the friction of the passing air, so that an actual increase in area of cross section is necessary, to avoid increasing resistance to the passage of air.

The cadaveric dimensions of the tracheobronchial tree may be epitomized approximately as follows:

	Adult Male	Female	Child	Infant
Diameter trachea,	14 X 20	12 X 16	8 X 10	6 X 7
Length trachea, cm.	12.0	10.0	6.0	4.0
Length right bronchus	2.5	2.5	2.0	1.5
Length left bronchus	5.0	5.0	3.0	2.5
Length upper teeth to trachea	15.0	23.0	10.0	9.0
Length total to secondary bronchus	32.0	28.0	19.0	15.0

In considering the foregoing table it is to be remembered that in life muscle tonus varies the lumen and on the whole renders it smaller. In the selection of tubes it must be remembered that the full diameter of the trachea is not available on account of the glottic aperture which in the adult is a triangle measuring approximately 12 X 22 X 22 mm. and permitting the passage of a tube not over 10 mm. in diameter without risk of injury. Furthermore a tube which filled the trachea would be too large to enter either main bronchus.

The normal movements of the trachea and bronchi are respiratory, pulsatory, bechic, and deglutitory. The two former are rhythmic while the two latter are intermittently noted during bronchoscopy. It is readily observed that the bronchi elongate and expand during inspiration while during expiration they shorten and contract. The bronchoscopist must learn to work in spite of the fact that the bronchi dilate, contract, elongate, shorten, kink, and are dinged and pushed this way and that. It is this resiliency and movability that make bronchoscopy possible. The inspiratory enlargement of lumen opens up the forceps spaces, and the facile bronchoscopist avails himself of the opportunity to seize the foreign body.

THE ESOPHAGUS

A few of the anatomical details must be kept especially in mind when it is desired to introduce straight and rigid instruments down the lumen of the gullet. First and most important is the fact that the esophageal walls are exceedingly thin and delicate and require the most careful manipulation. Because of this delicacy of the walls and because the esophagus, being a constant passageway for bacteria from the mouth to the stomach, is never sterile, surgical procedures are associated with infective risks. For some other and not fully understood reason, the esophagus is, surgically speaking, one of the most intolerant of all human viscera. The anterior wall of the esophagus is in a part of its course, in close relation to the posterior wall of the trachea, and this portion is called the party wall. It is this party wall that contains the lymph drainage system of the posterior portion of the larynx, and it is largely by this route that posteriorly located malignant laryngeal neoplasms early metastasize to the mediastinum.

[58] [FIG 46.—Esophagoscopic and Gastroscopic Chart

BIRTH 1 yr. 3 yrs. 6 yrs. 10 yrs. 14 yrs.ADULTS 23 27 30 33 36 43 53 Cm. GREATER CURVATURE 18 20 22 25 27 34 40 Cm. CARDIA 19 21 23 24 25 31 36 Cm. HIATUS 13 15 16 18 20 24 27 Cm. LEFT BRONCHUS 12 14 15 16 17 21 23 Cm. AORTA 7 9 10 11 12 14 16 Cm. CRICOPHARYINGEUS 0 0 0 0 0 0 0 Cm. INCISORS FIG. 46.—The author's esophagoscopic chart of approximate distances of the esophageal narrowings from the upper incisor teeth, arranged for convenient reference during esophagoscopy in the dorsally recumbent patient.]

The lengths of the esophagus at different ages are shown diagrammatically in Fig. 46. The diameter of the esophageal lumen varies greatly with the elasticity of the esophageal walls; its diameter at the four points of anatomical constriction is shown in the following table:

Constriction	Diameter	Vertebra
Cricopharyngeal	Transverse 23 mm. (1 in.) Antero-posterior 17 mm. (3/4 in.)	Sixth cervical
Aortic	Transverse 24 mm. (1 in.)	Fourth thoracic

Antero-posterior 19 mm. (3/4 in.)
Left-bronchial Transverse 23 mm. (1 in.) Fifth thoracic
Antero-posterior 17 mm. (3/4 in.)
Diaphragmatic Transverse 23 mm. (1 in+) Tenth thoracic
Antero-posterior 23 mm. (in.—)

For practical endoscopic purposes it is only necessary to remember that in a normal esophagus, straight and rigid tubes of 7 mm. diameter should pass freely in infants, and in adults, tubes of 10 mm.

The 4 demonstrable constrictions from above downward are at 1. The crico-pharyngeal fold. 2. The crossing of the aorta. 3. The crossing of the left bronchus. 4. The hiatus esophageus. There is a definite fifth narrowing of the esophageal lumen not easily demonstrated esophagoscopically and not seen during dissection, but readily shown functionally by the fact that almost all foreign bodies lodge at this point. This narrowing occurs at the superior aperture of the thorax and is probably produced by the crowding of the numerous organs which enter or leave the thorax through this orifice.

The crico-pharyngeal constriction, as already mentioned, is produced by the tonic contraction of a specialized band of the orbicular fibers of the lowermost portion of the inferior pharyngeal constrictor muscle, called the cricopharyngeal muscle. As shown by the author it is this muscle and not the cricoid cartilage alone that causes the difficulty in the insertion of an esophagoscope.

This muscle is attached laterally to the edges of the signet of the cricoid which it pulls with an incomprehensible power against the posterior wall of the hypopharynx, thus closing the mouth of the esophagus. Its other attachment is in the median posterior raphe. Between these circular fibers (the cricopharyngeal muscle) and the oblique fibers of the inferior constrictor muscle there is a weakly supported point through which the esophageal wall may herniate to form the so-called pulsion diverticulum. It is at this weak point that fatal esophagoscopic perforation by inexperienced operators is most likely to occur.

The aortic narrowing of the esophagus may not be noticed at all if the patient is placed in the proper sequential "high-low" position. It is only when the tube-mouth is directed against the left anterior wall that the actively pulsating aorta is felt.

The bronchial narrowing of the esophagus is due to backward displacement caused by the passage of the left bronchus over the anterior wall of the esophagus at about 27 cm. from the upper teeth in the adult. The ridge is quite prominent in some patients, especially those with dilatation from stenoses lower down.

The hiatal narrowing is both anatomic and spasmodic. The peculiar arrangement of the tendinous and muscular structure of the diaphragm acts on this hiatal opening in a sphincter-like fashion. There are also special bundles of muscle fibers extending from the crura of the diaphragm and surrounding the esophagus, which contribute to tonic closure in the same way that a pinch-cock closes a rubber tube. The author has called the hiatal closure the "diaphragmatic pinchcock."

Direction of the Esophagus.—The esophagus enters the chest in a decidedly backward as well as downward direction, parallel to that of the trachea, following the curves of the cervical and upper dorsal spine. Below the left bronchus the esophagus turns forward, passing through the hiatus in the diaphragm anterior to and to the left of the aorta. The lower third of the esophagus in addition to its anterior curvature turns strongly to the left, so that an esophagoscope inserted from the right angle of the mouth, when introduced into the stomach, points in the direction of the anterior superior spine of the left ileum.

It is necessary to keep this general course constantly in mind in all cases of esophagoscopy, but particularly in those cases in which there is marked dilatation of the esophagus following spasm at the diaphragm level. In such cases the aid of this knowledge of direction will greatly simplify the finding of the hiatus esophageus in the floor of the dilatation.

The extrinsic or transmitted movements of the esophagus are respiratory and pulsatory, and to a slight extent, bechic. The respiratory movements consist in a dilatation or opening up of the thoracic esophageal lumen during inspiration, due to the negative intrathoracic pressure. The normal pulsatory movements are due to the pulsatile pressure of the aorta, found at the 4th thoracic vertebra (24 cm. from the upper teeth in the adult), and of the heart itself, most markedly felt at the level of the 7th and 8th thoracic vertebrae (about 30 cm. from the upper teeth in adults). As the distances of all the narrowings vary with age, it is useful to frame and hang up for reference a copy of the chart (Fig. 46).

The intrinsic movements of the esophagus are involuntary muscular contractions, as in deglutition and regurgitation; spasmodic, the latter usually having some pathologic cause; and tonic, as the normal

hiatal closure, in the author's opinion may be considered. Swallowing may be involuntary or voluntary. The constrictors are anatomically not considered part of esophagus proper. When the constrictors voluntarily deliver the bolus past the cricopharyngeal fold, the involuntary or peristaltic contractions of the esophageal mural musculature carry the bolus on downward. There is no sphincter at the cardiac end of the esophagus. The site of spasmodic stenosis in the lower third, the so-called cardiospasm, was first demonstrated by the author to be located at the hiatus esophageus and the spasmodic contractions are of the specialized muscle fibers there encircling the esophagus, and might be termed "phrenospasm," or "hiatal esophagismus." Regurgitation of food from the stomach is normally prevented by the hiatal muscular diaphragmatic closure (called by the author the "diaphragmatic pinchcock") plus the kinking of the abdominal esophagus.

In the author's opinion there is no spasm in the disease called "cardiospasm." It is simply the failure of the diaphragmatic pinchcock to open normally in the deglutitory cycle. A better name is functional hiatal stenosis.

At retrograde esophagoscopy the cardia and abdominal esophagus do not seem to exist. The top of the stomach seems to be closed by the diaphragmatic pinchcock in the same way that the top of a bag is closed by a puckering string.

[63] CHAPTER III—PREPARATION OF THE PATIENT FOR PERORAL ENDOSCOPY

The suggestions of the author in the earlier volumes in regard to preparation of the patient, as for any operation, by a bath, laxative, etc., and especially by special cleansing of the mouth with 25 per cent alcohol, have received general endorsement. Care should be taken not to set up undue reaction by vigorous scrubbing of gums unaccustomed to it. Artificial dentures should be removed. Even if no anesthetic is to be used, the patient should be fasted for five hours if possible, even for direct laryngoscopy in order to forestall vomiting. Except in emergency cases every patient should be gone over by an internist for organic disease in any form. If an endolaryngeal operation is needed by a nephritic, preparatory treatment may prevent laryngeal edema or other complications. Hemophilia should be thought of. It is quite common for the first symptom of an aortic aneurysm to be an impaired power to swallow, or the lodgment of a bolus of meat or other foreign body. If aneurysm is present and esophagoscopy is necessary, as it always is in foreign body cases, "to be fore-warned is to be forearmed." Pulmonary tuberculosis is often unsuspected in very young children. There is great danger from tracheal pressure by an esophageal diverticulum or dilatation distended with food; or the food maybe regurgitated and aspirated into the larynx and trachea. Therefore, in all esophageal cases the esophagus should be emptied by regurgitation induced by titillating the fauces with the finger after swallowing a tumblerful of water, pressure on the neck, etc. Aspiration will succeed in some cases. In others it is absolutely necessary to remove food with the esophagoscope. If the aspirating tube becomes clogged by solid food, the method of swab aspiration mentioned under bronchoscopy will succeed. Of course there is usually no cough to aid, but the involuntary abdominal and thoracic compression helps. Should a patient arrive in a serious state of water-hunger, as part of the preparation the patient must be given water by hypodermoclysis and enteroclysis, and if necessary the endoscopy, except in dyspneic cases, must be delayed until the danger of water-starvation is past.

As pointed out by Ellen J. Patterson the size of the thymus gland should be studied before an esophagoscopy is done on a child.

Every patient should be examined by indirect, mirror laryngoscopy as a preliminary to peroral endoscopy for any purpose whatsoever. This becomes doubly necessary in cases that are to be anesthetized.

[65] CHAPTER IV—ANESTHESIA FOR PERORAL ENDOSCOPY

A dyspneic patient should never be given a general anesthetic. Cocaine should not be used on children under ten years of age because of its extreme toxicity. To these two postulates always in mind, a third one, applicable to both general and local anesthesia, is to be added—total abolition of the cough-reflex should be for short periods only. General anesthesia is never used in the Bronchoscopic Clinic for endoscopic procedures. The choice for each operator must, however, be a matter for individual decision, and will depend upon the personal equation, and degree of skill of the operator, and his ability to quiet the apprehensions of the patient. In other words, the operator must decide what is best for his particular patient under the conditions then existing.

Children in the Bronchoscopic Clinic receive neither local nor general anesthesia, nor sedative, for

laryngoscopic operations or esophagoscopy. Bronchoscopy in the older children when no dyspnea is present has in recent years, at the suggestion of Prof. Hare, been preceded by a full dose of morphin sulphate (i.e., 1/8 grain for a child of six years) or a full physiologic dose of sodium bromide. The apprehension is thus somewhat allayed and the excessive cough-reflex quieted. The morphine should be given not less than an hour and a half before bronchoscopy to allow time for the onset of the soporific and antispasmodic effects which are the desiderata, not the analgesic effects. Dosage is more dependent on temperament than on age or body weight. Atropine is advantageously added to morphine in bronchoscopy for foreign bodies, not only for the usual reasons but for its effect as an antispasmodic, and especially for its diminution of endobronchial secretions. True, it does not diminish pus, but by diminishing the outpouring of normal secretions that dilute the pus the total quantity of fluid encountered is less than it otherwise would be. In cases of large quantities of pus, as in pulmonary abscess and bronchiectasis, however, no diminution is noticeable. No food or water is allowed for 5 hours prior to any endoscopic procedure, whether sedatives or anesthetics are to be given or not. If the stomach is not empty vomiting from contact of the tube in the pharynx will interfere with work.

With *adults* no anesthesia, general or local, is given for esophagoscopy. For laryngeal operation and bronchoscopy the following technic is used:

One hour before operation the patient is given hypodermatically a full physiologic dose of morphin sulphate (from 1/4, to 3/8 gr.) guarded with atropin sulphate (gr. 1/150). Care must be taken that the injection be not given into a vein. On the operating table the epiglottis and pharynx are painted with 10 per cent solution of cocain. Two applications are usually sufficient completely to anesthetize the exterior and interior of the larynx by blocking of the superior laryngeal nerve without any endolaryngeal applications. The laryngoscope is now introduced and if found necessary a 20 per cent cocain solution is applied to the interior of the larynx and subglottic region, by means of gauze swabs fastened to the sponge carriers. Here also two applications are quite sufficient to produce complete anesthesia in the larynx. If bronchoscopy is to be done the gauze swab is carried down through the exposed glottis to the carina, thus anesthetizing the tracheal mucosa. If further anesthetization of the bronchial mucosa is required, cocain may be applied in the same manner through the bronchoscope. In all these local applications prolonged contact of the swab is much more efficient than simply painting the surface.

[67] In cases in which cocain is deemed contraindicated morphin alone is used. If given in sufficient dosage cocain can be altogether dispensed with in any case.

It is perhaps *safer for the beginner* in his early cases of esophagoscopy to have the patient relaxed by an ether anesthesia, provided the patient is not dyspneic to begin with, or made so by faulty position or by pressure of the esophagoscopic tube mouth on the tracheoesophageal "party wall." As proficiency develops, however, he will find anesthesia unnecessary. Local anesthesia is needless for esophagoscopy, and if used at all should be limited to the laryngopharynx and never applied to the esophagus, for the esophagus is without sensation, as anyone may observe in drinking hot liquids.

Direct laryngoscopy in children requires neither local nor general anesthesia, either for diagnosis or for removal of foreign bodies or growths from the larynx. General anesthesia is contraindicated because of the dyspnea apt to be present, and because the struggles of the patient might cause a dislodgment of the laryngeal intruder and aspiration to a lower level. The latter accident is also prone to follow attempts to cocainize the larynx.

Technic for General Anesthesia.—For esophagoscopy and gastroscopy, if general anesthesia is desired, ether may be started by the usual method and continued by dropping upon folded gauze laid over the mouth after the tube is introduced. Endo-tracheal administration of ether is, however, far safer than peroral administration, for it overcomes the danger of respiratory arrest from pressure of the esophagoscope, foreign body, or both, on the trachea. Chloroform should not be used for esophagoscopy or gastroscopy because of its depressant action on the respiratory center.

For bronchoscopy, ether or chloroform may be started in the usual way and continued by insufflating through the branch tube of the bronchoscope by means of the apparatus shown in Fig. 13.

In case of paralysis of the larynx, even if only monolateral, a general anesthetic if needed should be given by intratracheal insufflation. If the apparatus for this is not available the patient should be tracheotomized. Hence, every adult patient should be examined with a throat mirror before general anesthesia for any purpose, and the necessity becomes doubly imperative before goiter operations. A number of fatalities have occurred from neglect of this precaution.

Anesthetizing a tracheotomized patient is free from danger so long as the cannula is kept free from secretion. Ether is dropped on gauze laid over the tracheotomic cannula and the anesthesia watched in the usual manner. If the laryngeal stenosis is not complete, ether-saturated gauze is to be placed over

the mouth as well as over the tracheotomy tube.

Endo-tracheal anesthesia is by far the safest way for the administration of ether for any purpose. By means of the silk-woven catheter introduced into the trachea, ether-laden air from an insufflation apparatus is piped down to the lungs continuously, and the strong return-flow prevents blood and secretions from entering the lower air-passages. The catheter should be of a size, relative to that of the glottic chink, to permit a free return-flow. A number 24 French is readily accommodated by the adult larynx and lies well out of the way along the posterior wall of the larynx. Because of the little room occupied by the insufflation catheter this method affords ideal anesthesia for external laryngeal operations. Operations on the nose, accessory sinuses and the pharynx, apt to be attended by considerable bleeding, are rendered free from the danger of aspiration pneumonia by endotracheal anesthesia. It is the safest anesthesia for goiter operations. Endo-tracheal anesthesia has rendered needless the intricate negative pressure chamber formerly required for thoracic surgery, for by proper regulation of the pressure under which the ether ladened air is delivered, a lung may be held in any desired degree of expansion when the pleural cavity is opened. It is indicated in operations of the head, neck, or thorax, in which there is danger of respiratory arrest by centric inhibition or peripheral pressure; in operations in which there is a possibility of excessive bleeding and aspiration of blood or secretions; and in operations where it is desired to keep the anesthetist away from the operating field. Various forms of apparatus for the delivery of the ether-laden vapor are supplied by instrument makers with explicit directions as to their mechanical management.

We are concerned here mainly with the technic of the insertion of the intratracheal tube. The larynx should be examined with the mirror, preferably before the day of operation, for evidence of disease, and incidentally to determine the size of the catheter to be introduced, though the latter can be determined after the larynx is laryngoscopically exposed. The following list of rules for the introduction of the catheter will be of service (see Fig. 59).

RULES FOR INSERTION OF THE CATHETER FOR INSUFFLATION ANESTHESIA

1. The patient should be fully under the anesthetic by the open method so as to get full relaxation of the muscles of the neck. 2. The patient's head must be in full extension with the vertex firmly pushed down toward the feet of the patient, so as to throw the neck upward and bring the occiput down as close as possible beneath the cervical vertebrae. 3. No gag should be used, because the patient should be sufficiently anesthetized not to need a gag, and because wide gagging defeats the exposure of the larynx by jamming down the mandible. 4. The epiglottis must be identified before it is passed. 5. The speculum must pass sufficiently far below the tip of the epiglottis so that the latter will not slip. 6. Too deep insertion must be avoided, as in this case the speculum goes posterior to the cricoid, and the cricoid is lifted, exposing the mouth of the esophagus, which is bewildering until sufficient education of the eye enables the operator to recognize the landmarks. 7. The patient's head is lifted off the table by the spatular tip of the laryngoscope. Actual lifting of the head will not be necessary if the patient is fully relaxed; but the idea of lifting conveys the proper conception of laryngeal exposure (Fig. 55).

[71] CHAPTER V—BRONCHOSCOPIC OXYGEN INSUFFLATION

Bronchoscopic oxygen insufflation is a life-saving measure equalled by no other method known to the science of medicine, in all cases of asphyxia, or apnea, present or impending. Its especial sphere of usefulness is in severe cases of electric shock, hanging, smoke asphyxia, strangulation, suffocation, thoracic or abdominal pressure, apnea, acute traumatic pneumothorax, respiratory arrest from absence of sufficient oxygen, or apnea from the presence of quantities of irrespirable or irritant gases. Combined with bronchoscopic aspiration of secretions it is the best method of treatment for poisoning by chlorine gas, asphyxiating, and other war gases.

Bronchoscopic oxygen insufflation should be taught to every interne in every hospital. The emergency or accident ward of every hospital should have the necessary equipment and an interne familiar with its use. The method is simple, once the knack is acquired. The patient being limp and recumbent on a table, the larynx is exposed with the laryngoscope, and the bronchoscope is inserted as hereinafter described. The oxygen is turned on at the tank and the flow regulated before the rubber tube from the wash-bottle of tank is attached to the side-outlet of the bronchoscope. It is necessary to be certain that the flow is gentle, so that, with a free return flow the introduced pressure does not exceed the capillary pressure; otherwise the blood will be forced out of the capillaries and the ischemia of the lungs will be fatal. Another danger is that overdistension causes inhibition of inspiration resulting in apnea continuing as long as the distension is maintained, if not longer. The return flow from the bronchoscope should be interrupted for 2 or 3 seconds several times a minute to inflate the lungs, but the flow must not be occluded longer than 3 seconds, because the intrapulmonary pressure would rise. A pearl of

amyl nitrite may be broken in the wash bottle. Slow rhythmic artificial respiratory movements are a useful adjunct, and unless the operator is very skillful in gauging the alternate pressures and releases with the thumb according to the oxygen pressure, it is vitally necessary to fill and deflate the lungs rhythmically by one of the well known methods of artificial respiration. Anyone skilled in the introduction of the bronchoscope can do bronchoscopy in a few seconds, and it is especially easy in cases of respiratory arrest, because of the limp condition of the patient.

The foregoing applies to cases in which a pulmotor would be used, such as apnea from electric shocks, etc. For obstructive dyspnea and asphyxia, tracheotomy is the procedure of choice, and the skillful tracheotomist would be justified in preferring tracheotomy for the other class of cases, insufflating the oxygen and amyl nitrite through the tracheotomic wound. The pulmotor and similar mechanisms are, perhaps, the best things the use of which can be taught to laymen; but as compared to bronchoscopic oxygen insufflation they are woefully inefficient, because the intraoral pressure forces the tongue back over the laryngeal orifice, obstructing the airway in this "death zone." By the introduction of the bronchoscope this death zone is entirely eliminated, and a free airway established for piping the oxygen directly into the lungs.

[73] CHAPTER VI—POSITION OF THE PATIENT FOR PERORAL ENDOSCOPY

It is the author's invariable practice to place the patient in the dorsally recumbent position. The sitting position is less favorable. While lying on a well-padded, flat table the patient is readily controlled, the head is freely movable, secretions can be easily removed, the view obtained by the endoscopist is truly direct (without reversal of sides), and, most important, the employment of one position only favors smoother and more efficient team work, and a better endoscopic technic.

General Principles of Position.—As will be seen in Fig. 47 the trachea and esophagus are not horizontal in the thorax, but their long axes follow the curves of the cervical and dorsal spine. Therefore, if we are to bring the buccal cavity and pharynx in a straight line with the trachea and esophagus it will be found necessary to elevate the whole head above the plane of the table, and at the same time make extension at the occipito-atloid joint. By this maneuver the cervical spine is brought in line with the upper portion of the dorsal spine as shown in Fig. 55. It was formerly taught, and often in spite of my better knowledge I am still unconsciously prone to allow the head and cervical spine to assume a lower position than the plane of the table, the so-called Rose position. With the head so placed, it is impossible to enter the lower air or food passages with a rigid tube, as will be shown by a study of the radiograph shown in Fig. 49. Extension of the head on the occipito-atloid joint is for the purpose of freeing the tube from the teeth, and the amount required will vary with the degree to which the mouth can be opened. Whether the head be extended, flexed, or kept mid-way, the fundamental principle in the introduction of all endoscopic tubes is the anterior placing of the cervical spine and the high elevation of the head. The esophagus, just behind the heart, turns ventrally and to the left. In order to pass a rigid tube through this ventral curve the dorsal spine is now extended by lowering the head and shoulders below the plane of the table. This will be further explained in the chapter on esophagoscopy. In all of these procedures, the nose of the patient should be directed toward the zenith, and the assistant should *prevent rotation of the head* as well as *prevent lowering of the head*. The patient should be urged as follows: "Don't hold yourself so rigid." "Let your head and neck go loose." "Let your head rest in my hand." "Don't try to hold it." "Let me hold it." "Relax." "Don't raise your chest."

[FIG. 47.—Schematic illustration of normal position of the intra-thoracic trachea and esophagus and also of the entire trachea when the patient is in the correct position for peroral bronchoscopy. When the head is thrown backward (as in the Rose position) the anterior convexity of the cervical spine is transmitted to the trachea and esophagus and their axes deviated. The anterior deviation of the lower third of the esophagus shows the anatomical basis for the "high low" position for esophagoscopy]

[FIG. 48.—Correct position of the cervical spine for esophagoscopy
and
bronchoscopy. (*Illustration reproduced from author's article Jour. Am. Med. Assoc., Sept. 25, 1909*)]

[FIG. 49.—Curved position of the cervical spine, with anterior convexity, in the Rose position, rendering esophagoscopy and bronchoscopy difficult or impossible. The devious course of the pharynx, larynx and trachea are plainly visible. The extension is incorrectly imparted to the whole cervical spine instead of only to the occipito-atloid joint. This is the usual and very faulty conception of the extended position. (*Illustration reproduced from author's article, Jour. Am. Med. Assoc., Sept. 25, 1909.*)]

[76] For *direct laryngoscopy* the patient's head is raised above the plane of the table by the first

assistant, who stands to the right of the patient, holding the bite block on his right thumb inserted in the left corner of the patient's mouth, while his extended right hand lies along the left side of the patient's cheek and head, and prevents rotation. His left hand, placed under the patient's occiput, elevates the head and maintains the desired degree of extension at the occipito-atloid joint (Fig. 50).

[FIG 50.—Direct laryngoscopy, recumbent patient. The second assistant is sitting holding the head in the Boyce position, his left forearm on his left thigh his left foot on a stool whose top is 65 cm. lower than the table-top. His left hand is on the patient's sterile-covered scalp, the thumb on the forehead, the fingers under the occiput, making forced extension. The right forearm passes under the neck of the patient, so that the index finger of the right hand holds the bite-block in the left corner of the patient's mouth. The fingers of the operator's right hand pulls the upper lip out of all danger of getting pinched between the teeth and the laryngoscope. This is a precaution of the utmost importance and the trained habit of doing it must be developed by the peroral endoscopist.]

Position for Bronchoscopy and Esophagoscopy.—The dorsally recumbent patient is so placed that the head and shoulders extend beyond the table, the edge of which supports the thorax at about the level of the scapulae. During introduction, the head must be maintained in the same relative position to the table as that described for direct laryngoscopy, that is, elevated and extended. The first assistant, in this case, sits on a stool to the right of the patient's head, his left foot resting on a box about 14 inches in height, the left knee supporting the assistant's left hand, which being placed under the occiput of the patient maintains elevation and extension. The right arm of the assistant passes under the neck of the patient, the bite block being carried on the middle finger of the right hand and inserted into the left side of the patient's mouth. The right hand also prevents rotation of the head (Fig. 51). As the bronchoscope or esophagoscope is further inserted, the head must be placed so that the tube corresponds to the axis of the lumen of the passage to be examined. If the left bronchus is being explored, the head must be brought strongly to the right. If the right middle lobe bronchus is being searched, the head would require some left lateral deflection and a considerable degree of lowering, for this bronchus, as before mentioned, extends anteriorly. During esophagoscopy when the level of the heart is reached, the head and upper thorax must be strongly depressed below the plane of the table in order to follow the axis of the lumen of the ventrally turning esophagus; at the same time the head must be brought somewhat to the right, since the esophagus in this region deviates strongly to the left.

[FIG. 51.—Position of patient and assistant for introduction of the bronchoscope and esophagoscope. The middle of the scapulae rest on the edge of the table; the head and shoulders, free to move, are supported by the assistant, whose right arm passes under the neck; the right middle finger inserts the bite block into the left side of the mouth. The left hand, resting on the left knee maintains the desired degree of elevation, extension and lateral deflection required by the operator. The patient's vertex should be 10 cm. higher than the level of the top of the table. This is the Boyce position, which has never been improved upon for bronchoscopy and esophagoscopy.]

[FIG. 52.—Schema of position for endoscopy. A. Normal recumbency on the table with pillow supporting the head. The larynx can be directly examined in this position, but a better position is obtainable. B. Head is raised to proper position with head flexed. Muscles of front of neck are relaxed and exposure of larynx thus rendered easier; but, for most endoscopic work, a certain amount of extension is desired. The elevation is the important thing. C. The neck being maintained in position B, the desired amount of extension of the head is obtained by a movement limited to the occipito-atloid articulation by the assistant's hand placed as shown by the dart (B). D. Faulty position. Unless prevented, almost all patients will heave up the chest and arch the lumbar spine so as to defeat the object and to render endoscopy difficult by bringing the chest up to the high-held head, thus assuming the same relation of the head to the chest as exists in the Rose position (a faulty one for endoscopy) as will be understood by assuming that the dotted line, E, represents the table. If the pelvis be not held down to the table the patient may even assume the opisthotonous position by supporting his weight on his heels on the table and his head on the assistant's hand.]

In obtaining the position of high head with occipito-atloid extension, the easiest and most certain method, as pointed out to me by my assistant, Gabriel Tucker, is first to raise the head, strongly flexed, as shown in Fig. 52; then while maintaining it there, make the occipito-atloid extension. This has proven better than to elevate and extend in a combined simultaneous movement.

If the patient would relax to limpness exposure of the larynx would be easily obtained, simply by lifting the head with the lip of the laryngoscope passed below the tip of the epiglottis (as in Fig. 55) and no holding of the head would be necessary. But only rarely is a patient found who can do this. This degree of relaxation is of course, present in profound general ether anesthesia, which is not to be thought of for direct laryngoscopy, except when it is used for the purpose of insertion of intratracheal insufflation anesthetic tubes. For this, of course, the patient is already to be deeply anesthetized. The muscular tension exerted by some patients in assuming and holding a faulty position is almost as much

of a hindrance to peroral endoscopy as is the position itself. The tendency of the patient to heave up his chest and assume a false position simulating the opisthotonous position (Fig. 52) must be overcome by persuasion. This position has all the disadvantages of the Rose position for endoscopy.

[FIG. 53.—The author's position for the removal of foreign bodies from the larynx or from any of the upper air or food passages. If dislodged, the intruder will not be aided by gravity to reach a deeper lodgement.]

The one exception to these general positions is found in procedures for the removal of foreign bodies from the larynx. In such cases, while the same relative position of the head to the plane of the table is maintained, the whole table top is so inclined as to elevate the feet and lower the head, known as Jackson's position. This semi-inversion of the patient allows the foreign body to drop into the pharynx if it should be dislodged, or slip from the forceps (Fig. 53).

[82] CHAPTER VII—DIRECT LARYNGOSCOPY

Importance of Mirror Examination of the Larynx.—The presence of the direct laryngoscope incites spasmodic laryngeal reflexes, and the traction exerted somewhat distorts the tissues, so that accurate observations of variations in laryngeal mobility are difficult to obtain. The function of the laryngeal muscles and structures, therefore, can best be studied with the laryngeal mirror, except in infants and small children who will not tolerate the procedure of indirect laryngoscopy. A true idea of the depth of the larynx is not obtained with the mirror, and a view of the ventricles is rarely had. With the introduction of the direct laryngoscope it is found that the larynx is funnel shaped, and that the adult cords are situated about 3 cm. below the aryepiglottic folds; the cords also assume their true shelf-like character and take on a pinkish or yellowish tinge, rather than the pearly white seen in the mirror. They are not to any extent differentiated by color from the neighboring structures. Their recognition depends almost wholly on form, position and movement.

Accurate observation is stimulated in all pathologic cases by making colored crayon sketches, however crude, of the mirror image of the larynx. The location of a growth may be thus graphically recorded, so that at the time of operation a glance will serve to refresh the memory as to its site. It is to be constantly kept in mind, however, that in the mirror image the sides are reversed because of the facing positions of the examiner and patient. Direct laryngoscopy is the only method by which the larynx of children can be seen. The procedure need require less than a minute of time, and an accurate diagnosis of the condition present, whether papilloma, foreign body, diphtheria, paralysis, etc., may be thus obtained. The posterior pharyngeal wall should be examined in all dyspneic children for the possible existence of retropharyngeal abscess.

[PLATE II—DIRECT AND INDIRECT LARYNGEAL VIEWS FROM AUTHOR'S OIL-COLOR DRAWINGS FROM LIFE: 1, Epiglottis of child as seen by direct laryngoscopy in the recumbent position. 2, Normal larynx spasmodically closed, as is usual on first exposure without anesthesia. 3, Same on inspiration. 4, Supraglottic papillomata as seen on direct laryngoscopy in a child of two years. 5, Cyst of the larynx in a child of four years, seen on direct laryngoscopy without anesthesia. 6, Indirect view of larynx eight weeks after thyrotomy for cancer of the right cord in a man of fifty years. 7, Same after two years. An adventitious band indistinguishable from the original one has replaced the lost cord. 8, Condition of the larynx three years after hemilaryngectomy for epithelioma in a patient fifty-one years of age. Thyrotomy revealed such extensive involvement, with an open ulceration which had reached the perichondrium, that the entire left wing of the thyroid cartilage was removed with the left arytenoid. A sufficiently wide removal was accomplished without removing any part of the esophageal wall below the level of the crico-arytenoid joint. There is no attempt on the part of nature to form an adventitious cord on the left side. The normal arytenoid drew the normal cord over, approximately to the edge of the cicatricial tissue of the operated side. The voice, at first a very hoarse whisper, eventually was fairly loud, though slightly husky and inflexible. 9, The pharynx seen one year after laryngectomy for endothelioma in a man aged sixty-eight years. The purple papilla; anteriorly are at the base of the tongue, and from this the mucosa slopes downward and backward smoothly into the esophagus. There are some slight folds toward the left and some of these are quite cicatricial. The epiglottis was removed at operation. The trachea was sutured to the skin and did not communicate with the pharynx. (Direct view.)]

Contraindications to Direct Laryngoscopy.—There are no absolute contraindications to direct laryngoscopy in any case where direct laryngoscopy is really needed for diagnosis or treatment. In extremely dyspneic patients, if the operator is not confident in his ability for a prompt and sure introduction of a bronchoscope, it may be wise to do a tracheotomy first.

Instructions to the Patient.—Before beginning endoscopy the patient should be told that he will feel a very disagreeable pressure on his neck and that he may feel as though he were about to choke. He must be gently but positively made to understand (1) that while the procedure is alarming, it is absolutely free from danger; (2) that you know just how it feels; (3) that you will not allow his breath to be shut off completely; (4) that he can help you and himself very much by paying close attention to breathing deeply and regularly; (5) and that he must not draw himself up rigidly as though "walking on ice," but must be easy and relaxed.

Direct Laryngoscopy. Adult Patient.—Before starting, every detail in regard to instrumental equipment and operating room assistants, (including an assistant to hold the arms and legs of the patient) must be complete. Preparation of the patient and the technic of local anesthesia have been discussed in their respective chapters. The dorsally recumbent patient is draped with (not pinned in) a sterile sheet. The head, covered by sterile towels, is elevated, and slight extension is made at the occipitoatloid joint by the left hand of the first assistant. The bite block placed on the assistant's right thumb is inserted into the left angle of the patient's open mouth (see Fig. 50).

The laryngoscope must always and invariably be held in the left hand, and in such a manner that the greatest amount of traction is made at the swell of the horizontal bar of the handle, rather than on the vertical bar.

The right hand is then free for the manipulation of forceps, and the insertion of the bronchoscope or other instrument. During introduction, the fingers of the right hand retract the upper lip so as to prevent its being pinched between the laryngoscope and the teeth. The introduction of the direct laryngoscope and exposure of the larynx is best described in two stages. 1. Exposure and identification of the epiglottis. 2. Elevation of the epiglottis and all the tissues attached to the hyoid bone, so as to expose the larynx to direct view.

First Stage.—The spatular end of the laryngoscope is introduced in the right side of the patient's mouth, along the right side of the anterior two-thirds of the tongue. It was the German method to introduce the laryngoscope over the dorsum of the tongue but in order to elevate this sometimes powerful muscular organ considerable force may be required, which exercise of force may be entirely avoided by crowding the tongue over to the left. When the posterior third stage of the tongue is reached, the tip of the laryngoscope is directed toward the midline and the dorsum of the tongue is elevated by a lifting motion imparted to the laryngoscope. The epiglottis will then be seen to project into the endoscopic field, as seen in Fig. 54.

[FIG. 54.—End of the first of direct laryngoscopy, recumbent adult patient. The epiglottis is exposed by a lifting motion of the spatular tip on the tongue anterior to the epiglottis.]

Second Stage.—The spatular end of the laryngoscope should now be tipped back toward the posterior wall of the pharynx, passed posterior to the epiglottis, and advanced about 1 cm. The larynx is now exposed by a motion that is best described as a suspension of the head and all the structures attached to the hyoid bone on the tip of the spatular end of the laryngoscope (Fig. 55). Particular care must be taken at this stage not to pry on the upper teeth; but rather to impart a lifting motion with the tip of the speculum without depressing the proximal tubular orifice. It is to be emphasized that while some pressure is necessary in the lifting motion, great force should never be used; the art is a gentle one. The first view is apt to find the larynx in state of spasm, and affords an excellent demonstration of the fact that the larynx can he completely closed without the aid of the epiglottis. Usually little more is seen than the two rounded arytenoid masses, and, anterior to them, the ventricular bands in more or less close apposition hiding the cords (Fig. 56). With deep general anesthesia or thorough local anesthesia the spasm may not be present. By asking the patient to take a deep breath and maintain steady breathing, or perhaps by requesting a phonatory effort, the larynx will open widely and the cords be revealed. If the anterior commissure of the larynx is not readily seen, the lifting motion and elevation of the head should be increased, and if there is still difficulty in exposing the anterior commissure the assistant holding the head should with the index finger externally on the neck depress the thyroid cartilage. If by this technic the larynx fails to be revealed the endoscopist should ask himself which of the following rules he has violated.

[FIG. 55.—Schema illustrating the technic of direct laryngoscopy on the recumbent patient. The motion is imparted to the tip of the laryngoscope as if to lift the patient by his hyoid hone. The portion of the table indicated by the dotted line may be dropped or not, but the back of the head must never go lower than here shown, for direct laryngoscopy; and it is better to have it at least 10 cm. above the level of the table. The table may be used as a rest for the operator's left elbow to take the weight of the head. (Note that in bronchoscopy and esophagoscopy the head section of the table must be dropped, so as to leave the head and neck of the patient out in the air, supported by the second assistant.)]

[FIG. 56.—Endoscopic view at the end of the second stage of direct laryngoscopy. Recumbent patient.

Larynx exposed waiting for larynx to relax its spasmodic contraction.]

RULES FOR DIRECT LARYNGOSCOPY 1. The laryngoscope must always be held in the left hand, never in the right. 2. The operator's right index finger (never the left) should be used to retract the patient's upper lip so that there is no danger of pinching the lip between the instrument and the teeth. 3. The patient's head must always be exactly in the middle line, not rotated to the right or left, nor bent over sidewise; and the entire head must be forward with extension at the occipitoatloid joint only. 4. The laryngoscope is inserted to the right side of the anterior two-thirds of the tongue, the tip of the spatula being directed toward the midline when the posterior third of the tongue is reached. 5. The epiglottis must always be identified before any attempt is made to expose the larynx. 6. When first inserting the laryngoscope to find the epiglottis, great care should be taken not to insert too deeply lest the epiglottis be overridden and thus hidden. 7. After identification of the epiglottis, too deep insertion of the laryngoscope must be carefully avoided lest the spatula be inserted back of the arytenoids into the hypo-pharynx. 8. Exposure of the larynx is accomplished by pulling forward the epiglottis and the tissues attached to the hyoid bone, and not by prying these tissues forward with the upper teeth as a fulcrum. 9. Care must be taken to avoid mistaking the ary-epiglottic fold for the epiglottis itself. (Most likely to occur as the result of rotation of the patient's head.) 10. The tube should not be retained too long in place, but should be removed and the patient permitted to swallow the accumulated saliva, which, if the laryngoscope is too long in place, will trickle down the trachea and cause cough. (Swallowing is almost impossible while the laryngoscope is in position.) The secretions may be removed with the aspirator. 11. The patient must be instructed to breathe deeply and quietly without making a sound.

[88] *Difficulties of Direct Laryngoscopy*.—The larynx can be directly exposed in any patient whose mouth can be opened, although the ease varies greatly with the type of patient. Failure to expose the epiglottis is usually due to too great haste to enter the speculum all the way down. The spatula should glide slowly along the posterior third of the tongue until it reaches the glossoepiglottic fossa, while at the same time the tongue is lifted; when this is done the epiglottis will stand out in strong relief. The beginner is apt to insert the speculum too far and expose the hypopharynx rather than the larynx. The elusiveness of the epiglottis and its tendency to retreat downward are very much accentuated in patients who have worn a tracheotomic cannula; and if still wearing it, the patient can wait indefinitely before opening his glottis. Over extension of the patient's head is a frequent cause of difficulty. If the head is held high enough extension is not necessary, and the less the extension the less muscular tension there is in the anterior cervical muscles. Only one arytenoid eminence may be seen. The right and the left look different. Practice will facilitate identification, so that the endoscopist will at once know which way to look for the glottis.

Of the difficulties that pertain to the operator himself the greatest is lack of practice. He must learn to recognize the landmarks even though a high degree of spasm be present. The epiglottis and the two rounded eminences corresponding to the arytenoids must be in the mind's eye, for it is only on deep, relaxed inspiration that anything like a typical picture of the larynx will be seen. He must know also the right from the left arytenoid when only one is seen in order to know whether to move the lip of the laryngoscope to the right or the left for exposure of the interior of the larynx.

Instruments for Direct Laryngoscopy.—In undertaking direct laryngoscopy one must always be prepared for bronchoscopy, esophagoscopy, and tracheotomy, as well. Preparations for bronchoscopy are necessary because the pathological condition may not be found in the larynx, and further search of the trachea or bronchi may be required. A foreign body in the larynx may be aspirated to a deeper location and could only be followed with the bronchoscope. Sudden respiratory arrest might occur, from pathology or foreign body, necessitating the inserting of the bronchoscope for breathing purposes, and the insufflation of oxygen and amyl nitrite. Trachectomy might be required for dyspnea or other reasons. It might be necessary to explore the esophagus for conditions associated with laryngeal lesions, as for instance a foreign body in the esophagus causing dyspnea by pressure. In short, when planning for direct laryngoscopy, bronchoscopy, or esophagoscopy, prepare for all three, and for tracheotomy. A properly done direct laryngoscopy would never precipitate a tracheotomy in an unanesthetized patient; but direct laryngoscopy has to deal so frequently with laryngeal stenosis, that routine preparation for tracheotomy a hundred unnecessary times is fully compensated for by the certainty of preparedness when the rare but urgent occasion arises.

Direct Laryngoscopy in Children.—The epiglottis in children is usually strongly curled, often omega shaped, and is very elusive and slippery. The larynx of a child is very freely movable in the neck during respiration and deglutition, and has a strong tendency to retreat downward during examination, and thus withdraw the epiglottis after the arytenoids have been exposed. In following down with the laryngoscope the speculum is prone to enter the hypopharynx. Lifting in this location will expose the mouth of the esophagus and shut off the larynx, and may cause respiratory arrest. Practice, however, will soon develop a technic and ability to recognize the landmarks in state of spasm, so that on

exposing the approximated arytenoid eminences the endoscopist will maintain his position and wait for the larynx to open. The procedure should be done without any form of anesthesia for the following reasons: 1. Anesthesia is unnecessary. 2. It is extremely dangerous in a dyspneic patient. 3. It is inadmissable in a patient with diphtheria. 4. If anesthesia is to be used, direct laryngoscopy will never reach its full degree of usefulness, because anesthesia makes a major procedure out of a minor one. 5. Cocain in children is dangerous, and its application more annoying than the examination.

Inducing a Child to Open its Mouth (Author's Method).—The wounding of the child's mouth, gums, and lips, in the often inefficacious methods with gags, hemostats, raspatories, etcetera, are entirely unnecessary. The mouth of any child not unconscious can be opened quickly and without the slightest harm by passing a curved probe between the clenched jaws back of the molars and down back of the tongue toward the laryngopharynx. This will cause the child to gag, when its mouth invariably opens.

[91] CHAPTER VIII—DIRECT LARYNGOSCOPY (*Continued*)

Technic of Laryngeal Operations.—Preparation of the patient and anesthesia have been mentioned under their respective chapters. The prime essential of successful laryngeal operations is perfect mastery of continuous left-handed laryngeal exposure. The right hand must be equally trained in the manipulation of forceps, and the right eye to gauge depth. Blood and secretions are best removed by a suction tube (Fig. 9) inserted through the laryngoscope, or directly into the pharynx outside the laryngoscope.

For the removal of benign growths the author's papilloma forceps, Fig. 29, or the laryngeal grasping forceps shown in Fig. 17 will prove more satisfactory than any form of cutting forceps. These growths should be removed superficially flush with the normal structure. The crushing of the base incident to the plucking off of the growth causes its recession. By this conservative method damage to the cords and impairment of the voice are avoided. For growths in the anterior portion of the larynx, and in fact for the removal of most small benign growths, the anterior commissure laryngoscope is especially adapted. Its shape allows its introduction into the vestibule of the larynx, and if desired it may be introduced through the glottic chink for the treatment of subglottic conditions. It will not infrequently be observed that a pedunculated subglottic growth which is found with difficulty will be pulled upward into view by the gauze swab introduced to remove secretions. The growth is then often held tightly between the approximated cords for a few seconds—perhaps long enough to grasp it with forceps.

[92] *Removal of Growth from the Laryngeal Ventricle.*—After exposing the larynx in the usual manner, if the head is turned strongly to the right, the tip of the laryngoscope, directed from the right side of the mouth, may be used to lift the left ventricular hand and thus expose the ventricle, from which a growth may be removed in the usual manner (Fig. 57). The right ventricle is exposed by working from the left side of the mouth.

[FIG. 57.-Schema illustrating the lateral method of exposing a growth in the ventricle of Morgagni, by bending the patient's head to the opposite side, while the second assistant externally fixes the larynx with his hand. M, Patient's mouth; T, thyroid cartilage; R, right side; L, left. V, B, ventricular band. C, C, vocal cord. The circular drawing indicates the endoscopic view obtainable by this method. The tube, E, is dropped to the corner of the mouth, B, and the tube is inserted down to R. The lip of the spatula can then be used to lift the ventricular band so as to expose more of the ventricle. The drawing shows an unusually shallow ventricle.]

Taking a Laryngeal Specimen for Diagnosis.—The diagnosis of carcinoma, sarcoma, and some other conditions can be made certain only by microscopic study of tissue removed from the growth. The specimen should be ample but will necessarily be small. If the suspected growth be small it should be removed entire, together with some of the basal tissues. If it is a large growth, and there are objections to its entire removal, the edge of the growth, including apparently normal as well as neoplastic tissue, is necessary. If it is a diffuse infiltrative process, a specimen should be taken from at least two locations. Tissue for biopsy is to be taken with the punch forceps shown in Fig. 28 or that in Fig. 33. The forceps may be inserted through the tube or from the angle of the mouth; the "extubal" method (see Fig. 58).

[FIG. 58.—Schema illustrating removal of a tumor from the upper part of the larynx by the author's "extubal" method for large tumors. The large alligator basket punch forceps, F, is inserted from the right corner of the mouth and the jaws are placed over the tumor, T, under guidance of the eye looking through the laryngoscope, L. This method is not used for small tumors. It is excellent for amputation of the epiglottis with these same punch forceps or with the heavy snare.]

Removal of large benign tumors above the cords may be done with the snare or with the large

laryngeal punch forceps. Both are used in the extubal method.

Amputation of the epiglottis for palliation of odynophagia or dysphagia in tuberculous or malignant disease, is of benefit when the ulceration is confined to this region; though as to tuberculosis the author feels rather conservatingly inclined. Early malignancy of the extreme tip can be cured by such means. The function of the epiglottis seems to be to split the food bolus and direct its portions laterally into the pyriform sinuses, rather than to take any important part in the closure of the larynx. Following the removal of the epiglottis there is rarely complaint of food entering the larynx. The projecting portion of the epiglottis may be amputated with a heavy snare, or by means of the large laryngeal punch forceps (Fig. 33).

Endoscopic Operations for Laryngeal Stenosis.—Web formations may be excised with sliding punch forceps, or if the web is due to contraction only, incision of the true band may allow its retraction. In some instances liberation of adhesions will favor the formation of adventitious vocal cords. A sharp anterior commissure is a large factor in good phonation.

Endoscopic evisceration of the larynx will cure a few cases of laryngeal cicatricial stenosis, and should be tried before resorting to laryngostomy. A sliding punch forceps is used to remove all the tissue in the larynx out to the perichondrium, but care should be taken in cicatricial cases to avoid removing any part of either arytenoid cartilage. In cases of posticus paralysis the excision may include portions of the vocal processes of the arytenoids. Ventriculocordectomy is preferable to evisceration. The ventricular floor is removed with punch forceps (Fig. 33) first on one side, then after two months, on the other.

Vocal Results.—A whispering voice can always be had as long as air can pass through the larynx, and this may be developed to a very loud penetrating stage whisper. If the arytenoid motility has been uninjured the repeated pulls on the scar tissue may draw out adventitious bands and develop a loud, useful, though perhaps rough and inflexible voice.

Galvano-cauterization is the best method of treatment for chronic subglottic edema or hyperplasia such as is seen in children following diphtheria, when the stenosis produced prevents extubation or decannulation. The utmost caution should be used to avoid deep cauterizations; they are almost certain to set up perichondritis which will increase the stenosis. Some of the most difficult cases that have come to the author have been previously cauterized too deeply.

Galvano-cautery puncture of tuberculous infiltrations of the larynx at times yields excellent results in cases with mild pulmonary lesions, and has quite replaced the use of the curette, lactic acid, and other caustics. The direct method of exposing the larynx renders the application of the cautery point easy and accurate. In severely stenosed tuberculous larynges a tracheotomy should first be done, for though the reaction is slight it might be sufficient to close a narrowed glottis. The technic is the usual one for laryngeal operations. Local anesthesia suffices. The larynx is exposed. The rheostat having been previously adjusted to heat the electrode to nearly white heat, the circuit is broken and the electrode introduced cold. When the point is in contact with the desired location the current is turned on and the point thrust in as deeply as desired. Usually it should penetrate until a firm resistance is felt; but care must be used not to damage the cricoarytenoid joint. The circuit is broken at the instant of withdrawal. Punctures should be made as nearly as possible perpendicular to the surface, so as to minimize the destruction of epithelium and thus lessen the reaction. A minute gray fibrous slough detaches itself in a few days. Cautery puncture should be repeated every two or three weeks, selecting a new location each time, until the desired result is obtained. Great caution, as mentioned above, must be used to avoid setting up perichondritis. Many cases of laryngeal tuberculosis will recover as quickly by silence and a general antituberculous regime.

Radium, in form of capsules or of needles inserted in the tissues may be applied with great accuracy; but the author is strongly impressed with pyriform sinus applications by the Freer method.

After-care of endolaryngeal operations includes careful cleansing of the teeth and mouth; and if the extrinsic area of the larynx is involved in the wound, sterile liquid food and water should be given for four days. The patient should be watched for complications by a special nurse who is familiar with the signs of laryngeal dyspnea (q.v.). *Complications during endolaryngeal operations* are rare. Dyspnea may require tracheotomy. Idiosyncrasy to cocain, or the sight or taste of blood may nauseate the patient and cause syncope. Serious hemorrhage could occur only in a hemophile. The careless handling of a bite block might damage a frail tool or dental fixture.

Complications after endolaryngeal operations are unusual. Carelessness in asepsis has been known to cause cervical cellulitis. Emphysema of the neck has occurred. Edema of the larynx occasionally occurs, and might necessitate tracheotomy. Serious bleeding after operation is very rare except in bleeders. Hemorrhage within the larynx can be stopped by the introduction of a roll of gauze from above,

tracheotomy having been previously performed. Morphin subcutaneously administered, has a constricting action on the vessels which renders it of value in controlling hemorrhage.

[97] CHAPTER IX—INTRODUCTION OF THE BRONCHOSCOPE

No one should do bronchoscopy until he is able to expose the glottis by left-handed direct laryngoscopy in less than one minute. When he has mastered this, one minute more should be sufficient to introduce the bronchoscope into the trachea.

TECHNIC OF BRONCHOSCOPY

Local anesthesia is usually employed in the adult. The patient is placed in the Boyce position shown in Fig. 51, with head and shoulders projecting over the edge of the table and supported by an assistant. The glottis is exposed by left-handed laryngoscopy. The instrument-assistant now inserts the distal end of the bronchoscope into the lumen of the laryngoscope, the handle being directed to the right in a horizontal position. The operator now grasps the bronchoscope, his eye is transferred from the laryngoscope to the bronchoscope, and the bronchoscope is advanced and so directed that a good view of the glottis is obtained. The slanted end of the bronchoscope should then be directed to the left, so as clearly to expose the left cord. In this position it will be found that the tip of the slanted end is in the center of the glottic chink and will slip readily into the trachea. No great force should be used, because if the bronchoscope does not go through readily, either the tube is too large a size or it is not correctly placed (Fig. 60). Normally, however, there is some slight resistance, which in cases of subglottic laryngitis may be considerable. The trained laryngologist will readily determine by sense of touch the degree of pressure necessary to overcome it. When the bronchoscope has been inserted to about the second or third tracheal ring, the heavy laryngoscope is removed by rotating the handle to the left, removing the slide, and withdrawing the instrument. Care must be taken that the bronchoscope is not withdrawn or coughed out during the removal of the laryngoscope; this can be avoided by allowing the ocular end to rest against the gown-covered chest of the operator. If preferred the operator may train his instrumental assistant to take off the laryngoscope, while the operator devotes his attention to preventing the withdrawal of the bronchoscope by holding the handle with his right hand. At the moment of insertion of the bronchoscope through the glottis, an especially strong upward lift on the beak of the spatula will facilitate the passage. It is necessary to be certain that the axis of the bronchoscope corresponds to the axis of the trachea, in order to avoid injury to the subglottic tissue which might be followed by subglottic edema (Fig. 47). If the subglottic region is already edematous and causes resistance, slight rotation to the laryngoscope, and bronchoscope will cause the bronchoscope to enter more easily.

[FIG. 59.—Insufflation anesthesia with Elsberg apparatus. Anesthetist has exposed the larynx and is about to introduce the silk-woven catheter. Note the full extension of the head on the table.]

[FIG. 60.—Schema illustrating the introduction of the bronchoscope through the glottis, recumbent patient. The handle, H, is always horizontally to the right. When the glottis is first seen through the tube it should be centrally located as at K. At the next inspiration the end B, is moved horizontally to the left as shown by the dart, M, until the glottis shows at the right edge of the field, C. This means that the point of the lip, B, is at the median line, and it is then quickly (not violently) pushed through into the trachea. At this same moment or the instant before, the hyoid bone is given a quick additional lift with the tip of the laryngoscope.]

[FIG. 61.—Schema illustrating oral bronchoscopy. The portion of the table here shown under the head is, in actual work, dropped all the way down perpendicularly. It appears in these drawings as a dotted line to emphasize the fact that the head must be above the level of the table during introduction of the bronchoscope into the trachea. A, Exposure of larynx; B, bronchoscope introduced; C, slide removed; D, laryngoscope removed leaving bronchoscope alone in position.]

Difficulties in the Introduction of the Bronchoscope.—The beginner may enter the esophagus instead of the trachea: this might be a dangerous accident in a dyspneic case, for the tube could, by pressure on the trachea, cause respiratory arrest. A bronchoscope thus misplaced should be resterilized before introducing it into the air passages, for while the lower air passages are usually free from bacteria, the esophagus is a septic canal. If the given technic is carefully carried out the bronchoscope will not be contaminated with mouth secretions. The trachea is recognized as an open tube, with whitish rings, and the expiratory blast can be felt and tubular breathing heard; while if by mistake the bronchoscope has entered the gullet it will be observed that the cervical esophagus has collapsed walls. A puff of air may be felt and a fluttering sound heard when the tube is in the esophagus, but these lack the intensity of the tracheal blast. Usually a free flow of secretion is met with in the esophagus. In diseased states

the tracheal rings may not be visible because of swollen mucosa, or the trachea itself may be in partial collapse from external pressure. The true expiratory blast will, however, always be recognized when the tube is in the trachea. Wide gagging of the mouth renders exposure of the larynx difficult.

[FIG. 62.—Insertion of the bronchoscope. Note direction of the trachea as indicated by the bronchoscope. Note that the patient's head is held above the level of the table. The assistant's left hand should be at the patient's mouth holding the bite-block. This is removed and the assistant is on the wrong side of the table in the illustration in order not to hide the position of the operator's hands. Note the handle of the bronchoscope is to the right.]

[FIG. 63.—The heavy laryngoscope has been removed leaving the light bronchoscope in position. The operator is inserting forceps. Note how the left hand of the operator holds the tube lightly between the thumb and first two fingers of the left hand, while the last two fingers are hooked over the upper teeth of the patient "anchoring" the tube to prevent it moving in or out or otherwise changing the relation of the distal tube-mouth to a foreign body or a growth while forceps are being used. Thus, also, any desired location of the tube can be maintained in systematic exploration. The assistant's left hand is dropped out of the way to show the operator's method. The assistant during bronchoscopy holds the bite-block like a thimble on the index finger of the left hand, and the assistant should be on the right side of the patient. He is here put wrongly on the left side so as not to hide the instruments and the manner of holding them.]

Examination of the Trachea and Bronchi.—All bronchial orifices must be identified *seriatim*; because this is the only way by which the bronchoscopist can know what part of the tree he is examining. Appearances alone are not enough. It is the order in which they are exposed that enables the inexperienced operator to know the orifices. After the removal of the laryngoscope, the bronchoscope is to be held by the left hand like a billiard cue, the terminal phalanges of the left middle and ring fingers hooking over the upper teeth, while the thumb and index finger hold the bronchoscope, clamping it to the teeth tightly or loosely as required (Fig. 63). Thus the tube may be anchored in any position, or at any depth, and the right hand which was directing the tube may be used for the manipulation of instruments. The grasp of the bronchoscope in the right hand should be similar to that of holding a pen, that is, the thumb, first, and second fingers, encircle the shaft of the tube. The bronchoscope should never be held by the handle (Fig. 64) for this grasp does not allow of tactile sense transmission, is rigid, awkward, and renders rotation of the tube a wrist motion instead of but a gentle finger action. Any secretion in the trachea is to be removed by sponge pumping before the bronchoscope is advanced. The inspection of the walls of the trachea is accomplished by weaving from side to side and, if necessary, up and down; the head being deflected as required during the search of the passages, so that the larynx be not made the fulcrum in the lever-like action.

[FIG. 64.—At A is shown an incorrect manner of holding the bronchoscope. The grasp is too rigid and the position of the hand is awkward. B, Correct manner, the collar being held lightly between the finger and the thumb The thumb must not occlude the tube mouth.]

The Fulcrum of the Bronchoscopic Lever is at the Upper Thoracic Aperture; Never at the Larynx.—Disregard of this rule will cause subglottic edema and will limit the lateral motion of the tip of the bronchoscope. It is the function of the assistant to make the head and neck follow the direction of the proximal end of the bronchoscope and thus avoid any pressure on the larynx (see Peroral Endoscopy, Fig. 135, p. 164).

In passing down the trachea the following two rules must be kept in mind: 1. Before attempting to enter either main bronchus the carina must be identified. 2. Before entering either main bronchus the orifices of both should be identified and inspected. *The carina* is identified as a sharp vertical spur (recumbent patient) at the distal end of the trachea, on either side of which are the openings of the main bronchi. As the carina is situated to the left of the midline of the trachea, the lip of the bronchoscope should be turned toward the left, and slight lateral pressure should be made on the left tracheal wall while the head of the patient is held slightly to the right. This will expose the left bronchial orifice and carina.

Entering the Bronchi.—The lip of the bronchoscope should be turned in the direction of the bronchus to be explored, and the axis of the bronchoscope should be made to correspond as nearly as possible to the axis of this bronchus. The position of the lip is designated by the direction taken by the handle. Upon entering the right bronchus, the handle of the bronchoscope is turned horizontally to the right, and at the same time the assistant deflects the head to the left.

The right upper-lobe bronchus is recognized by its vertical spur; the orifice is exposed by displacing the right lateral wall of the right main bronchus at the level of the carina. Usually this orifice will be thus brought into view. If not the bronchoscope may be advanced downward 1 or 2 cm., carefully to avoid overriding. This branch is sometimes found coming off the trachea itself, and even if it does not,

the overriding of the orifice is certain if the right bronchus is entered before search is made for the upper-lobe-bronchial orifice. The head must be moved strongly to the left in order to view the orifice. A lumen image of the right upper-lobe bronchus is not obtainable because of the sharp angles at which it is given off. *The left upper-lobe bronchus* is entered by keeping the handle of the bronchoscope (and consequently the lip) to the left, and, by keeping the head of the patient strongly to the right as the bronchoscopist goes down the left main bronchus. This causes the lip of the bronchoscope to bear strongly on the left wall of the left main bronchus, consequently the left upper-lobe-bronchial orifice will not be overridden. The spur separating the upper-lobe-bronchial orifice from the stem bronchus is at an angle approximately from two to eight o'clock, as usually seen in the recumbent patient. A lumen image of a descending branch of the upper-lobe bronchus is often obtained, if the patient's head be borne strongly enough to the right.

[FIG. 65.—Schema illustrating the entering of the anteriorly branching middle lobe bronchus. T, Trachea; B, orifice of left main bronchus at bifurcation of trachea. The bronchoscope, S, is in the right main bronchus, pointing in the direction of the right inferior lobe bronchus, I. In order to cause the lip to enter the middle lobe bronchus, M, it is necessary to drop the head so that the bronchoscope in the trachea TT, will point properly to enable the lip of the tube mouth to enter the middle lobe bronchus, as it is seen to have done at ML.]

Branches of the stem bronchus in either lung are exposed, or their respective lumina presented, by manipulation of the lip of the bronchoscope, with movement of the head in the required direction. Posterior branches require the head quite high. A large one in the left stem just below the left upper-lobe bronchus is often invaded by foreign bodies. Anterior branches require lowering the head. The *middle-lobe bronchus* is the largest of all anterior branches. Its almost horizontal spur is brought into view by directing the lip of the bronchoscope upward, and dropping the head of the patient until the lip bears strongly on the anterior wall of the right bronchus (see Fig. 65).

[106] CHAPTER X—INTRODUCTION OF THE ESOPHAGOSCOPE

The esophagoscope is to be passed only with ocular guidance, never blindly with a mandrin or obturator, as was done before the bevel-ended esophagoscope was developed. Blind introduction of the esophagoscope is equally as dangerous as blind bouginage. It is almost certain to cause over-riding of foreign bodies and disease. In either condition perforation of the esophagus is possible by pushing a sharp foreign body through the normal wall or by penetrating a wall weakened by disease. Landmarks must be identified as reached, in order to know the locality reached. The secretions present form sufficient lubrication for the instrument. A clear conception of the endoscopic anatomy, the narrowings, direction, and changes of direction of the axis of the esophagus, are necessary. The services of a trained assistant to place the head in the proper sequential "high-low" positions are indispensible (Figs. 52 and 70). Introduction may be divided into four stages. 1. Entering the right pyriform sinus. 2. Passing the cricopharyngeus. 3. Passing through the thoracic esophagus. 4. Passing through the hiatus.

The patient is placed in the Boyce position as described in Chapter VI. As previously stated, the esophagus in its upper portion follows the curves of the cervical and dorsal spine. It is necessary, therefore, to bring the cervical spine into a straight line with the upper portion of the dorsal spine and this is accomplished by elevation of the head—the "high" position (Figs. 66-71).

[PLATE III—ESOPHAGOSCOPIC VIEWS FROM OIL-COLOR DRAWINGS FROM LIFE, BY THE AUTHOR: 1, Direct view of the larynx and laryngopharynx in the dorsally recumbent patient, the epiglottis and hyoid bone being lifted with the direct laryngoscope or the esophageal speculum. The spasmodically adducted vocal cords are partially hidden by the over-hang of the spasmodically prominent ventricular hands. Posterior to this the aryepiglottic folds ending posteriorly in the arytenoid eminences are seen in apposition. The esophagoscope should be passed to the right of the median line into the right pyriform sinus, represented here by the right arm of the dark crescent. 2, The right pyriform sinus in the dorsally recumbent patient, the eminence at the upper left border, corresponds to the edge of the cricoid cartilage. 3, The cricopharyngeal constriction of the esophagus in the dorsally recumbent patient, the cricoid cartilage being lifted forward with the esophageal speculum. The lower (posterior) half of the lumen is closed by the fold corresponding to the orbicular fibers of the cricopharyngeus which advances spasmodically from the posterior wall. (Compare Fig. 10.) This view is not obtained with an esophagoscope. 4, Passing through the right pyriform sinus with the esophagoscope; dorsally recumbent patient. The walls seem in tight apposition, and, at the edges of the slit-like lumen, bulge toward the observer. The direction of the axis of the slit varies, and in some instances it is like a rosette, depending on the degree of spasm. 5, Cervical esophagus. The lumen is not so patulent during inspiration as lower down; and it closes completely during expiration. 6, Thoracic esophagus; dorsally recumbent patient. The ridge crossing above the lumen corresponds to

the left bronchus. It is seldom so prominent as in this patient, but can always be found if searched for. 7, The normal esophagus at the hiatus. This is often mistaken for the cardia by esophagoscopists. It is more truly a sphincter than the cardia itself. In the author's opinion there is no truly sphincteric action at the cardia. It is the failure of this hiatal sphincter to open as in the normal deglutitory cycle that produces the syndrome called "cardiospasm." 8, View in the stomach with the open-tube gastroscope. The form of the folds varies continually. 9, Sarcoma of the posterior wall of the upper third of the esophagus in a woman of thirty-one years. Seen through the esophageal speculum, patient sitting. The lumen of the mouth of the esophagus, much encroached upon by the sarcomatous infiltration, is seen at the lower part of the circle. 10, Coin (half-dollar) wedged in the upper third of the esophagus of a boy aged fourteen years. Seen through the esophageal speculum, recumbent patient. Forceps are retracting the posterior lip of the esophageal "mouth" preparatory to removal. 11, Fungating squamous-celled epithelioma in a man of seventy-four years. Fungations are not always present, and are often pale and edematous. 12, Cicatricial stenosis of the esophagus due to the swallowing of lye in a boy of four years. Below tile upper stricture is seen a second stricture. An ulcer surrounded by an inflammatory areola and the granulation tissue together illustrates the etiology of cicatricial tissue. The fan-shaped scar is really almost linear, but it is viewed in perspective. Patient was cured by esophagoscopic dilatation. 13, Angioma of the esophagus in a man of forty years. The patient had hemorrhoids and varicose veins of the legs. 14, Luetic ulcer of the esophagus 26 cm. from the upper teeth in a woman of thirty-eight years. Two scars from healed ulcerations are seen in perspective on the anterior wall. Branching vessels are seen in the livid areola of the ulcers. 15, Tuberculosis of the esophagus in a man of thirty-four years. 16, Leukoplakia of the esophagus near the hiatus in a man aged fifty-six years.]

The hypopharynx tapers down to the gullet like a funnel, and the larynx is suspended in its lumen from the anterior wall. The larynx is attached only to the anterior wall, but is held closely against the posterior pharyngeal wall by the action of the inferior constrictor of the pharynx, and particularly by its specialized portion—the cricopharyngeus muscle. A bolus of food is split by the epiglottis and the two portions drifted laterally into the pyriform sinuses, the recesses seen on either side of the larynx. But little of the food bolus passes posterior to the larynx during the act of swallowing. It is through the pyriform sinus that the esophagoscope is to be inserted, thereby following the natural food passage. To insert the esophagoscope in the midline, posterior to the arytenoids, requires a degree of force dangerous to exert and almost certain to produce damage to the cricoarytenoid joint or to the pharyngeal wall, or to both.

The esophagoscope is steadied by the left hand like a billiard cue, the terminal phalanges of the left middle and ring fingers hooked over the upper teeth, while the left index finger and thumb encircle the tube and retract the upper lip to prevent its being pinched between the tube and upper teeth. The right hand holds the tube in pen fashion at the collar of the handle, not by the handle. During introduction the handle is to be pointed upward toward the zenith.

Stage I. Entering the Right Pyriform Sinus.—The operator standing (as in Fig. 66), inserts the esophagoscope along the right side of the tongue as far as and down the posterior pharyngeal wall. A lifting motion imparted to the tip of the esophagoscope by the left thumb will bring the rounded right arytenoid eminence into view (A, Fig. 69). This is the landmark of the pyriform sinus, and care must be taken to avoid injury by hooking the tube mouth over it or its fellow. The tip of the tube should now be directed somewhat toward the midline, remembering the funnel shape of the hypopharynx. It will then be found to glide readily through the right pyriform sinus for 2 or 3 cm., when it comes to a full stop, and the lumen disappears. This is the spasmodically closed cricopharyngeal constriction.

[FIG. 66.—Esophagoscopy by the author's "high-low" method. First stage. "High" position. Finding the right pyriform sinus. In this and the second stage the patient's vertex is about 15 cm. above the level of the table.]

Stage 2. Passing the cricopharyngeus is the most difficult part of esophagoscopy, especially if the patient is unanesthetized. Local anesthesia helps little, if at all. The handle of the esophagoscope is still pointing upward and consequently we are sure that the lip of the esophagoscope is directed anteriorly. Force must not be used, but steady firm pressure against the tonically contracted cricopharyngeus is made, while at the same time the distal end of the esophagoscope is lifted by the left thumb. At the first inspiration a lumen will usually appear in the upper portion of the endoscopic field. The tip of the esophagoscope enters this lumen and the slanted end slides over the fold of the cricopharyngeus into the cervical esophagus. There is usually from 1 to 3 cm. of this constricted lumen at the level of the cricopharyngeus and the subjacent orbicular esophageal fibers.

[109] [FIG. 67.—Schematic illustration of the author's "high-low" method of esophagoscopy. In the first and second stages the patient's head fully extended is held high so as to bring it in line with the thoracic esophagus, as shown above. The Rose position is shown by way of accentuation.]

[FIG. 68.—Schematic illustration of the anatomic basis for difficulty in introduction of the esophagoscope. The cricoid cartilage is pulled backward against the cervical spine, by the cricopharyngeus, so strongly that it is difficult to realize that the cricopharyngeus is not inserted into the vertebral periosteum instead of into the median raphe.]

[FIG. 69.—The upper illustration shows movements necessary for passing the cricopharyngeus.

The lower illustration shows schematically the method of finding the pyriform sinus in the author's method of esophagoscopy. The large circle represents the cricoid cartilage. G, Glottic chink, spasmodically closed; VB, ventricular band; A, right arytenoid eminence; P, right pyriform sinus, through which the tube is passed in the recumbent posture. The pyriform sinuses are the normal food passages.]

Stage 3. Passing Through the Thoracic Esophagus.—The thoracic esophagus will be seen to expand during inspiration and contract during expiration, due to the change in thoracic pressure. The esophagoscope usually glides easily through the thoracic esophagus if the patient's position is correct. After the levels of the aorta and left bronchus are passed the lumen of the esophagus seems to have a tendency to disappear anteriorly. The lumen must be kept in axial view and the head lowered as required for this purpose.

Stage 4. Passing Through the Hiatus Esophageus.—When the head is dropped, it must at the same time be moved horizontally to the right in order that the axis of the tube shall correspond to the axis of the lower third of the esophagus, which deviates to the left and turns anteriorly. The head and shoulders at this time will be found to be considerably below the plane of the table top (Fig. 71). The hiatal constriction may assume the form of a slit or rosette. If the rosette or slit cannot be promptly found, as may be the case in various degrees of diffuse dilatation, the tube mouth must be shifted farther to the left and anteriorly. When the tube mouth is centered over the hiatal constriction moderately firm pressure continued for a short time will cause it to yield. Then the tube, maintaining this same direction will, without further trouble glide into and through the abdominal esophagus. The cardia will not be noticed as a constriction, but its appearance will be announced by the rolling in of reddish gastric mucosal folds, and by a gush of fluid from the stomach.

[FIG. 70.—Schematic illustration of the author's "high-low" method of esophagoscopy, fourth stage. Passing the hiatus. The head is dropped from the position of the 1st and 2nd stages, CL, to the position T, and at the same time the head and shoulders are moved to the right (without rotation) which gives the necessary direction for passing the hiatus.]

[FIG. 71.—Esophagoscopy by the author's "high-low" method. Stage 4. Passing the hiatus The patient's vertex is about 5 cm. below the top of the table.]

Normal esophageal mucosa under proper illumination is glistening and of a yellowish or bluish pink. The folds are soft and velvety, rendering infiltration quickly noticeable. The cricoid cartilage shows white through the mucosa. The gastric mucosa is a darker pink than that of the esophagus and when actively secreting, its color in some cases tends toward crimson.

Secretions in the esophagus are readily aspirated through the drainage canal by a negative pressure pump. Food particles are best removed by "sponge pumping," or with forceps. Should the drainage canal become obstructed positive pressure from the pump will clear the canal.

Difficulties of Esophagoscopy.—The beginner may find the esophagoscope seemingly rigidly fixed, so that it can be neither introduced nor withdrawn. This usually results from a wedging of the tube in the dental angle, and is overcome by a wider opening of the jaws, or perhaps by easing up of the bite block, but most often by correcting the position of the patient's head. If the beginner cannot start the tube into the pyriform sinus in an adult, it is a good plan to expose the arytenoid eminence with the laryngoscope and then to insert the 7 mm. esophagoscope into the right pyriform sinus by direct vision. Passing the cricopharyngeal and hiatal spasmodically contracted narrowings will prove the most trying part of esophagoscopy; but with the head properly held, and the tube properly placed and directed, patient waiting for relaxation of the spasm with gentle continuous pressure will usually expose the lumen ahead. In his first few esophagoscopies the novice had best use general anesthesia to avoid these difficulties and to accustom himself to the esophageal image. In the first favorable subject—an emaciated individual with no teeth—esophagoscopy without anesthesia should be tried.

In cases of kyphosis it is a mistake to try to straighten the spine. The head should be held correspondingly higher at the beginning, and should be very slowly and cautiously lowered.

Once inserted, the esophagoscope should not be removed until the completion of the procedure, unless respiratory arrest demands it. Occasionally in stenotic conditions the light may become covered

by the upwelling of a flood of fluid, and it will be thought the light has gone out. As soon as the fluid has been aspirated the light will be found burning as brightly as before. If a lamp should fail it is unnecessary to remove the tube, as the light carrier and light can be withdrawn and quickly adjusted. A complete instrument equipment with proper selection of instruments for the particular case are necessary for smooth working.

Ballooning Esophagoscopy.—By inserting the window plug shown in Fig. 6 the esophagus may be inflated and studied in the distended state. The folds are thus smoothed out and constrictions rendered more marked. Ether anesthesia is advocated by Mosher. The danger of respiratory arrest from pressure, should the patient be dyspneic, is always present unless the anesthetic be given by the intratracheal method. If necessary to use forceps the window cap is removed. If the perforated rubber diaphragm cap be substituted the esophagus can be reballooned, but work is no longer ocularly guided. The fluoroscope may be used but is so misleading as to render perforation and false passage likely.

Specular Esophagoscopy.—Inspection of the hypopharynx and upper esophagus is readily made with the esophageal speculum shown in Fig. 4. High lesions and foreign bodies lodged behind the larynx are thus discovered with ease, and such a condition as a retropharyngeal abscess which has burrowed downward is much less apt to be overlooked than with the esophagoscope. High strictures of the esophagus may be exposed and treated by direct visual bouginage until the lumen is sufficiently dilated to allow the passage of the esophagoscope for bouginage of the deeper strictures.

Technic of Specular Esophagoscopy.—Recumbent patient. Boyce position. The larynx is to be exposed as in direct laryngoscopy, the right pyriform sinus identified, the tip of the speculum inserted therein, and gently insinuated to the cricopharyngeal constriction. Too great extension of the head is to be avoided—even slight flexion at the occipito-atloid joint may be found useful at times. Moderate anterior or upward traction pulls the cricoid away from the posterior pharyngeal wall and the lumen of the esophagus opens above a crescentic fold (the cricopharyngeus). The speculum readily slides over this fold and enters the cervical esophagus. In searching for foreign bodies in the esophagus the speculum has the disadvantage of limited length, so that should the foreign body move downward it could not be followed.

Complications Following Esophagoscopy.—These are to be avoided in large measure by the exercise of gentleness, care, and skill that are acquired by practice. If the instructions herein given are followed, esophagoscopy is absolutely without mortality apart from the conditions for which it is done.

Injury to the crico-arytenoid joint may simulate recurrent paralysis. Posticus paralysis may occur from recurrent or vagal pressure by a misdirected esophagoscope. These conditions usually recover but may persist. Perforation of the esophageal wall may cause death from septic mediastinitis. The pleura may be entered,—pyopneumothorax will result and demand immediate thoracotomy and gastrostomy. Aneurysm of the aorta may be ruptured. Patients with tuberculosis, decompensating cardiovascular lesions, or other advanced organic disease, may have serious complications precipitated by esophagoscopy.

Retrograde Esophagoscopy.—The first step is to get rid of the gastric secretions. There is always fluid in the stomach, and this keeps pouring out of the tube in a steady stream. Fold after fold is emptied of fluid. Once the stomach is empty, the search begins for the cardial opening. The best landmark is a mark with a dermal pencil on the skin at a point corresponding to the level of the hiatus esophageus. When it is desired to do a retrograde esophagoscopy and the gastrostomy is done for this special purpose, it is wise to have it very high. Once the cardia is located and the esophagus entered, the remainder of the work is very easy. Bouginage can be carried out from below the same as from above and may be of advantage in some cases. Strictural lumina are much more apt to be concentric as approached from below because there has been no distortion by pressure dilatation due to stagnation of the food operating through a long period of time. At retrograde esophagoscopy there seems to be no abdominal esophagus and no cardia. The esophagoscope encounters only the diaphragmatic pinchcock which seems to be at the top of the stomach like the puckering string at the top of a bag.

Retrograde esophagoscopy is sometimes useful for "stringing" the esophagus in cases in which the patient is unable to swallow a string because he is too young or because of an epithelial scaling over of the upper entrance of the stricture. In such cases the smallest size of the author's filiform bougies (Fig. 40) is inserted through the retrograde esophagoscope (Fig. 43) and insinuated upward through the stricture. When the tip reaches the pharynx coughing, choking and gagging are noticed. The filiform end is brought out the mouth sufficiently far to attach a silk braided cord which is then pulled down and out of the gastrostomic opening. The braided silk "string" must be long enough so that the oral and the abdominal ends can be tied together to make it "endless;" but before doing so the oral end should be drawn through nose where it will be less annoying than in the mouth. The purpose of the "string" is to pull up the retrograde bougies (Fig. 35)

Endoscopic ability cannot be bought with the instruments. As with all mechanical procedures, facility can be obtained only by educating the eye and the fingers in repeated exercise of a particular series of maneuvers. As with learning to play a musical instrument, a fundamental knowledge of technic, positions, and landmarks is necessary, after which only continued manual practice makes for proficiency. For instance, efficient use of forceps requires that they be so familiar to the grasp that their use is automatic. Endoscopy is a purely manual procedure, hence to know how is not enough: manual practice is necessary. Even in the handling of the electrical equipment, practice in quickly locating trouble is as essential as theoretic knowledge. There is no mystery about electric lighting. No source of illumination other than electricity is possible for endoscopy. Therefore a small amount of electrical knowledge, rendered practical by practice, is essential to maintain the simple lighting system in working order. It is an insult to the intelligence of the physician to say that he cannot master a simple problem of electric testing involving the locating of one or more of five possibilities. It is simply a matter of memorizing five tests. It is repeated for emphasis that a commercial current reduced by means of a rheostat should never be used as a source of current for endoscopy with any kind of instrument, because of the danger to the patient of a possible "grounding" of the circuit during the extensive moist contact of a metallic endoscopic tube in the mediastinum. The battery shown in Fig. 8 should be used. The most frequent cause of trouble is the mistake of over-illuminating the lamps. *The lamp should not be over-illuminated to the dazzling whiteness usually used in flash lights*. Excessive illumination alters the proper perception of the coloring of the mucosa, besides shortening the life of the lamps. The proper degree of brightness is obtained when, as the current is increased, the first change from yellow to white light is obtained. Never turn up the rheostat without watching the lamp.

Testing for Electric Defects.—These tests should be made beforehand; not when about to commence introduction.

If the first lamp lights up properly, use it with its light-carrier to test out the other cords.

If the lamp lights up, but flickers, locate the trouble before attempting to do an endoscopy. If shaking the carrier cord-terminal produces flickering there may be a film of corrosion on the central contact of the light carrier that goes into the carrier cord-terminal.

If the lamp fails to show a light, the trouble may be in one of five places which should be tested for in the following order and manner. 1. The lamp may not be firmly screwed into the light-carrier. Withdraw the light-carrier and try screwing it in, though not too strongly, lest the central wire terminal in the lamp be bent over. 2. The light-carrier may be defective. 3. The cord may be defective or its terminals not tight in the binding posts. If screwing down the thumb nuts does not produce a light, test the light-carrier with lamp on the other cords. Reserve cords in each pair of binding posts are for use instead of the defective cords. The two sets of cords from one pair of binding posts should not be used simultaneously. 4. The lamp may be defective. Try another lamp. 5. The battery may be defective. Take a cord and light-carrier with lamp that lights up, detaching the cord-terminals at the binding posts, and attach the terminals to the binding posts of the battery to be tested.

Efficient use of forceps requires previous practice in handling of the forceps until it has become as natural and free from thought as the use of knife and fork. Indeed the coordinate use of the bronchoscopic tube-mouth and the forceps very much resembles the use of knife and fork. Yet only too often a practitioner will telegraph for a bronchoscope and forceps, and without any practice start in to remove an entangled or impacted foreign body from the tiny bronchi of a child. Failure and mortality are almost inevitable. A few hundred hours spent in working out, on a bit of rubber tubing, the various mechanical problems given in the section on that subject will save lives and render easily successful many removals that would otherwise be impossible.

It is often difficult for the beginner to judge the distance the forceps have been inserted into the tube. This difficulty is readily solved if upon inserting the forceps slowly into the tube, he observes that as the blades pass the light they become brightly illuminated. By this *light reflex* it is known, therefore, that the forceps blades are at the tube-mouth, and distance from this point can be readily gauged. Excellent practice may be had by picking up through the bronchoscope or esophagoscope black threads from a white background, then white threads from a black background, and finally white threads on a white background and black threads on a black background. This should be done first with the 9 mm. bronchoscope. It is to be remembered that the majority of foreign body accidents occur in children, with whom small tubes must be used; therefore, practice work, after say the first 100 hours, should be done with the 5 mm. bronchoscope and corresponding forceps rather than adult size tubes, so that the operator will be accustomed to work through a small calibre tube when the actual case presents itself.

[120] *Cadaver Practice*.—The fundamental principles of peroral endoscopy are best taught on the

cadaver. It is necessary that a specially prepared subject be had, in order to obtain the required degree of flexibility. Injecting fluid of the following formula worked out by Prof. J. Parsons Schaeffer for the Bronchoscopic Clinic courses, has proved very satisfactory: Sodium carbonate—1 1/2 lbs. White arsenic —2 1/2 lbs. Potassium nitrate—3 lbs. Water—5 gal.

Boil until arsenic is dissolved. When cold add:
Carbolic acid 1500 c.c.
Glycerin 1250 c.c.
Alcohol (95%) 1250 c.c.

For each body use about 3 gal. of fluid.

The method of introduction of the endoscopic tube, and its various positions can be demonstrated and repeatedly practiced on the cadaver until a perfected technic is developed in both the operator and assistant who holds the head, and the one who passes the instruments to the operator. In no other manner can the landmarks and endoscopic anatomy be studied so thoroughly and practically, and in no other way can the pupil be taught to avoid killing his patient. The danger-points in esophagoscopy are not demonstrable on the living without actually incurring mortality. Laryngeal growths may be simulated, foreign body problems created and their mechanical difficulties solved and practice work with the forceps and tube perfected.

Practice on the Rubber-tube Manikin.—This must be carried out in two ways. 1. General practice with all sorts of objects for the education of the eye and the fingers. 2. Before undertaking a foreign body case, practice should be had with a duplicate of the foreign body.

It is not possible to have a cadaver for daily practice, but fortunately the eye and fingers may be trained quite as effectually by simulating foreign body conditions in a small red rubber tube and solving these mechanical problems with the bronchoscope and forceps. The tubing may be placed on the desk and held by a small vise (Fig. 72) so that at odd moments during the day or evening the fascinating work may be picked up and put aside without loss of time. Complicated rubber manikins are of no value in the practice of introduction, and foreign body problems can be equally well studied in a piece of rubber tubing about 10 inches long. No endoscopist has enough practice on the living subject, because the cases are too infrequent and furthermore the tube is inserted for too short a space of time. Practice on the rubber tube trains the eye to recognize objects and to gauge distance; it develops the tactile sense so that a knowledge of the character of the object grasped or the nature of the tissues palpated may be acquired. Before attempting the removal of a particular foreign body from a living patient, the anticipated problem should be simulated with a duplicate of the foreign body in a rubber tube. In this way the endoscopist may precede each case with a practical experience equivalent to any number of cases of precisely the same kind of foreign body. If the object cannot be removed from the rubber tube without violence, it is obvious that no attempt should be made on the patient until further practice has shown a definite method of harmless removal. During practice work the value of the beveled lip of the bronchoscope and esophagoscope in solving mechanical problems will be evidenced. With it alone, a foreign body may be turned into favorable positions for extraction, and folds can always be held out of the way. Sufficient combined practice with the bronchoscope and the forceps enable the endoscopist easily to do things that at first seem impossible. It is to be remembered that lateral motion of the long slender tube-forceps cannot be controlled accurately by the handle, this is obtained by a change in position of the endoscopic tube, the object being so centered that it is grasped without side motion of the forceps. When necessary, the distal end of the forceps may be pushed laterally by the manipulation of the bronchoscope.

[FIG. 72.—A simple manikin. The weight of the small vise serves to steady the rubber tubing. By the use of tubing of the size of the invaded bronchus and a duplicate of the foreign body, any mechanical problem can he simulated for solution or for practice, study of all possible presentations, etc.]

Practice on the Dog.—Having mastered the technic of introduction on the cadaver and trained the eye and fingers by practice work on the rubber tube, experience should be had in the living lower air and food passages with their pulsatory, respiratory, bechic and deglutitory movements, and ever-present secretions. It is not only inhuman but impossible to obtain this experience on children. Fortunately the dog offers a most ready subject and need in no way be harmed nor pained by this invaluable and life-saving practice. A small dog the size of a terrier (say 6 to 10 pounds in weight) should be chosen and anesthetized by the hypodermic injection of morphin sulphate in dosage of approximately one-sixth of a grain per pound of body weight, given about 45 minutes before the time of practice. Dogs stand large doses of morphin without apparent ill effect, so that repeated injection may be given in smaller dosage until the desired degree of relaxation results. The first effect is vomiting which gives an empty stomach for esophagoscopy and gastroscopy. Vomiting is soon followed by relaxation and stupor. The dog is normal and hungry in a few hours. Dosage must be governed in the

clog as in the human being by the susceptibility to the drug and by the temperament of the animal. Other forms of anesthesia have been tried in my teaching, and none has proven so safe and satisfactory. Phonation may be prevented during esophagoscopy by preventing approximation of the cords, through inserting a silk-woven cathether in the trachea. The larynx and trachea may be painted with cocain solution if it is found necessary for bronchoscopy. A very comfortable and safe mouth gag is shown in Fig. 73. Great gentleness should be exercised, and no force should be used, for none is required in endoscopic work; and the endoscopist will lose much of the value of his dog practice if he fails to regard the dog as a child. He should remember he is not learning how to do endoscopy on the dog; but learning on the dog how safely to do bronchoscopy on a human being. The degree of resistance during introduction can be gauged and the color of the mucosa studied, while that interesting phenomenon, the dilatation and lengthening of the bronchi during inspiration and their contraction and shortening during expiration, is readily observed and always forms subject for thought in its possible connection with pathological conditions. Foreign body problems are now to be solved under these living conditions, and it is my feeling that no one should attempt the removal of a foreign body from the bronchus of a child until he has removed at least 100 foreign bodies from the dog without harming the animal. Dogs have the faculty of easily ridding their air-passages of foreign objects, so that one need not be alarmed if a foreign body is lost during practice removal. It is to be remembered that dogs swallow very large objects with apparent ease. The dog's esophagus is relatively much larger than that of human beings. Therefore a small dog (of six to eight pounds' weight) must be used for esophagoscopic practice, if practice is to be had with objects of the size usually encountered in human beings. The bronchi of a dog of this weight will be about the size of those of a child.

[FIG. 73.—Author's mouth gag for use on the dog. The thumb-nut serves to prevent an uncomfortable degree of expansion of the gag. A bandage may be wound around the dog's jaws to prevent undue spread of the jaws.]

Endoscopy on the Human Being.—Dog work offers but little practice in laryngoscopy. Because of the slight angle at which the dog's head joins his spine, the larynx is in a direct line with the open mouth; hence little displacement of the anterior cervical tissues is necessary. Moreover the interior of the larynx of the dog is quite different from that of the human larynx. The technic of laryngoscopy in the human subject is best perfected by a routine direct examination of the larynx of anesthetized patients after such an operation as, for instance, tonsillectomy, to see that the larynx and laryngopharynx are free of clots. To perform a bronchoscopy or esophagoscopy under these conditions would be reprehensible; but direct laryngoscopy for the seeking and removal of clots serves a useful purpose as a preventative of pulmonary abscess and similar complications.* Diagnosis of laryngeal conditions in young children is possible only by direct laryngoscopy and is neglected in almost all of the cases. No anesthesia, general or local, is required. Much clinical material is neglected. All cases of dyspnea or dysphagia should be studied endoscopically if the cause of the condition cannot be definitely found and treated by other means. Invaluable practice in esophagoscopy is found in the treatment of strictures of the esophagus by weekly or biweekly esophagoscopic bouginage.

* Dr. William Frederick Moore, of the Bronchoscopic Clinic, has recently collected statistics of 202 cases of post-tonsillectomic pulmonary abscess that point strongly to aspiration of infected clots and other infective materials as the most frequent etiologic mechanism (Moore, W. F., Pulmonary Abscess. Journ. Am. Med. Assn., April 29, 1922, Vol. 78, pp. 1279-1281).

In acquiring skill as an endoscopist the following paraphrased aphorisms afford food for thought.

APHORISMS

Educate your eye and your fingers.
Be sure you are right, but not too sure.
Follow your judgment, never your impulse.
Cry over spilled milk enough to memorize how you spilled it.
Let your mistakes worry you enough to prevent repetition.
Let your left hand know what your right hand does and how to do it.
Nature helps, but she is no more interested in the survival of your patient than in the survival of the attacking pathogenic bacteria.

[126] CHAPTER XII—FOREIGN BODIES IN THE AIR AND FOOD PASSAGES

The air and food passages may be invaded by any foreign substance of solid, liquid or gaseous nature, from the animal, vegetable, or mineral kingdoms. Its origin may be from within the body (blood, pus,

secretion, broncholiths, sequestra, worms); introduced from without by way of the natural passages (aspirated or swallowed objects); or it may enter by penetration (bullet, dart, drainage tube from the neck).

Prophylaxis.—If one put into his mouth nothing but food, foreign body accidents would be rare. The habit of holding tacks, pins and whatnot in the mouth is quite universal and deplorable. Children are prone to follow the bad example of their elders. No small objects such as safety pins, buttons, and coins should be left within a baby's reach; children should be watched and taught not to place things in their mouths. Mothers should be specially cautioned not to give nuts or nut candy of any kind to a child whose powers of mastication are imperfect, because the molar teeth are not erupted. It might be made a dictum that: "No child under 3 years of age should be allowed to eat nuts, unless ground finely as in peanut butter." Digital efforts at removal of foreign bodies frequently force the object downward, or may hook it forward into the larynx, whereas if not meddled with digitally the intruder might be spat out. Before general anesthesia the mouth should be searched for loose teeth, removable dentures, etc., and all unconscious individuals should be likewise examined. When working in the mouth precautions should be taken against the possible inhalation or swallowing of loose objects or instruments.

[126] Objects that have lodged in the esophagus, larynx, trachea, or bronchi should be endoscopically removed.

Foreign Bodies in the Insane.—Foreign bodies may be introduced voluntarily and in great numbers by the insane. Hysterical individuals may assert the presence of a foreign body, or may even volitionally swallow or aspirate objects. It is a mistake to do a bronchoscopy in order to cure by suggestion the delusion of foreign body presence. Such "cures" are ephemeral.

Foreign Bodies in the Stomach.—Gastroscopy is indicated in cases of a foreign body that refuses to pass after a month or two. Foreign bodies in very large numbers in the stomach, as in the insane, may be removed by gastrostomy.

The symptomatology of foreign bodies may be epitomized as given below; but it must be kept in mind, that certain symptoms may not be manifest immediately after intrusion, and others may persist for a time after the passage, removal, or expulsion of a foreign body.

ESOPHAGEAL FOREIGN BODY SYMPTOMS

1. There are no absolutely diagnostic symptoms. 2. Dysphagia, however, is the most constant complaint, varying with the size of the foreign body, and the degree of inflammatory or spasmodic reaction produced. 3. Pain may be caused by penetration of a sharp foreign body, by inflammation secondary thereto, by impaction of a large object, or by spasmodic closure of the hiatus esophageus. 4. The subjective sensation of foreign body is usually present, but cannot be relied upon as assuring the presence of a foreign body for this sensation often remains for a time after the passage onward of the intruder. 5. All of these symptoms may exist, often in the most intense degree, as the result of previous violent attempts at removal; and the foreign body may or may not be present.

SYMPTOMS OF LARYNGEAL FOREIGN BODY

1. Initial laryngeal spasm followed by wheezing respiration, croupy cough, and varying degrees of impairment of phonation. 2. Pain may be a symptom. If so, it is usually located in the laryngeal region, though in some cases it is referred to the ears. 3. The larynx may tolerate a thin, flat, foreign body for a relatively long period of time, a month or more; but the development of increasing dyspnea renders early removal imperative in the majority of cases.

SYMPTOMS OF TRACHEAL AND BRONCHIAL FOREIGN BODY

1. Tracheal foreign bodies are usually movable and their movements can usually be felt by the patient. 2. Cough is usually present at once, may disappear for a time and recur, or may be continuous, and may be so violent as to induce vomiting. In recent cases fixed foreign bodies cause little cough; shifting foreign bodies cause violent coughing. 3. Sudden shutting off of the expiratory blast and the phonation during paroxysmal cough is almost pathognomonic of a movable tracheal foreign body. 4. Dyspnea is usually present in tracheal foreign bodies, and is due to the bulk of the foreign body plus the subglottic swelling caused by the traumatism of the shiftings of the intruder. 5. Dyspnea is usually absent in bronchial foreign bodies. 6. The respiratory rate is increased only if a considerable portion of lung is out of function, by the obstruction of a main bronchus, or if inflammatory sequelae are extensive. 7. The asthmatoid wheeze is usually present in tracheal foreign bodies, and is often louder and of lower pitch than the asthmatoid wheeze of bronchial foreign bodies. It is heard at the open mouth, not at the chest wall; and prolonged expiration as though to rid the lungs of all residual air, may

be necessary to elicit it. 8. Pain is not a common symptom, but may occur and be accurately localized by the patient, in case of either tracheal or bronchial foreign body.

EARLY SYMPTOMS OF IRRITATING FOREIGN BODY SUCH AS A PEANUT KERNEL IN THE BRONCHUS

1. Initial laryngeal spasm is almost invariably present with foreign bodies of organic nature, such as nut kernels, peas, beans, maize, etc. 2. A diffuse purulent laryngo-tracheo-bronchitis develops within 24 hours in children under 2 years. 3. Fever, toxemia, cyanosis, dyspnea and paroxysmal cough are promptly shown. 4. The child is unable to cough up the thick mucilaginous pus through the swollen larynx and may "drown in its own secretions" unless the offender be removed. 5. "Drowned lung," that is to say natural passages idled with pus and secretions, rapidly forms. 6. Pulmonary abscess develops sooner than in case of mineral foreign bodies. 7. The older the child the less severe the reaction.

SYMPTOMS OF PROLONGED FOREIGN BODY SOJOURN IN THE BRONCHUS

1. The time of inhalation of a foreign body may be unknown or forgotten. 2. Cough and purulent expectoration ultimately result, although there may be a delusive protracted symptomless interval. [130] 3. Periodic attacks of fever, with chills and sweats, and followed by increased coughing and the expulsion of a large amount of purulent, usually more or less foul material, are so nearly diagnostic of foreign body as to call for exclusion of this probability with the utmost care. 4. Emaciation, clubbing of the fingers and toes, night sweats, hemoptysis, in fact all of the symptoms of tuberculosis are in most cases simulated with exactitude, even to the gain in weight by an out-door regime. 5. Tubercle bacilli have never been found, in the cases at the Bronchoscopic Clinic, associated with foreign body in the bronchus.* In cases of prolonged sojourn this has been the only element lacking in a complete clinical picture of advanced tuberculosis. One point of difference was the almost invariably rapid recovery after removal of the foreign body. The statement in all of the text-books, that foreign body is followed by phthisis pulmonalis is a relic of the days when the bacillary origin of true tuberculosis was unknown, hence the foreign-body phthisis pulmonalis, or pseudo tuberculosis, was confused with the true pulmonary tuberculosis of bacillary origin. 6. The subjective sensation of pain may allow the patient accurately to localize a foreign body. 7. Foreign bodies of metallic or organic nature may cause their peculiar taste in the sputum. 8. Offensive odored sputum should always suggest bronchial foreign body; but absence of sputum, odorous or not, should not exclude foreign body. 9. Sudden complete obstruction of one main bronchus does not cause noticeable dyspnea provided its fellow is functionating. [131] 10. Complete obstruction of a bronchus is followed by rapid onset of symptoms. 11. The physical signs usually show limitation of expansion on the affected side, impairment of percussion, and lessened trans-mission or absence of breath-sounds distal to the foreign body.

* The exceptional case has at last been encountered. A boy with a tack in the bronchus was found to have pulmonary tuberculosis.

SYMPTOMS OF GASTRIC FOREIGN BODY

Foreign body in the stomach ordinarily produces no symptoms. The roentgenogram and the fluoroscopic study with an opaque mixture are the chief means of diagnosis.

DIAGNOSIS OF FOREIGN BODY IN THE AIR OR FOOD PASSAGES

The questions arising are: I. Is a foreign body present? 2. Where is it located? 3. Is a peroral endoscopic procedure indicated? 4. Are there any contraindications to endoscopy?

In order to answer these questions the definite routine given below is followed unvaryingly in the Bronchoscopic Clinic.

1. History.
2. Complete physical examination, including mirror laryngoscopy.
3. Roentgenologic study.
4. Endoscopy.

The history should note the date of, and should delve into the details of the accident; special note being made of the occurrence of laryngeal spasm, wheezing respiration heard by the patient or others (asthmatoid wheeze), fever, cough, pain, dyspnea, dysphagia, odynphagia, regurgitation, etc. The amount, character and odor of sputum are important. Increasing amounts of purulent, foul-odored, sometimes blood-tinged sputum strongly suggest prolonged bronchial foreign body sojourn. The mode of onset of the persisting symptoms, whether immediately following the supposed accident or delayed in their occurrence, is to be noted. Do attacks of sudden dyspnea and cyanosis occur? What has been the previous treatment and what attempts at removal have been made? The nature of the foreign body is to be determined, and if possible a duplicate thereof obtained.

General physical examination should be complete including inspection of the eyes, ears, nose, pharynx, and mirror inspection of the naso-pharynx and larynx. Special attention is paid to the chest for the localization of the object. In order to discover conditions rendering endoscopy unusually hazardous, all parts of the body are to be examined. Aneurysm of the aorta, excessive blood pressure, serious cardiac and renal conditions, the presence of a hernia and the existence of central nervous disease, as tabes dorsalis, should be at least known before attempting any endoscopic procedure. Dysphagia might result from the pressure of an unknown aneurysm, the symptoms being attributed to a foreign body, and aortic aneurysm is a definite contraindication to esophagoscopy unless there be foreign body present also. There is no absolute contraindication to the endoscopic removal of a foreign body, though many conditions may render it wise to post-pone endoscopy. Laryngeal crises of tabes might, because of their sudden onset, be thought due to foreign body.

PHYSICAL SIGNS IN ESOPHAGEAL FOREIGN BODY

There are no constant physical signs associated with uncomplicated impaction of a foreign body in the esophagus. Should perforation of the cervical esophagus occur, subcutaneous emphysema, and perhaps cellulitis, may be found; while a perforation of the thoracic region causing mediastinitis is manifested by toxemia, fever, and rapid sinking. Perforation of the pleura, with the development of pyopneumothorax, is manifested by the usual signs. It is to be emphasized that blind bouginage has no place in the diagnosis of any esophageal condition. The roentgenologist will give the information we desire without danger to the patient, and with far greater accuracy.

FOREIGN BODIES IN THE LARYNX

Laryngeally lodged foreign bodies produce a wheezing respiration, the quality of which is peculiar to the larynx and is readily localized to this organ. If swelling or the size of the foreign body be sufficient to produce dyspnea, inspiratory indrawing of the suprasternal notch, supraclavicular fossae, costal interspaces and lower sternum will be present. Cyanosis is only an accompaniment of suddenly produced dyspnea; the facies will therefore usually be anxious and pale, unless the patient is seen immediately after the aspiration of the foreign body. If labored breathing has been prolonged, and exhaustion threatened, the heart's action will be irregular and weak. The foreign body can be seen with the mirror, but a roentgenograph must nevertheless be made, for the object may be of another nature than was first thought. The roentgenograph will show its position, and from this knowledge the plan of removal can be formulated. For example, a straight pin may be so placed in the larynx that only a portion of its shaft will be visible, the roentgenogram will tell where the head and point are located, and which of these will be the more readily disengaged. (See Chapter on Mechanical Problems.)

PHYSICAL SIGNS OF TRACHEAL FOREIGN BODY

If fixed in the trachea the only objective sign of foreign body may be a wheezing respiration, the site of which may be localized with the stethoscope, by the intensity of the sound. Movable foreign bodies may produce a palpatory thrill, and the rumble and sudden stop can be heard with the stethoscope and often with the naked ear. The lungs will show equal aeration, but there may be marked dyspnea without the indrawing of the fossae, if the object be of large size and located below the manubrium.

To the peculiar sound of the sudden subglottic, expiratory or bechic arrest of the foreign body the author has given the name "audible slap;" when felt by the thumb on the trachea he calls it the "palpatory thud." These signs can be produced by no condition other than the arrest of some substance by the subglottic taper. Once heard and felt they are unmistakable.

PHYSICAL SIGNS OF BRONCHIAL FOREIGN BODY

In most cases there will be limitation of expansion on the invaded side, even though the foreign body is of such a shape as to cause no bronchial obstruction. It has been noted frequently in conjunction with the presence of such objects as a common straight pin in a small branch bronchus. This peculiar phenomenon was first noted by Thomas McCrae in one of the author's cases and has since been abundantly corroborated by McCrae and others as one of the most constant physical signs.

To understand the peculiar physical findings in these cases it is necessary to remember that the bronchi are not tubes of constant caliber; there occurs a dilatation during inspiration, and a contraction of the lumen during expiration; furthermore, the lumen may be narrowed by swollen mucosa if the foreign body be of an irritant nature. The signs vary with the degree of obstruction of the bronchus, and with the consequent degree of interference with aeration and drainage of the subjacent portion of the lung. We have three definite types which show practically constant signs in the earlier stages of foreign body invasion.

1. Complete bronchial occlusion.
2. Obstruction complete during expiration, but allowing the passage of air during the bronchial dilatation incident to inspiration, constituting an expiratory valve-like obstruction.
3. Partial bronchial obstruction, allowing to-and-fro passage of air.

1. *Complete bronchial obstruction* is manifested by limitation of expansion, markedly impaired percussion note, particularly at the base, absence of breath-sounds, and rales on the invaded side. An atelectasis here exists; the air imprisoned in the lung is soon absorbed, and secretions rapidly accumulate. On the free side a compensatory emphysema is present.

2. *Expiratory Valve-like Obstruction.*—The obstructed side shows marked limitation of expansion. Percussion is of a tympanitic character. The duration of the vibrations may be shortened giving a muffled tympany. Various grades and degrees of tympany may be noted. Breath sounds are markedly diminished or absent. No rales are heard on the invaded side, although rales of all types may be present on the free side. In some cases it is possible to hear a short inspiratory sound. Vocal resonance and fremitus are but little altered. The heart will be found displaced somewhat to the opposite side. These signs are explained by the passage of some air past the foreign body during inspiration with its trapping during expiration, so that there is air under pressure constantly maintained in the obstructed area. This type of obstruction is most frequently observed when the foreign body is of an organic nature such as nut kernels, beans, corn, seed, etc. The localized swelling about the irritating foreign body completes the expiratory obstruction. It may also be present with any foreign body whose size and shape are such as to occlude the lumen of the bronchus during its contracted expiratory phase. It was present in cases of pebbles, cylindrical metallic objects, thick tough balls of secretion etcetera. The valvular action is here produced most often by a change in the size of the valve seat and not by a movement of the foreign body plug. In other cases I have found at bronchoscopy, a regular ball-valve mechanism. Pneumothorax is the only pathologic condition associated with signs similar to those of expiratory, valve-like bronchial obstruction by a foreign body.

3. *Partial bronchial obstruction* by an object such as a nail allows air to pass to and fro with some degree of retardation, and impairs the drainage of the subjacent lung. Limitation of expansion will be found on the invaded side. The area below the foreign body will give an impaired percussion note. Breath-sounds are diminished in the area of dullness, and vocal resonance and fremitus are impaired. Rales are of great diagnostic import; the passage of air past the foreign body is accompanied by blowing, harsh breathing, and snoring; snapping rales are heard usually with greatest intensity posteriorly over the site of the foreign body (usually about the scapular angle).

A knowledge of the topographical lung anatomy, the bronchial tree, and of endoscopic pathology* should enable the examiner of the chest to locate very accurately a bronchial foreign body by physical signs alone, for all the significant signs occur distal to the foreign body lodgment.

* Jackson, Chevalier. Pathology of Foreign Bodies in the Air and Food Passages. Mutter Lecture, 1918. Surgery, Gynecology and Obstetrics, March, 1919. Also, by the same author, Mechanism of the Physical Signs of Foreign Bodies in the Lungs. Proceedings of the College of Physicians, Philadelphia, 1922.

The asthmatoid wheeze has been found by the author a valuable confirmatory sign of bronchial foreign body. It is a wheezing heard by placing the observer's ear at the open mouth of the patient (not at the chest wall) during a prolonged forced expiration. Thomas McCrae elicits this sign by placing the stethoscope bell at the patient's open mouth. The quality of the sound is dryer than that heard in asthma and the wheeze is clearest after all secretion has been removed by coughing. The mechanism of production is, probably, the passage of air by a foreign body which narrows the lumen of a large bronchus. As the foreign body works downward the wheeze lessens. The wheeze is often so loud as to be heard at some distance from the patient. It is of greatest value in the diagnosis of non-roentgenopaque foreign body but its absence in no way negates foreign body. Its presence or absence should be recorded in every case.

Prolonged bronchial obstruction by foreign body is followed by bronchiectasis and lung abscess usually in a lower lobe. The symptoms may with exactitude simulate tuberculosis, but this disease should be readily excluded by the basal, unilateral site of the lesion, absence of tubercle bacilli in the sputum, and roentgenographic study. Chest examination in the foreign body cases reveals limitation of expansion, often some retraction, flat percussion note, and greatly diminished or absent breath-sounds over the site of the pulmonary lesion. Rales vary with the amount of secretion present. These physical signs suggest empyema; and rib resection had been done before admission in a number of cases only to

find the pleura normal.

ROENTGENRAY STUDY IN FOREIGN BODY CASES

Roentgenography.—All cases of chest disease should have the benefit of a roentgenologic study to exclude bronchial foreign body as an etiological factor. Negative opinions should never be based upon any plates except the best that the wonderful modern development of the art and science of roentgenology can produce. In doubtful cases, the negative opinion should not be conclusive until a roentgenologist of long experience in chest work, and especially in foreign body cases, has been called in consultation. Even then there will be an occasional case calling for diagnostic bronchoscopy. Antero-posterior and lateral roentgenograms should always be made. In an antero-posterior film a flat foreign body lying in the lateral body plane might be invisible in the shadow of the spine, heart, and great vessels; but would be revealed in the lateral view because of the greater edgewise density of the intruder and the absence of other confusing shadows. Fluoroscopic examination will often discover the best angle from which to make a plate; but foreign bodies casting a very faint shadow on a plate may be totally invisible on the fluoroscopic screen. The value of a roentgenogram after the removal of a foreign body cannot be too strongly emphasized. It is evidence of removal and will exclude the presence of a second intruder which might have been overlooked in the first study.

Fluoroscopic study of the swallowing function with barium mixture, or a barium-filled capsule, will give the location of a nonroentgenopaque object (such as bone, meat, etc.) in the esophagus. If a flat or disc-shaped object located in the cervical region is seen to be lying in the lateral body plane, it will be found to be in the esophagus, for it assumed that position by passing down flatwise behind the larynx. If, however, the object is seen to be in the sagittal plane it must lie in the trachea. This position was necessary for it to pass through the glottic chink, and can be maintained because of the yielding of the posterior membranous wall of the trachea.

THE ROENTGENOGRAPHIC SIGNS OF EXPIRATORY-VALVE-LIKE BRONCHIAL OBSTRUCTION

The roentgenray signs in expiratory valve-like obstruction of a bronchus are those of *an acute obstructive emphysema* (Fig. 74), namely, 1. Greater transparency on the obstructed side (Iglauer). 2. Displacement of the heart to the free side (Iglauer). 3. Depression and flattening of the dome of the diaphragm on the invaded side (Iglauer). 4. Limitation of the diaphragmatic excursion on the obstructed side (Manges).

It is very important to note that, as discovered by Manges, the differential emphysema occurs at the end of expiration and the plate must be exposed at that time, before inspiration starts. He also noted that at fluoroscopy the heart moved laterally toward the uninvaded side during expiration.*

* Dr. Manges has developed such a high degree of skill in the fluoroscopic diagnosis of non-opaque foreign bodies by the obstructive emphysema they produce that he has located peanut kernels and other vegetable substances with absolute accuracy and unfailing certainty in dozens of cases at the Bronchoscopic Clinic.

[FIG. 74—Expiratory valve-like bronchial obstruction by non-radiopaque foreign body, producing an acute obstructive emphysema. Peanut kernel in right main bronchus. Note (a) depression of right diaphragm; (b) displacement of heart and mediastinum to left; (c) greater transparency of the invaded side. Ray-plate made by Willis F. Manges.]

Complete bronchial obstruction shows a density over the whole area the aeration and drainage of which has been cut off (Fig. 75). Pulmonary abscess formation and "drowned lung" (accumulated secretion in the bronchi and bronchioli) are shown by the definite shadows produced (Fig. 76).

[140] Dense and metallic objects will usually be readily seen in the roentgenograms and fluoroscope, but many foreign bodies are of a nature which will produce no shadow; the roentgenologist should, therefore, be prepared to interpret the pulmonary pathology, and should not dismiss the case as negative for foreign body because one is not seen. Even metallic objects are in rare cases exceedingly difficult to demonstrate.

[FIG. 75.—Radiograph showing pathology resulting from complete obstruction of a bronchus with atelectasis and drowned lung resulting. Foot of an alarm clock in left bronchus of 4 year old child. Present 25 days. Plate made by Johnston and Grier.]

Positive Films of the Tracheo-bronchial Tree as an Aid to Localization.—In order to localize the bronchus invaded by a small foreign body the positive film is laid over the negative of the patient showing the foreign body. The shadow of the foreign body will then show through the overlying positive film. These positive films are made in twelve sizes, and the size selected should be that corresponding

to the size of the patient as shown by the roentgenograph. The dome of the diaphragm and the dome of the pleura are taken as visceral landmarks for placing the positive films which have lines indicating these levels. If the shadow of the foreign body be faint it may be strengthened by an ink mark on the uncoated side of the plate.

[FIG. 76.—Partial bronchial obstruction for long period of time Pathology, bronchiectasis and pulmonary abscess, produced by the presence for 4 years of a nail in the left lung of a boy of 10 years]

Bronchial mapping is readily accomplished by the author's method of endobronchial insufflation of a roentgenopaque inert powder such as bismuth subnitrate or subcarbonate (Fig. 77). The roentgenopaque substance may be injected in a fluid mixture if preferred, but the walls are better outlined with the powder (Fig. 77).

[FIG. 77.—Roentgenogram showing the author's method of bronchial mapping or lung-mapping by the bronchoscopic introduction of opaque substances (in this instance powdered bismuth subnitrate) into the lung of the patient. Plate made by David R. Bowen. (Illustration, strengthened for reproduction, is from author's article in American Journal of Roentgenology, Oct., 1918.)]

ERRORS TO AVOID IN SUSPECTED FOREIGN BODY CASES

1. Do not reach for the foreign body with the fingers, lest the foreign body be thereby pushed into the larynx, or the larynx be thus traumatized. 2. Do not hold up the patient by the heels, lest a tracheally lodged foreign body be dislodged and asphyxiate the patient by becoming jammed in the glottis. [143] 3. Do not fail to have a roentgenogram made, if possible, whether the foreign body in question is of a kind dense to the ray or not. 4. Do not fail to search endoscopically for a foreign body in all cases of doubt. 5. Do not pass blindly an esophageal bougie, probang, or other instrument. 6. Do not tell the patient he has no foreign body until after roentgenray examination, physical examination, indirect examination, and endoscopy have all proven negative.

SUMMARY

SYMPTOMATOLOGY AND DIAGNOSIS OF FOREIGN BODIES IN THE AIR AND FOOD PASSAGES

Initial symptoms are choking, gagging, coughing, and wheezing, often followed by a symptomless interval. The foreign body may be in the larynx, trachea, bronchi, nasal chambers, nasopharynx, fauces, tonsil, pharynx, hypopharynx, esophagus, stomach, intestinal canal, or may have been passed by bowel, coughed out or spat out, with or without the knowledge of the patient. Initial choking, etcetera may have escaped notice, or may have been forgotten.

Laryngeal Foreign Body.—One or more of the following laryngeal symptoms may be present: Hoarseness, croupy cough, aphonia, odynphagia, hemoptysis, wheezing, dyspnea, cyanosis, apnea, subjective sensation of foreign body. Croupiness in foreign body cases, as in diphtheria, usually means subglottic swelling. Obstructive foreign body may be quickly fatal by laryngeal impaction on aspiration, or on abortive bechic expulsion. Lodgement of a non-obstructive foreign body may be followed by a symptomless interval. Direct laryngoscopy for diagnosis is indicated in every child having laryngeal diphtheria without faucial membrane. (No anesthetic, general or local is needed.) In the presence of laryngeal symptoms, think of the following: 1. A foreign body in the larynx. 2. A foreign body loose or fixed in the trachea. 3. Digital efforts at removal. 4. Instrumentation. 5. Overflow of food into the larynx from esophageal obstruction due to the foreign body. 6. Esophagotracheal fistula from ulceration set up by a foreign body in the esophagus, followed by the leakage of food into the air-passages. 7. Laryngeal symptoms may persist from the trauma of a foreign body that has passed on into the deeper air or food passages or that has been coughed or spat out. 8. Laryngeal symptoms (hoarseness, croupiness, etcetera) may be due to digital or instrumental efforts at the removal of a foreign body that never was present. 9. Laryngeal symptoms may be due to acute or chronic laryngitis, diphtheria, pertussis, infective laryngotracheitis, and many other diseases. 10. Deductive decisions are dangerous. 11. If the roentgenray is negative, laryngoscopy (direct in children, indirect in adults) without anesthesia, general or local, is the only way to make a laryngeal diagnosis. 12. Before doing a diagnostic laryngoscopy, preparation should be made for taking a swab-specimen and for bronchoscopy and esophagoscopy.

Tracheal Foreign Body.—(1) "Audible slap," (2) "palpatory thud," and (3) "asthmatoid wheeze" are pathognomonic. The "tracheal flutter" has been observed by McCrae in a case of watermelon seed. Cough, hoarseness, dyspnea, and cyanosis are often present. Diagnosis is by roentgenray, auscultation, palpation, and bronchoscopy. Listen long for "audible slap," best heard at open mouth during cough. The "asthmatoid wheeze" is heard with the ear or stethoscope bell (McCrae) at the patient's open mouth. History of initial choking, gagging, and wheezing is important if elicited, but is valueless

negatively.

Bronchial Foreign Body.—Initial symptoms are coughing, choking, asthmatoid wheeze, etc. noted above. There may be a history of these or of tooth extraction. At once, or after a symptomless interval, cough, blood-streaked sputum, metallic taste, or special odor of foreign body may be noted. Non-obstructive metallic foreign bodies afford few symptoms and few signs for weeks or months. Obstructive foreign bodies cause atelectasis, drowned lung, and eventually pulmonary abscess. Lobar pneumonia is an exceedingly rare sequel. Vegetable organic foreign bodies as peanut-kernels, beans, watermelon seeds, etcetera, cause at once violent laryngotracheobronchitis, with toxemia, cough and irregular fever, the gravity and severity being inversely to the age of the child. Bones, animal shells and inorganic bodies after months or years produce changes which cause chills, fever, sweats, emaciation, clubbed fingers, incurved nails, cough, foul expectoration, hemoptysis, in fact, all the symptoms of chronic pulmonary sepsis, abscess, and bronchiectasis. These symptoms and some of the physical signs may suggest pulmonary tuberculosis, but the apices are normal and bacilli are absent from the sputum. Every acute or chronic chest case calls for the exclusion of foreign body.

The physical signs vary with conditions present in different cases and at different times in the same case. Secretions, normal and pathologic, may shift from one location to another; the foreign body may change its position admitting more, less, or no air, or it may shift to a new location in the same lung or even in the other lung. A recently aspirated pin may produce no signs at all. The signs of diagnostic importance are chiefly those of partial or complete bronchial obstruction, though a non-obstructive foreign body, a pin for instance, may cause limited expansion (McCrae) or, rarely, a peculiar rale or a peculiar auscultatory sound. The most nearly characteristic physical signs are: (1) Limited expansion; (2) decreased vocal fremitus; (3) impaired percussion note; (4) diminished intensity of the breath-sounds distal to the foreign body. Complete obstruction of a bronchus followed by drowned lung adds absence of vocal resonance and vocal fremitus, thus often leading to an erroneous diagnosis of empyema. Varying grades of tympany are obtained over areas of obstructive or compensatory emphysema. With complete obstruction there may be tympany from the collapsed lung for a time. Rales in case of complete obstruction are usually most intense on the uninvaded side. In partial obstruction they are most often found on the invaded side distal to the foreign body, especially posteriorly, and are most intense at the site corresponding to that of the foreign body. A foreign body at the bifurcation of the trachea may give signs in both lungs. Early in a foreign body case, diminished expansion of one side, with dulness, may suggest pneumonia in the affected side; but absence of, or decreased, vocal resonance, and absence of typical tubular breathing should soon exclude this diagnosis. Bronchial obstruction in pneumonia is exceedingly rare.

Memorize these signs suggestive of foreign body: 1. Expansion—diminished. 2. Percussion note—impaired (except in obstructive emphysema). 3. Vocal fremitus—diminished. 4. Breath sounds—diminished.

The foregoing is only for memorizing, and must be considered in the light of the following fundamental note by Prof. McCrae "There is no one description of physical signs which covers all cases. If the student will remember that complete obstruction of a bronchus leads to a shutting off of this area, there should be little difficulty in understanding the signs present. The diagnosis of empyema may be made, but the outline of the area of dulness, the fact that there is no shifting dulness, and the greater resistance which is present in empyema nearly always clear up any difficulty promptly. The absence of the frequent change in the voice sounds, so significant in an early small empyema, is of value. A large empyema should give no difficulty. If difficulty remains the use of the needle should be sufficient. In thickened pleura vocal fremitus is not entirely absent, and the breath-sounds can usually be heard, even if diminished. In case of partial obstruction of a bronchus, it is evident that air will still be present, hence the dulness may be only slight. The presence of air and secretion will probably result in the breath-sounds being somewhat harsh, and will cause a great variety of rales, principally coarse, and many of them bubbling. Difficulty may be caused by signs in the other lung or in a lobe other than the one affected by the foreign body. If it is remembered that these signs are likely to be only on auscultation, and to consist largely in the presence of rales, while the signs in the area supplied by the affected bronchus will include those on inspection, palpation, and percussion, there should be little difficulty."

The roentgenray is the most valuable diagnostic means; but careful notation of physical signs by an expert should be made in all cases preferably without knowledge of ray findings. Expert ray work will show all metallic foreign bodies and many of less density, such as teeth, bones, shells, buttons, etcetera. If the ray is negative, a diagnostic bronchoscopy should be done in all cases of unexplained bronchial obstruction.

Peanut kernels and watermelon seeds and, rarely, other foreign bodies in the bronchi produce obstructive emphysema of the invaded side. Fluoroscopy shows the diaphragm flattened, depressed

and of less excursion on the invaded side; at the end of expiration, the heart and the mediastinal wall move over toward the uninvaded side and the invaded lung becomes less dense than the uninvaded lung, from the trapping of the air by the expiratory, valve-like effect of obliteration of the "forceps spaces" that during inspiration afford air ingress between the foreign body and the swollen bronchial wall. This partial obstruction causes obstructive emphysema, which must be distinguished from compensatory emphysema, in which the ballooning is in the unobstructed lung, because its fellow is wholly out of function through complete "corking" of the main bronchus of the invaded side.

Esophageal Foreign Body.—After initial choking and gagging, or without these, there may be a subjective sense of a foreign body, constant or, more often, on swallowing. Odynphagia and dysphagia or aphagia may or may not be present. Pain, sub-sternal or extending to the back is sometimes present. Hematemesis and fever may occur from the foreign body or from rough instrumentation. Symptoms referable to the air-passages may be present due to: (1) Overflow of the secretions on attempts to swallow through the obstructed esophagus; (2) erosion of the foreign body through from the esophagus into the trachea; or (3) trauma inflicted on the larynx during attempts at removal, digital or instrumental, the foreign body still being present or not.

Diagnosis is by the roentgenray, first without, then, if necessary, with a capsule filled with an opaque mixture. Flat objects, like coins, always lie with their greatest diameter in the coronal plane of the body, when in the esophagus; in the sagittal plane, when in the trachea or larynx. Lateral, anteroposterior, and sometimes also quartering roentgenograms are necessary. One taken laterally, low down on the neck but clear of the shoulder, will often show a bone or other semiopaque object invisible in the anteroposterior exposure.

[149] CHAPTER XIII—FOREIGN BODIES IN THE LARYNX AND TRACHEOBRONCHIAL TREE

The protective reflexes preventing the entrance of foreign bodies into the lower air passages are: (1) The laryngeal closing reflex and (2) the bechic reflex. Laryngeal closing for normal swallowing consists chiefly in the tilting and the closure of the upper laryngeal orifice. The ventricular bands help but slightly; and the epiglottis and the vocal cords little, if at all. The gauntlet to be run by foreign bodies entering the tracheobronchial tree is composed of: 1. Epiglottis. 2. Upper laryngeal orifice. 3. Ventricular bands. 4. Vocal cords. 5. Bechic blast.

The epiglottis acts somewhat as a fender. The superior laryngeal aperture, composed of a pair of movable ridges of tissue, has almost a sphincteric action, in addition to a tilting movement. The ventricular bands can approximate under powerful stimuli. The vocal cords act similarly. The one defect in the efficiency of this barrier, is the tendency to take a deep inspiration preparatory to the cough excited by the contact of a foreign body.

Site of Lodgment.—The majority of foreign bodies in the air passages occur in children. The right bronchus is more frequently invaded than the left because of the following factors: I. Its greater diameter. 2. Its lesser angle of deviation from the tracheal axis. 3. The situation of the carina to the left of the mid-line of the trachea. 4. The action of the trachealis muscle. 5. The greater volume of air going into the right bronchus on inspiration.

The middle lobe bronchus is rarely invaded by foreign body, and, fortunately, in less than one per cent of the cases is the object in an upper lobe bronchus.

Spontaneous Expulsion of Foreign Bodies from the Air Passages. A large, light, foreign body in the larynx or trachea may occasionally be coughed out, but the frequent newspaper accounts of the sudden death of children known to have aspirated objects should teach us never to wait for this occurrence. The cause of death in these cases is usually the impaction of a large foreign body in the glottis producing sudden asphyxiation, and in a certain proportion of these cases the impaction has occurred on the reverse journey, when cough forced the intruder upward from below. The danger of subglottic impaction renders it imperative that attempts to aid spontaneous expulsion by inverting the patient should be discouraged. Sharp objects, such as pins, are rarely coughed out. The tendency of all foreign bodies is to migrate down and out to the periphery as their size and shape will allow. Most of the reported cases of bechic expulsion of bronchially lodged foreign bodies have occurred after a prolonged sojourn of the object, associated which much lung pathology; and in some cases the object has been carried out along with an accumulation of pus suddenly liberated from an abscess cavity, and expelled by cough. This is a rare sequence compared to the usual formation of fibrous stricture above the foreign body that prevents the possibility of bechic expulsion. To delay bronchoscopy with the hope of such a solution of the problem is comparable to the former dependence on nature for the cure of

appendiceal abscess.

We do our full duty when we tell the patient or parents that while the foreign body may be coughed up, it is very dangerous to wait; and, further, that the difficulty of removal usually increases with the time the foreign body is allowed to remain in the air passages.

Mortality and morbidity of bronchoscopy vary directly with the degree of skill and experience of the operator, and the conditions for which the endoscopies are performed. The simple insertion of the bronchoscope is devoid of harm if carefully done. The danger lies in misdirected efforts at removal of the intruder and in repeating bronchoscopies in children at too frequent intervals, or in prolonging the procedure unduly. In children under one year endoscopy should be limited to twenty minutes, and should not be repeated sooner than one week after, unless urgently indicated. A child of 5 years will bear 40 to 60 minutes work, while the adult offers no unvarying time limit. More can be ultimately accomplished, and less reaction will follow short endoscopies repeated at proper intervals than in one long procedure.

Indications for bronchoscopy for suspected foreign body may be thus summarized: 1. The appearance of a suspicious shadow in the radiograph, in the line of a bronchus. 2. In any case in which lung symptoms followed a clear history of the patient having choked on a foreign body. 3. In any case showing signs of obstruction in the trachea or of a bronchus. 4. In suspected bronchiectasis. 5. Symptoms of pulmonary tuberculosis with sputum constantly negative for tubercle bacilli. If the physical signs are at the base, particularly the right base, the indication becomes very strong even in the absence of any foreign body circumstance in the history. 6. In all cases of doubt, bronchoscopy should be done anyway.

There is no absolute *contraindication to bronchoscopy for foreign bodies*. Extreme exhaustion or reaction from previous efforts at removal may call for delay for recuperation, but pulmonary abscess and even the rarer complications, bronchopneumonia and gangrene of the lung, are improved by the early removal of the foreign body.

Choice of Time to do Bronchoscopy for Foreign Body.—The difficulties of removal usually increase from the time of aspiration of the object. It tends to work downward and outward, while the mucosa becomes edematous, partly closing over the foreign body, and even completely obliterating the lumen of smaller bronchi. Later, granulation tissue and the formation of stricture further hide the object. The patient's health deteriorates with the onset of pulmonary pathology, and renders him a less favorable subject for bronchoscopy. Organic foreign bodies, which produce early and intense inflammatory reaction and are liable to swell, call for prompt bronchoscopy. When a bronchus is completely obstructed by the bulk of the foreign body itself immediate removal is urgently demanded to prevent serious lung changes, resulting from atelectasis and want of drainage. In short, removal of the foreign body should be accomplished as soon as possible after its entrance. This, however, does not justify hasty, ill-planned, and poorly equipped bronchoscopy, which in most cases is doomed to failure in removal of the object. The bronchoscopist should not permit himself to be stampeded into a bronchoscopy late at night, when he is fatigued after a hard day's work.

Bronchoscopic finding of a foreign body is not especially difficult if the aspiration has been recent. If secondary processes have developed, or the object be small and in a bronchus too small to admit the tube-mouth, considerable experience may be necessary to discover it. There is usually inflammatory reaction around the orifice of the invaded bronchus, which in a measure serves to localize the intruder. We must not forget, however, that objects may have moved to another location, and also that the irritation may have been the result of previous efforts at removal. Care must be exercised not to mistake the sharp, shining, interbronchial spurs for bright thin objects like new pins just aspirated; after a few days pins become blackened. If these spurs be torn pneumothorax may ensue. If a number of small bronchi are to be searched, the bronchoscope must be brought into the line of the axis of the bronchus to be examined, and any intervening tissue gently pushed aside with the lip of the bronchoscope. Blind probing for exploration is very dangerous unless carefully done. The straight forceps, introduced closed, form the best probe and are ready for grasping if the object is felt. Once the bronchoscope has been introduced, it should not be withdrawn until the procedure is completed. The light carrier alone may be removed from its canal if the illumination be faulty.

COMPLICATIONS AND AFTER-EFFECTS OF BRONCHOSCOPY

All foreign body cases should be watched day and night by special nurses until all danger of complications is passed. Complications are rare after careful work, but if they do occur, they may require immediate attention. This applies especially to the subglottic edema associated with arachidic bronchitis in children under 2 years of age.

General Reaction.—There is usually no elevation in temperature following a short bronchoscopy for the removal of a recently lodged metallic foreign body. If, however, an inflammatory condition of the bronchi existed previous to the bronchoscopy, as for instance the intense diffuse, purulent laryngotracheobronchitis associated with the aspiration of nut kernels, or in the presence of pulmonary abscess from long retained foreign bodies, a moderate temporary rise of temperature may be expected. These cases almost always have had irregular fever before bronchoscopy. Disturbance of the epithelium in the presence of pus without abscess usually permits enough absorption to elevate the temperature slightly for a few days.

Surgical shock in its true form has never followed a carefully performed and time-limited bronchoscopy. Severe fatigue resulting in deep sleep may be seen in children after prolonged work.

Local reaction is ordinarily noted by slight laryngeal congestion causing some hoarseness and disappearing in a few days. If dyspnea occur it is usually due to (1) Drowning of the patient in his own secretions. (2) Subglottic edema. (3) Laryngeal edema.

Drowning of the Patient in His Own Secretions.—The accumulation of secretions in the bronchi due to faulty bechic powers and seen most frequently in children, is quickly relievable by bronchoscopic sponge-pumping or aspiration through the tracheotomic wound, in cases in which the tracheotomy may be deemed necessary. In other cases, the aspirating bronchoscope with side drainage canal (Fig. 1, E) may be used through the larynx. Frequent peroral passage of the bronchoscope for this purpose is contraindicated only in case of children under 3 years of age, because of the likelihood of provoking subglottic edema. In such cases instead of inserting a bronchoscope the aspirating tube (Fig. 9) should be inserted through the direct laryngoscope, or a low tracheotomy should be done.

Supraglottic edema is rarely responsible for dyspnea except when associated with advanced nephritis.

Subglottic edema is a complication rarely seen except in children under 3 years of age. They have a peculiar histologic structure in this region, as is shown by Logan Turner. Even at the predisposing age subglottic edema is a very unusual sequence to bronchoscopy if this region was previously normal. The passage of a bronchoscope through an already inflamed subglottic area is liable to be followed by a temporary increase in the swelling. If the foreign body be associated with but slight amount of secretion, the child can usually obtain sufficient air through the temporarily narrowed lumen. If, however, as in cases of arachidic bronchitis, large amounts of purulent secretion must be expelled, it will be found in certain cases that the decreased glottic lumen and impaired laryngeal motility will render tracheotomy necessary to drain the lungs and prevent drowning in the retained secretions. Subglottic edema occurring in a previously normal larynx may result from: 1. The use of over-sized tubes. 2. Prolonged bronchoscopy. 3. Faulty position of the patient, the axis of the tube not being in that of the trachea. 4. Trauma from undue force or improper direction in the insertion of the bronchoscope. 5. The manipulation of instruments. 6. Trauma inflicted in the extraction of the foreign body.

Diagnosis must be made without waiting for cyanosis which may never appear. Pallor, restlessness, startled awakening after a few minutes sleep, occurring in a child with croupy cough, indrawing around the clavicles, in the intercostal spaces, at the suprasternal notch and at the epigastrium, call for tracheotomy which should always be low. Such a case should not be left unwatched. The child will become exhausted in its fight for air and will give up and die. The respiratory rate naturally increases because of air hunger, accumulating secretions that cannot be expelled because of impaired glottic motility give signs wrongly interpreted as pneumonia. Many children whose lives could have been saved by tracheotomy have died under this erroneous diagnosis.

Treatment.—Intubation is not so safe because the secretions cannot easily be expelled through the tube and postintubational stenosis may be produced. Low tracheotomy, the tracheal incision always below the second ring, is the safest and best method of treatment.

[156] CHAPTER XIV—REMOVAL OF FOREIGN BODIES FROM THE LARYNX

Symptoms and Diagnosis.—The history of a sudden choking attack followed by impairment of voice, wheezing, and more or less dyspnea can be usually elicited. Laryngeal diphtheria is the condition most frequently thought of when these symptoms are present, and antitoxin is rightly given while waiting for a positive diagnosis. Extreme dyspnea may render tracheotomy urgently demanded before any attempts at diagnosis are made. Further consideration of the symptomatology and diagnosis of laryngeal foreign body will be found on pages 128, 133 and 143.

Preliminary Examination.—In the adult, mirror examination of the larynx should be done, the patient being placed in the recumbent position. Whenever time permits roentgenograms, lateral and anteroposterior, should be made, the lateral one as low in the neck as possible. One might think this an unnecessary procedure because of the visibility of the larynx in the mirror; but a child's larynx cannot usually be indirectly examined, and even in the adult a pin may be so situated that neither head nor point is visible, only a portion of the shaft being seen. The roentgenogram will give accurate information as to the position, and will thus allow a planning of the best method for removal of the foreign body. A bone in the larynx usually is visible in a good roentgenogram. Accurate diagnosis in children is made by direct laryngoscopy without anesthesia, but direct laryngoscopy should not be done until one is prepared to remove a foreign body if found, to follow it into the bronchus and remove it if it should be dislodged and aspirated, and to do tracheotomy if sudden respiratory arrest occur.

[157] *Technic of Removal of Foreign Bodies from the Larynx*.—The patient is to be placed in the author's position, shown in Fig. 53. No general anesthesia should be given, and the application of local anesthesia is usually unnecessary and further, is liable to dislodge and push down the foreign body.* Because of the risk of loss downward it is best to seize the foreign body as soon as seen; then to determine how best to disimpact it. The fundamental principles are that a pointed object must either have its point protected by the forceps grasp or be brought out point trailing, and that a flat object must be so rotated that its plane corresponds to the sagittal plane of the glottic chink. The laryngeal grasping forceps (Fig. 53) will be found the most useful, although the alligator rotation forceps (Fig. 31) may occasionally be required.

* In adolescents or adults a few drops of a 4 per cent solution of cocain applied to the laryngopharynx with an atomizer or a dropper will afford the minimum risk of dislodgement; but the author's personal preference is for no anesthesia, general or local.

[158] CHAPTER XV—MECHANICAL PROBLEMS OF BRONCHOSCOPIC FOREIGN BODY EXTRACTION*

* For more extensive consideration of mechanical problems than is here possible the reader is referred to the Bibliography, page 311, especially reference numbers 1, 11, 37 and 56.

The endoscopic extraction of a foreign body is a mechanical problem pure and simple, and must be studied from this viewpoint. Hasty, ill-equipped, ill-planned, or violent endoscopy on the erroneous principle that if not immediately removed the foreign body will be fatal, is never justifiable. While the lodgement of an organic foreign body (such as a nut kernel) in the bronchus calls for prompt removal and might be included under the list of emergency operations, time is always available for complete preparation, for thorough study of the patient, and localization of the intruder. The patient is better off with the foreign body in the lung than if in its removal a mediastinitis, rupture into the pleura, or tearing of a thoracic blood vessel has resulted. The motto of the endoscopist should be "I will do no harm." If no harm be inflicted, any number of bronchoscopies can be done at suitable intervals, and eventually success will be achieved, whereas if mortality results, all opportunity ceases.

The first step in the solution of the mechanical problem is the study of the roentgenograms made in at least three planes; (1) anteroposterior, (2) lateral, and (3) the plane corresponding to the greatest plane of the foreign body. The next step is to put a duplicate of the foreign body into the rubber-tube manikin previously referred to, and try to simulate the probable position shown by the ray, so as to get an idea of the bronchoscopic appearance of the probable presentation. Then the duplicate foreign body is turned into as many different positions as possible, so as to educate the eye to assist in the comprehension of the largest possible number of presentations that may be encountered at the bronchoscopy on the patient. For each of these presentations a method of disimpaction, disengagement, disentanglement or version and seizure is worked out, according to the kind of foreign body. Prepared by this practice and the radiographic study, the bronchoscope is introduced into the patient. The location of the foreign body is approached slowly and carefully to avoid overriding or displacement. A *study of the presentation* is as necessary for the bronchoscopist as for the obstetrician. It should be made with a view to determining the following points: 1. The relation of the presenting part to the surrounding tissues. 2. The probable position of the unseen portion, as determined by the appearance of the presenting part taken in connection with the knowledge obtained by the previous ray study, and by inspection of the ray plate upside down on view in front of the bronchoscopist. 3. The version or other manipulation necessary to convert an unfavorable into a favorable presentation for grasping and disengagement. 4. The best instruments to use, and which to use first, as, hook, pincloser, forceps, etc. 5. The presence and position of the "forceps spaces" of which there must be two for all ordinary forceps, one for each jaw, or the "insertion space" for any other instrument.

Until all of these points are determined it is a grave error to insert any kind of instrument. If possible even swabbing of the foreign body should be avoided by swabbing out the bronchus, when necessary, before the region of the intruder is reached. When the operator has determined the instrument to be used, and the method of using it, the instrument is cautiously inserted, under guidance of the eye.

[160] *The lip of the bronchoscope* is one of the most valuable aids in the solution of foreign-body problems. With it partial or complete version of an object can be accomplished so as to convert an unfavorable presentation into one favorable for grasping with the forceps; edematous mucosa may be displaced, angles straightened and space made at the side of the foreign body for the forceps' jaw. It forms a shield or protector that can be slipped under the point of a sharp foreign body and can make counterpressure on the tissues while the forceps are disembedding the point of the foreign body. With the bronchoscopic lip and the forceps or other instrument inserted through the tube, the bronchoscopist has bimanual, eye-guided control, which if it has been sufficiently practiced to afford the facility in coordinate use common to everyone with knife and fork, will accomplish maneuvers that seem marvelous to anyone who has not developed facility in this coordinate use of the bronchoscopic instruments.

The relation of the tube mouth and foreign body is of vital importance. Generally considered, the tube mouth should be as near the foreign body as possible, and the object must be placed in the center of the bronchoscopic field, so that the ends of the open jaws of the forceps will pass sufficiently far over the object. But little lateral control is had of the long instruments inserted through the tube; sidewise motion is obtained by a shifting of the end of the bronchoscope. When the foreign body has been centered in the bronchoscopic field and placed in a position favorable for grasping, it is important that this position be maintained by anchoring the tube to the upper teeth with the left, third, and fourth fingers hooked over the patient's upper alveolus (Fig. 63)

The Light Reflex on the Forceps.—It is often difficult for the beginner to judge to what depth an instrument has been inserted through the tube. On slowly inserting a forceps through the tube, as the blades come opposite the distal light they will appear brightly illuminated; or should the blades lie close to the light bulb, a shadow will be seen in the previously brilliantly lighted opposite wall. It is then known that the forceps are at the tube mouth, and the endoscopist has but to gauge the distance from this to the foreign body. This assistance in gauging depth is one of the great advances in foreign body bronchoscopy obtained by the development of distal illumination.

Hooks are useful in the solution of various mechanical problems, and may be turned by the operator himself into various shapes by heating small probe-pointed steel rods in a spirit lamp, the proximal end being turned over at a right angle for a controlling handle. Hooks with a greater curve than a right angle are prone to engage in small orifices from which they are with difficulty removed. A right angle curve of the distal end is usually sufficient, and a corkscrew spiral is often advantageous, rendering removal easy by a reversal of the twisting motion (Bib. 11, p. 311).

The Use of Forceps in Endoscopic Foreign Body Extraction.—Two different strengths of forceps are supplied, as will be seen in the list in Chapter 1. The regular forceps have a powerful grasp and are used on dense foreign bodies which require considerable pressure on the object to prevent the forceps from slipping off. For more delicate manipulation, and particularly for friable foreign bodies, the lighter forceps are used. Spring-opposed forceps render any delicacy of touch impossible. Forceps are to be held in the right hand, the thumb in one ring, and the third, or ring finger, in the other ring. These fingers are used to open and close the forceps, while all traction is to be made by the right index finger, which has its position on the forceps handle near the stylet, as shown in Fig. 78. It is absolutely essential for accurate work, that the forceps jaws be seen to close upon the foreign body. The impulse to seize the object as soon as it is discovered must be strongly resisted. A careful study of its size, shape, and position and relation to surrounding structures must be made before any attempt at extraction. The most favorable point and position for grasping having been obtained, the closed forceps are inserted through the bronchoscope, the light reflex obtained, the forceps blades now opened are turned in such a position that, on advancing, the foreign body will enter the open V, a sufficient distance to afford a good grasp. The blades are then closed and the foreign body is drawn against the tube mouth. Few foreign bodies are sufficiently small to allow withdrawal through the tube, so that tube, forceps and foreign body are usually withdrawn together.

[FIG. 78.—Proper hold of forceps. The right thumb and third fingers are inserted into the rings while the right index finger has its place high on the handle. All traction is made with the index finger, the ring fingers being used only to open and close the forceps. If any pushing is deemed safe it may be done by placing the index finger back of the thumb-nut on the stylet.]

Anchoring the Foreign Body Against the Tube Mouth.—If withdrawal be made a bimanual procedure it is almost certain that the foreign body will trail a centimeter or more beyond the tube mouth, and

that the closure of the glottic chink as soon as the distal end of the bronchoscope emerges will strip the foreign body from the forceps grasp, when the foreign body reaches the cords. This is avoided by anchoring the foreign body against the tube mouth as soon as the foreign body is grasped, as shown in Fig. 79. The left index finger and thumb grasp the shaft of the forceps close to the ocular end of the tube, while the other fingers encircle the tube; closure of the forceps is maintained by the fingers of the right hand, while all traction for withdrawal is made with the left hand, which firmly clamps forceps and bronchoscope as one piece. Thus the three units are brought out as one; the bronchoscope keeping the cords apart until the foreign body has entered the glottis.

[FIG. 79—Method of anchoring the foreign body against the tube mouth After the object has been drawn firmly against the lip of the endoscopic tube the left finger and thumb grasp the forceps cannula and lock it against the ocular end of the tube, the other fingers of the left hand encircle the tube. Withdrawal is then done with the left hand; the fingers of the right hand maintaining closure of the forceps.]

[164] *Bringing the Foreign Body Through the Glottis*.—Stripping of the foreign body from the forceps at the glottis may be due to:

1. Not keeping the object against the tube mouth as just mentioned.
2. Not bringing the greatest diameter of the foreign body into the sagittal plane of the glottic chink.
3. Faulty application of the forceps on the foreign body.
4. Mechanically imperfect forceps.

Should the foreign body be lost at the glottis it may, if large become impacted and threaten asphyxia. Prompt insertion of the laryngoscope will usually allow removal of the object by means of the laryngeal grasping forceps. The object may be dropped or expelled into the pharynx and be swallowed. It may even be coughed into the naso-pharynx or it may be re-aspirated. In the latter event the bronchoscope is to be re-inserted and the trachea carefully searched. Care must be used not to override the object. If much inflammatory reaction has occurred in the first invaded bronchus, temporarily suspending the aerating function of the corresponding lung, reaspiration of a dislodged foreign body is liable to carry it into the opposite main bronchus, by reason of the greater inspiratory volume of air entering that side. This may produce sudden death by blocking the only aerating organ.

Extraction of Pins, Needles and Similar Long Pointed Objects.—When searching for such objects especial care must be taken not to override them. Pins are almost always found point upward, and the dictum can therefore be made, "Search not for the pin, but for the point of the pin." If the point be found free, it should be worked into the lumen of the bronchoscope by manipulation with the lip of the tube. It may then be seized with the forceps and withdrawn. Should the pin be grasped by the shaft, it is almost certain to turn crosswise of the tube mouth, where one pull may cause the point to perforate, enormously increasing the difficulties by transfixation, and perhaps resulting fatally (Fig. 80).

[FIG. 80.—Schematic illustration of a serious phase of the error of hastily seizing a transfixed pin near its middle, when first seen as at M. Traction with the forceps in the direction of the dart in Schema B will rip open the esophagus or bronchus inflicting fatal trauma, and probably the pin will be stripped off at the glottic or the cricopharyngeal level, respectively. The point of the pin must be disembedded and gotten into the tube mouth as at A, to make forceps traction safe.]

[FIG. 81.—Schema illustrating the mechanical problem of extracting a pin, a large part of whose shaft is buried in the bronchial wall, B. The pin must be pushed downward and if the orifice of the branches, C, D, are too small to admit the head of the pin some other orifice (as at A) must be found by palpation (not by violent pushing) to admit the head, so that the pin can be pushed downward permitting the point to emerge (E). The point is then manipulated into the bronchoscopic tube-mouth by means of co-ordinated movements of the bronchoscopic lip and the side-curved forceps, as shown at F.]

Inward Rotation Method.—When the point is found to be buried in the mucosa, the best and usually successful method is to grasp the pin as near the point as possible with the side-grasping forceps, then with a spiral motion to push the pin downward while rotating the forceps about ninety degrees. The point is thus disengaged, and the shaft of the pin is brought parallel with that of the forceps, after which the point may be drawn into the tube mouth. The lips added to the side-curved forceps by my assistant Dr. Gabriel Tucker I now use exclusively for this inward rotation method. They are invaluable in preventing the escape of the pin during the manipulation. A hook is sometimes useful in disengaging a buried point. The method of its use is illustrated in Fig. 82.

[FIG. 82.—Mechanical problem of pin, needle, tack or nail with embedded point. If the forceps are pulled upon the pin point will be buried still deeper. The side curved forceps grasp the pin as near the point as possible then with a corkscrew motion the pin is pushed downward and rotated to the right when the pin will be found to be parallel with the shaft of the forceps and can be drawn into the tube. If

the pin is prevented by its head from being pushed downward the point may be extracted by the hook as shown above The side curved forceps may be used instead of the hook for freeing the point, the author's "inward rotation" method. The very best instrument for the purpose is the forceps devised by my assistant, Dr. Gabriel Tucker (Fig. 21). The lips prevent all risk of losing the pin from the grasp, and at the same time bring the long axis of the pin parallel to that of the bronchoscope.]

Pins are very prone to drop into the smaller bronchi and disappear completely from the ordinary field of endoscopic exploration. At other times, pins not dropping so deeply may show the point only during expiration or cough, at which times the bronchi are shortened. In such instances the invaded bronchial orifice should be clearly exposed as near the axis of its lumen as possible; the forceps are now inserted, opened, and the next emergence watched for, the point being grasped as soon as seen.

Extraction of Tacks, Nails and Large Headed Foreign Bodies from the Tracheobronchial Tree.—In cases of this sort the point presents the same difficulty and requires solution in the same manner as mentioned in the preceding paragraphs on the extraction of pins. The author's inward-rotation method when executed with the Tucker forceps is ideal. The large head, however, presents a special problem because of its tendency to act as a mushroom anchor when buried in swollen mucosa or in a fibrous stenosis (Fig. 83). The extraction problems of tacks are illustrated in Figs. 84, 85, and 86. Nails, stick pins, and various tacks are dealt with in the same manner by the author's "inward rotation" method.

Hollow metallic bodies presenting an opening toward the observer may be removed with a grooved expansile forceps as shown in Figs 23 and 25, or its edge may be grasped by the regular side-grasping forceps. The latter hold is apt to be very dangerous because of the trauma inflicted by the catching of the free edge opposite the forceps; but with care it is the best method. Should the closed end be uppermost, however, it may be necessary to insert a hook beyond the object, and to coax it upward to a point where it may be turned for grasping and removal with forceps.

[FIG. 83.—"Mushroom anchor" problem of the upholstery tack. If the tack has not been *in situ* more than a few weeks the stenosis at the level of the darts is simply edematous mucosa and the tack can be pulled through with no more than slight mucosal trauma, *provided* axis-traction only be used. If the tack has been in situ a year or more the fibrous stricture may need dilatation with the divulsor. Otherwise traction may rupture the bronchial wall. The stenotic tissue in cases of a few months' sojourn maybe composed of granulations, in which case axis-traction will safely withdraw it. The point of a tack rarely projects freely into the lumen as here shown. More often it is buried in the wall.]

[168] [FIG. 84.-Schema illustrating the "mushroom anchor" problem of the brass headed upholstery tack. At A the tack is shown with the head bedded in swollen mucosa. The bronchoscopist, looking through the bronchoscope, E, considering himself lucky to have found the point of the tack, seizes it and starts to withdraw it, making traction as shown by the dart in drawing B. The head of the tack catches below a chondrial ring and rips in, tearing its way through the bronchial wall (D) causing death by mediastinal emphysema. This accident is still more likely to occur if, as often happens, the tack-head is lodged in the orifice of the upper lobe bronchus, F. But if the bronchoscopist swings the patient's head far to the opposite side and makes axis-traction, as shown at C, the head of the tack can be drawn through the swollen mucosa without anchoring itself in a cartilage. If necessary, in addition, the lip of the bronchoscope can be used to repress the angle, h, and the swollen mucosa, H. If the swollen mucosa, H, has been replaced by fibrous tissue from many months' sojourn of the tack, the stenosis may require dilatation with the divulsor.]

[FIG. 85.—Problem of the upholstery tack with buried point. If pulled upon, the imminent perforation of the mediastinum, as shown at A will be completed, the bronchus will be torn and death will follow even if the tack be removed, which is of doubtful possibility. The proper method is gently to close the side curved forceps on the shank of the tack near the head, push downward as shown by the dart, in B, until the point emerges. Then the forceps are rotated to bring the point of the tack away from the bronchial wall.]

[169] *Removal of Open Safety Pins from the Trachea and Bronchi*.— Removal of a closed safety pin presents no difficulty if it is grasped at one or the other end. A grasp in the middle produces a "toggle and ring" action which would prevent extraction. When the safety pin is *open with the point downward* care must be exercised not to override it with the bronchoscope or to push the point through the wall. The spring or near end is to be grasped with the side-curved or the rotation forceps (Figs. 19, 20 and 31) and pulled into the bronchoscope, thus closing the pin. An open safety pin lodged point up presents an entirely different and a very difficult problem. If traction is made without closing the pin or protecting the point severe and probably fatal trauma will be produced. The pin may be closed with the pin-closer as illustrated in Fig. 37, and then removed with forceps. Arrowsmith's pin-closer is excellent. Another method (Fig. 87) consists in bringing the point of the safety pin into the bronchoscope, after disengaging the point with the side curved forceps, by the author's "inward rotation" method. The

forceps-jaws (Fig. 21) devised recently by my assistant, Dr. Gabriel Tucker, are ideal for this maneuver. As the point is now protected, the spring, seen just off the tube mouth, is best grasped with the rotation forceps, which afford the securest hold. The keeper and its shaft are outside the bronchoscope, but its rounded portion is uppermost and will glide over the tissues without trauma upon careful withdrawal of the tube and safety pin. Care must be taken to rotate the pin so that it lies in the sagittal plane of the glottis with the keeper placed posteriorly, for the reason that the base of the glottic triangle is posterior, and that the posterior wall of the larynx is membranous above the cricoid cartilage, and will yield. A small safety-pin may be removed by version, the point being turned into a branch bronchial orifice. No one should think of attempting the extraction of a safety pin lodged point upward without having practiced for at least a hundred hours on the rubber tube manikin. This practice should be carried out by anyone expecting to do endoscopy, because it affords excellent education of the eye and the fingers in the endoscopic manipulation of any kind of foreign body. Then, when a safety pin case is encountered, the bronchoscopist will be prepared to cope with its difficulties, and he will be able to determine which of the methods will be best suited to his personal equation in the particular case.

[FIG. 86.—Schema illustrating the "upper-lobe-bronchus problem," combined with the "mushroom-anchor" problem and the author's method for their solution. The patient being recumbent, the bronchoscopist looking down the right main bronchus, M, sees the point of the tack projecting from the right upper-lobe-bronchus, A. He seizes the point with the side-curved forceps; then slides down the bronchoscope to the position shown dotted at B. Next he pushes the bronchoscopic tube-mouth downward and medianward, simultaneously moving the patient's head to the right, thus swinging the bronchoscopic level on its fulcrum, and dragging the tack downward and inward out of its bed, to the position, 1). Traction, as shown at C, will then safely and easily withdraw the tack. A very small bronchoscope is essential. The lip of the bronchoscopic tube-mouth must be used to pry the forceps down and over, and the lip must be brought close to the tack just before the prying-pushing movement. S, right stem-bronchus.]

[FIG. 87.—One method of dealing with an open safety pin without closing it.]

Removal of Double Pointed Tacks.—If the tack or staple be small, and lodged in a relatively large trachea a version may be done. That is, the staple may be turned over with the hook or rotation forceps and brought out with the points trailing. With a long staple in a child's trachea the best method is to "coax" the intruder along gently under ocular guidance, never making traction enough to bury the point deeply, and lifting the point with the hook whenever it shows any inclination to enter the wall. Great care and dexterity are required to get the intruder through the glottis. In certain locations, one or both points may be turned into branch bronchi as illustrated in Fig. 88, or over the carina into the opposite main bronchus. Another method is to get both points into the tube-mouth. This may be favored, as demonstrated by my assistant, Dr. Gabriel Tucker, by tilting the staple so as to get both points into the longest diameter of the tube-mouth. In some cases I have squeezed the bronchoscope in a vise to create an oval tube-mouth. In other cases I have used expanding forceps with grooved blades.

[FIG. 88.-Schema illustrating podalic version of bronchially-lodged staples or double-pointed tacks. H, bronchoscope. A, swollen mucosa covering points of staple. At E the staple has been manipulated upward with bronchoscopic lip and hooks until the points are opposite the branch bronchial orifices, B, C. Traction being made in the direction of the dart (F), by means of the rotation forceps, and counterpressure being made with the bronchoscopic lip on the points of the staple, the points enter the branch bronchi and permit the staple to be turned over and removed with points trailing harmlessly behind (K).]

The Extraction of Tightly Fitting Foreign Bodies from the Bronchi. Annular Edema.—Such objects as marbles, pebbles, corks, etc., are drawn deeply and with force by the inspiratory blast into the smallest bronchus they can enter. The air distal to the impacted foreign body is soon absorbed, and the negative pressure thus produced increases the impaction. A ring of edematous mucosa quickly forms and covers the presenting part of the object, leaving visible only a small surface in the center of an acute edematous stenosis. A forceps with narrow, stiff, expansive-spring jaws may press back a portion of the edema and may allow a grasp on the sides of the foreign body; but usually the attempt to apply forceps when there are no spaces between the presenting part of the foreign body and the bronchial wall, will result only in pushing the foreign body deeper.* A better method is to use the lip of the bronchoscope to press back the swollen mucosa at one point, so that a hook may be introduced below the foreign body, which then can be worked up to a wider place where forceps may be applied (Fig. 89). Sometimes the object may even be held firmly against the tube mouth with the hook and thus extracted. For this the unslanted tube-mouth is used.

* The author's new ball forceps are very successful with ball-bearing balls and marbles.

[FIG. 89.—Schema illustrating the use of the lip of the bronchoscope in disimpaction of foreign

bodies. A and B show an annular edema above the foreign body, F. At C the edematous mucosa is being repressed by the lip of the tube mouth, permitting insinuation of the hook, H, past one side of the foreign body, which is then withdrawn to a convenient place for application of the forceps. This repression by the lip is often used for purposes other than the insertion of hooks. The lip of the esophagoscope can be used in the same way.]

Extraction of Soft Friable Foreign Bodies from the Tracheobronchial Tree.—The difficulties here consist in the liability of crushing or fragmenting the object, and scattering portions into minute bronchi, as well as the problem of disimpaction from a ring of annular edema, with little or no forceps space. There is usually in these cases an abundance of purulent secretion which further hinders the work. The great danger of pushing the foreign body downward so that the swollen mucosa hides it completely from view, must always be kept in mind. Extremely delicate forceps with rather broad blades are required for this work. The fenestrated "peanut" forceps are best for large pieces in the large bronchi. The operator should develop his tactile sense with forceps by repeated practice in order to acquire the skill to grasp peanut kernels sufficiently firmly to hold them during withdrawal, yet not so firmly as to crush them. Nipping off an edge by not inserting the forceps far enough is also to be avoided. Small fragments under 2 mm. in diameter may be expelled with the secretions and fragments may be found on the sponges and in the secretions aspirated or removed by sponge pumping. It is, however, never justifiable deliberately to break a friable foreign body with the hope that the fragments will be expelled, for these may be aspirated into small bronchi, and cause multiple abscesses. A hook may be found useful in dealing with round, friable, foreign bodies; and in some cases the mechanical spoon or safety-pin closer may be used to advantage. The foreign body is then brought close to, but not crushed against the tube mouth.

[174] *Removal of animal objects from the tracheobronchial tree* is readily accomplished with the side-curved forceps. Leeches are not uncommon intruders in European countries. Small insects are usually coughed out. Worms and larvae may be found. Cocaine or salt solution will cause a leech to loosen its hold.

Foreign bodies in the upper-lobe bronchi are fortunately not common. If the object is not too far out to the periphery it may be grasped by the upper-lobe-bronchus forceps (Fig. 90), guided by the collaboration of the fluoroscopist. These forceps are made so as to reach high into the ascending branches of the upper-lobe bronchus. Full-curved coil-spring hooks will reach high, but must be used with the utmost caution, and the method of their disengagement must be practiced beforehand.

Penetrating Projectiles.—Foreign bodies that have penetrated the chest wall and lodged in the lung may be removed by oral bronchoscopy if the intruder is not larger than the lumen of the corresponding main bronchus (see Bibliography, 43)

[FIG. 90.—Schematic illustration of the author's upper-lobe-bronchus forceps in position grasping a pin in an anteriorly ascending branch of the upper-lobe bronchus. T, Trachea; UL, upper-lobe bronchus; LB, left bronchus; SB, stem bronchus. These forceps are made to extend around 180 degrees.]

RULES FOR ENDOSCOPIC FOREIGN BODY EXTRACTION

1. Never endoscope a foreign body case unprepared, with the idea of taking a preliminary look. 2. Approach carefully the suspected location of a foreign body, so as not to override any portion of it. [175] 3. Avoid grasping a foreign body hastily as soon as seen. 4. The shape, size and position of a foreign body, and its relations to surrounding structures, should be studied before attempting to apply the forceps. (Exception cited in Rule 10.) 5. Preliminary study of a foreign body should be from a distance. 6. As the first grasp of the forceps is the best, it should be well planned beforehand so as to seize the proper part of the intruder. 7. With all long foreign bodies the motto should be "Search, not for the foreign body, but for its nearer end." With pins, needles, and the like, with point upward, *search always for the point*. Try to see it first. 8. Remember that a long foreign body grasped near the middle becomes, mechanically speaking, a "toggle and ring." 9. Remember that the mortality to follow failure to remove a foreign body does not justify probably fatal violence during its removal. 10. *Laryngeally lodged* foreign bodies, because of the likelihood of dislodgment and loss, may be seized by any part first presented, and plan of withdrawal can be determined afterward. 11. For similar reasons, laryngeal cases should be dealt with only in the author's position (Fig. 53). 12. An esophagoscopy may be needed in a bronchoscopic case, or a bronchoscopy in an esophageal case. In every case both kinds of tubes should be sterile and ready before starting. It is the unexpected that happens in foreign body endoscopy. 13. Do not pull on a foreign body unless it is properly grasped to come away readily without trauma. Then do not pull hard. 14. Do no harm, if you cannot remove the foreign body. 15. Full-curved hooks are to be used in the bronchi with greatest caution, if used at all, lest they catch inextricably in branch bronchi. [176] 16. Don't force a foreign body downward. Coax it back. The deeper it gets the greater your difficulties. 17. The watchword of the bronchoscopist should be, "If I can do no good, I will

at least do no harm."

Fluoroscopic bronchoscopy is so deceptively easy from a superficial, theoretical, point of view that it has been used unsuccessfully in cases easily handled in the regular endoscopic way with the eye at the proximal tube-mouth. In a collected series of cases by various operators the object was removed in 66.7 per cent with a mortality of 41.6 per cent. In the problem of a pin located out of the field of bronchoscopic vision, the fluoroscopist will yield invaluable aid. An extremely delicate forceps is to be inserted closed into the invaded bronchus, the grasp on the object being confirmed by the fluoroscopist. It is to be kept in mind that while the object itself may be in the grasp of the forceps, the fluoroscope will not show whether there may not be included in the forceps' grasp a bronchial spur or other tissue, the tearing of which may be fatal. Therefore traction must not be sufficient to lacerate tissue. If the foreign body does not come readily it must be released, and a new grasp may then be taken. All of the cautions in faulty seizure already mentioned, apply with particular force to fluoroscopic bronchoscopy. The fluoroscope is of aid in finding foreign bodies held in abscess cavities. The fluoroscope should show both the lateral and anteroposterior planes. To accomplish this quickly, two Coolidge tubes and two screens are necessary. Fluoroscopic bronchoscopy, because of its high mortality and low percentage of successes, should be tried only after regular, ocularly guided, peroral bronchoscopy has failed, and only by those who have had experience in ocularly guided bronchoscopy.

[177] CHAPTER XVI—FOREIGN BODIES IN THE BRONCHI FOR PROLONGED PERIODS

The sojourn of an inorganic foreign body in the bronchus for a year or more is followed by the development of bronchiectasis, pulmonary abscess, and fibrous changes. The symptoms of tuberculosis may all be presented, but tubercle bacilli have never been found associated with any of the many cases that have come to the Bronchoscopic Clinic.* The history of repeated attacks of malaise, fever, chills, and sweats lasting for a few days and terminated by the expulsion of an amount of foul pus, suggests the intermittent drainage of an abscess cavity, and special study should be made to eliminate foreign body as the cause of the condition, in all such cases, whether there is any history of a foreign body accident or not. Bronchoscopy for diagnosis is to be done unless the etiology can be definitely proven by other means. In all cases of chronic chest disease foreign body should be eliminated as a matter of routine.

* One exception has recently come to the Clinic. 12

The time of aspiration of a foreign body may be unknown, having possibly occurred in infancy, during narcosis, or the object may even enter the lower air passages without the patient being aware of the accident, as happened with a particularly intelligent business man who unknowingly aspirated the tip of an atomizer while spraying his throat. In many other cases the accident had been forgotten. In still others, in spite of the patient's statement of a conviction that the trouble was due to a foreign body he had aspirated, the physician did not consider it worthy of sufficient consideration to warrant a roentgenray examination. It is curious to note the various opinions held in regard to the gravity of the presence of a bronchial foreign body. One patient was told by his physician that the presence of a staple in his bronchus was an impossibility, for he would not have lived five minutes after the accident. Others consider the presence of a foreign body in the bronchus as comparatively harmless, in spite of the repeated reports of invalidism and fatality in the medical literature of centuries. The older authorities state that all cases of prolonged bronchial foreign body sojourn died from phthisis pulmonalis, and it is still the opinion of some practitioners that the presence of a foreign body in the lung predisposes to the development of true tuberculosis. With the dissemination of knowledge regarding the possibility of bronchial foreign body, and the marvellous success in their removal by bronchoscopy, the cases of prolonged foreign body sojourn should decrease in number. It should be the recognized rule, and not the exception, that all chest conditions, acute or chronic, should have the benefit of roentgenographic study, even apart from the possibility of foreign body.

Often even with the clear history of foreign-body aspiration, both patient and physician are deluded by a relatively long period of quiescence in which no symptoms are apparent. This symptomless interval is followed sooner or later by ever increasing cough and expectoration of sputum, finally by bronchiectasis and pulmonary abscess, chronic sepsis, and invalidism.

Pathology.—If the foreign body completely obstructs a main bronchus, preventing both aeration and drainage, such rapid destruction of lung tissue follows that extensive pathologic changes may result in a few months, or even in a few weeks, in the case of irritating foreign bodies such as peanut kernels and soft rubber. Very minute, inorganic foreign bodies may become encysted as in anthracosis. Large objects, however, do not become encysted. The object is drawn down by gravity and aspirated into the

smallest bronchus it can enter. Later the negative pressure below from absorption of air impacts it still further. Swelling of the bronchial mucosa from irritation plus infection completes the occlusion of the bronchus. Retention of secretions and bacterial decomposition thereof produces first a "drowned lung" (natural passages full of pus); then sloughing or ulceration in the tissues plus the pressure of the pus, causes bronchiectasis; further destruction of the cartilaginous rings results in true abscess formation below the foreign body. The productive inflammation at the site of lodgement of the foreign body results in cicatricial contraction and the formation of a stricture at the top of the cavity, in which the foreign body is usually held. The abscess may extend to the periphery and rupture into the pleural cavity. It may drain intermittently into a bronchus. Certain irritating foreign bodies, such as soft rubber, may produce gangrenous bronchitis and multiple abscesses. For observations on pathology (see Bibliography, 38).

Prognosis.—If the foreign body be not removed, the resulting chronic sepsis or pulmonary hemorrhage will prove fatal. Removal of the foreign body usually results in complete recovery without further local treatment. Occasionally, secondary dilatation of a bronchial stricture may be required. All cases will need, besides removal of the foreign body, an antituberculous regimen, and offer a good prognosis if this be followed.

Treatment.—Bronchoscopy should be done in all cases of chronic pulmonary abscess and bronchiectasis even though radiographic study reveals no shadow of foreign body. The patient by assuming a posture with the head lowered is urged to expel spontaneously all the pus possible, before the bronchoscopy. The aspirating bronchoscope (Fig. 2, E) is often useful in cases where large amounts of secretion may be anticipated. Granulations may require removal with forceps and sponging. Disturbed granulations result in bleeding which further hampers the operation; therefore, they should not be touched until ready to apply the forceps, unless it is impossible to study the presentation without disturbing them. For this reason secretions hiding a foreign body should be removed with the aspirating tube (Fig. 9) rather than by swabbing or sponge-pumping, when the bronchoscopic tube-mouth is close to the foreign body. It is inadvisable, however, to insert a forceps into a mass of granulations to grope blindly for a foreign body, with no knowledge of the presentation, the forceps spaces, or the location of branch-bronchial orifices into which one blade of the forceps may go. Dilatation of a stricture may be necessary, and may be accomplished by the forms of bronchial dilators shown in Fig. 25. The hollow type of dilator is to be used in cases in which the foreign body is held in the stricture (Fig. 83). This dilator may be pushed down over the stem of such an object as a tack, and the stricture dilated without the risk of pushing the object downward. It is only rarely, however, that the point of a tack is free. Dense cicatricial tissue may require incision or excision. *Internal bronchotomy* is doubtless, a very dangerous procedure, though no fatalities have occurred in any of the three cases in the Bronchoscopic Clinic. It is advisable only as a last resort.

[181] CHAPTER XVII—UNSUCCESSFUL BRONCHOSCOPY FOR FOREIGN BODIES

The limitations of bronchoscopic removal of foreign bodies are usually manifested in the failure to find a small foreign body which has entered a minute bronchus far down and out toward the periphery. When localization by means of transparent films, fluoroscopy, and endobronchial bismuth insufflation has failed, the question arises as to the advisability of endoscopic excision of the tissue intervening between the foreign body and bronchoscope with the aid of two fluoroscopes, one for the lateral and the other the vertical plane. With foreign bodies in the larger bronchi near the root of the lung such a procedure is unnecessary, and injury to a large vessel would be almost certain. At the extreme periphery of the lung the danger is less, for the vessels are smaller and serious hemorrhage less probable, through the retention and decomposition of blood in small bronchi with later abscess formation is a contingency. The nature of the bridge of tissue is to be considered; should it be cicatricial, the result of prolonged inflammatory processes, it may be carefully excised without very great risk of serious complications. The blood vessels are diminished in size and number by the chronic productive inflammation, which more than offsets their lessened contractility.

The possibility of the foreign body being coughed out after suppurative processes have loosened its impaction is too remote; and the lesions established may result fatally even after the expulsion of the object. Pulmonary abscess formation and rupture into the pleura should not be awaited, for the foreign body does not often follow the pus into the pleural cavity. It remains in the lung, held in a bed of granulation tissue. Furthermore, to await the development is to subject the patient to a prolonged and perhaps fatal sepsis, or a fatal pulmonary hemorrhage from the erosion of a vessel by the suppurative process. The recent developments in thoracic surgery have greatly decreased the operative mortality of thoracotomy, so that this operation is to be considered when bronchoscopy has failed. Bronchoscopy can be considered as having failed, for the time being, when two or more expert bronchoscopists on repeated search have been unable to find the foreign body or to disentangle it; but the art of

bronchoscopy is developing so rapidly that the failures of a few years ago would be easy successes today. Before considering thoracotomy months of study of the mechanical problem are advisable. It is probable that any foreign body of appreciable size that has gone down the natural passages can be brought back the same way.

In the event of a foreign body reaching the pleura, either with or without pus, it should be removed immediately by pleuroscopy or by thoracotomy, without waiting for adhesive pleuritis.

The problem may be summarized thus: 1. Large foreign bodies in the trachea or large bronchi can always be removed by bronchoscopy. 2. The development of bronchoscopy having subsequently solved the problems presented by previous failures, it seems probable that by patient developmental endeavor, any foreign body of appreciable size that has gone down through the natural passages, can be bronchoscopically removed the same way, provided fatal trauma is avoided.

At the author's Bronchoscopic Clinics 98.7 per cent of foreign bodies have been removed.

CHAPTER XVIII—FOREIGN BODIES IN THE ESOPHAGUS

Etiology.—The lodgement of foreign bodies in the esophagus is influenced by:

1. The shape of the foreign body (disc-shaped, pointed, irregular).
2. Resiliency of the object (safety pins).
3. The size of the foreign body.
4. Narrowing of the esophagus, spasmodic or organic, normal, or pathologic.
5. Paralysis of the normal esophageal propulsory mechanism.

The lodgement of a bolus of ordinary food in the esophagus is strongly suggestive of a preexisting narrowing of the lumen of either a spasmodic or organic nature; a large bolus of food, poorly masticated and hurriedly swallowed, may, however, become impacted in a perfectly normal esophagus.

Carelessness is the cause of over 80 per cent of the foreign bodies in the esophagus (see Bibliography, 29).

Site of Lodgement.—Almost all foreign bodies are arrested in the cervical esophagus at the level of the superior aperture of the thorax. A physiologic narrowing is present at this level, produced in part by muscular contraction, and mainly by the crowding of the adjacent viscera into the fixed and narrow upper thoracic aperture. If dislodged from this position the foreign body usually passes downward to be arrested at the next narrowing or to pass into the stomach. The esophagoscopist who encounters the difficulty of introduction at the cricopharyngeal fold expects to find the foreign body above the fold. Such, however, is almost never the case. The cricopharyngeus muscle functionates in starting the foreign body downward as if it were food; but the narrowing at the upper thoracic aperture arrests it because the esophageal peristaltic musculature is feeble as compared to the powerful inferior constrictor.

Symptoms.—*Dysphagia* is the most frequent complaint in cases of esophageally lodged foreign bodies. A very small object may excite sufficient spasm to cause aphagia, while a relatively large foreign body may be tolerated, after a time, so that the swallowing function may seem normal. Intermittent dysphagia suggests the tilting or shifting of a foreign body in a valve-like fashion; but may be due to occlusion of the by-passages by food arrested by the foreign body. *Dyspnea* may be present if the foreign body is large enough to compress the trachea. *Cough* may be excited by reflex irritation, overflow of secretions into the larynx, or by perforation of the posterior tracheal wall, traumatic or ulcerative, allowing leakage of food or secretion into the trachea. (See Chapter XII for discussion of symptomatology and diagnosis.)

Prognosis.—A foreign body lodged in the esophagus may prove quickly fatal from *hemorrhage* due to perforation of a large vessel; from *asphyxia* by pressure on the trachea; or from *perforation* and *septic mediastinitis*. Slower fatalities may result from suppuration extending to the trachea or bronchi with consequent edema and asphyxia. Sooner or later, if not removed, the foreign body causes death. It may be tolerated for a long period of time, causing abscess, cervical cellulitis, fistulous tracts, and ultimately extreme stenosis from cicatricial contraction. Perichondritis of the laryngeal or tracheal cartilages may follow, and result in laryngeal stenosis requiring tracheotomy. The damage produced by the foreign body is often much less than that caused by blind and ill-advised attempts at removal. If the foreign body becomes dislodged and moves downward, the danger of intestinal perforation is encountered. The *prognosis*, therefore, must be guarded so long as the intruder remains in the body.

Treatment.—It is a mistake to try to force a foreign body into the stomach with the stomach tube or bougie. Sounding the esophagus with bougies to determine the level of the obstruction, or to palpate the nature of the foreign body, is unnecessary and dangerous. Esophagoscopy should not be done without a previous roentgenographic and fluoroscopic examination of the chest and esophagus, except for urgent reasons. The level of the stenosis, and usually the nature of the foreign body, can thus be decided. Blind instrumentation is dangerous, and in view of the safety and success of esophagoscopy, reprehensible.

If for any reason removal should be delayed, bismuth sub-nitrate, gramme 0.6, should be given dry on the tongue every four hours. It will adhere to the denuded surfaces. The addition of calomel, gramme 0.003, for a few doses will increase the antiseptic action. Should swallowing be painful, gramme 0.2 of orthoform or anesthesin will be helpful. Emetics are inefficient and dangerous. Holding the patient up by the heels is rarely, if ever, successful if the foreign body is in the esophagus. In the reported cases the intruder was probably in the pharynx.

External esophagotomy for the removal of foreign bodies is unjustifiable until esophagoscopy has failed in the hands of at least two skillful esophagoscopists. It has been the observation in the Bronchoscopic Clinic that every foreign body that has gone down through the mouth into the esophagus can be brought back the same way, unless it has already perforated the esophageal wall, in which event it is no longer a case of foreign body in the esophagus. The mortality of external esophagotomy for foreign bodies is from twenty to forty-two per cent, while that of esophagoscopy is less than two per cent, if the foreign body has not already set up a serious complication before the esophagoscopy. Furthermore, external esophagotomy can be successful only with objects lodged in the cervical esophagus and, moreover, it has happened that after the esophagus has been opened, the foreign body could not be found because of dislodgement and passage downward during the relaxation of the general anesthesia. Should this occur during esophagoscopy, the foreign body can be followed with the esophagoscope, and even if it is not overtaken and removed, no risk has been incurred.

Esophagoscopy is the one method of removal worthy of serious consideration. Should it repeatedly fail in the hands of two skillful endoscopists, which will be very rarely, if ever, then external operation is to be considered in cervically lodged foreign bodies.

[187] CHAPTER XIX—ESOPHAGOSCOPY FOR FOREIGN BODY

Indications.—Esophagoscopy is demanded in every case in which a foreign body is known to be, or suspected of being, in the esophagus.

Contraindications.—There is no absolute contraindication to careful esophagoscopy for the removal of foreign bodies, even in the presence of aneurism, serious cardiovascular disease, hypertension or the like, although these conditions would render the procedure inadvisable. Should the patient be in bad condition from previous ill-advised or blind attempts at extraction, endoscopy should be delayed until the traumatic esophagitis has subsided and the general state improved. It is rarely the foreign body itself which is producing these symptoms, and the removal of the object will not cause their immediate subsidence; while the passage of the tube through the lacerated, infected, and inflamed esophagus might further harm the patient. Moreover, the foreign body will be difficult to find and to remove from the edematous and bleeding folds, and the risk of following a false passage into the mediastinum or overriding the foreign body is great. Water starvation should be relieved by means of proctoclysis and hypodermoclysis before endoscopy is done. The esophagitis is best treated by placing dry on the tongue at four-hour intervals the following powder: Rx. Anesthesin…gramme 0.12 Bismuth subnitrate… gramme 0.6 Calomel, gramme 0.006 to 0.003 may be added to each powder for a few doses to increase the antiseptic effect. If the patient can swallow liquids it is best to wait one week from the time of the last attempt at removal before any endoscopy for extraction be done. This will give time for nature to repair the damage and render the removal of the object more certain and less hazardous. Perforation of the esophagus by the foreign body, or by blind instrumentation, is a contraindication to esophagoscopy. It is manifested by such signs as subcutaneous emphysema, swelling of the neck, fever, irritability, increase in pulsatory and respiratory rates, and pain in the neck or chest. Gaseous emphysema is present in some cases, and denotes a dangerous infection. Esophagoscopy should be postponed and the treatment mentioned at the end of this chapter instituted. After the subsidence of all symptoms other than esophageal, esophagoscopy may be done safely. Pleural perforation is manifested by the usual signs of pneumothorax, and will be demonstrated in the roentgenogram.

ESOPHAGOSCOPIC EXTRACTION OF FOREIGN BODIES

It is unwise to do an endoscopy in a foreign-body case for the sole purpose of taking a preliminary

look. Everything likely to be needed for extraction of the intruder should be sterile and ready at hand. Furthermore, all required instruments for laryngoscopy, bronchoscopy or tracheotomy should be prepared as a matter of routine, however rarely they may be needed.

Sponging should be done cautiously lest the foreign body be hidden in secretions or food accumulation, and dislodged. Small food masses often lodge above the foreign body and are best removed with forceps. The folds of the esophagus are to be carefully searched with the aid of the lip of the esophagoscope. If the mucosa of the esophagus is lacerated with the forceps all further work is greatly hampered by the oozing; if the laceration involve the esophageal wall the accident may be fatal: and at best the tendency of the tube-mouth to enter the laceration and create a false passage is very great.

"Overriding" or failure to find a foreign body known to be present is explained by the collapsed walls and folds covering the object, since the esophagoscope cannot be of sufficient size to smooth out these folds, and still be of small enough diameter to pass the constricted points of the esophagus noted in the chapter on anatomy. Objects are often hidden just distal to the cricopharyngeal fold, which furthermore makes a veritable chute in throwing the end of the tube forward to override the foreign body and to interpose a layer of tissue between the tube and the object, so that the contact at the side of the tube is not felt as the tube passes over the foreign body (Fig. 91). The chief factors in overriding an esophageal foreign body are: 1. The chute-like effect of the plica cricopharyngeus. 2. The chute-like effect of other folds. 3. The lurking of the foreign body in the unexplored pyriform sinus. 4. The use of an esophagoscope of small diameter. 5. The obscuration of the intruder by secretion or food debris. 6. The obscuration of the intruder by its penetration of the esophageal wall. 7. The obscuration of the intruder by inflammatory sequelae.

[FIG. 91.—Illustrating the hiding of a coin by the folding downward of the plica cricopharyngeus. The muscular contraction throws the beak of the esophagoscope upward while the interposed tissue prevents the tactile appreciation of contact of the foreign body with the side of the tube after the tip has passed over the foreign body. Other folds may in rare instances act similarly in hiding a foreign body from view. This overriding of a foreign body is apt to cause dangerous dyspnea by compression of the party wall.]

The esophageal speculum for the removal of foreign bodies is useful when the object is not more than 2 cm. below the cricoid in a child, and 3 cm. in the adult. The fold of the cricopharyngeus can be repressed posteriorward by the forceps which are then in position to grasp the object when it is found. The author's down-jaw forceps (Fig. 22) are very useful to reach down back of the cricopharyngeal fold, because of the often small posterior forceps space. The speculum has the disadvantage of not allowing deeper search should the foreign body move downward. In infants, the child's size laryngoscope may be used as an esophageal speculum. General anesthesia is not only unnecessary but dangerous, because of the dyspnea created by the endoscopic tube. Local anesthesia is unnecessary as well as dangerous in children; and its application is likely to dislodge the foreign body unless used as a troche. Forbes esophageal speculum is excellent.

MECHANICAL PROBLEMS OF ESOPHAGOSCOPIC REMOVAL OF FOREIGN BODIES

The bronchoscopic problems considered in the previous chapter should be studied.

The extraction of transfixed foreign bodies presents much the same problem as those in the bronchi, though there is no limit here to the distance an object may be pushed down to free the point. Thin, sharp foreign bodies such as bones, dentures, pins, safety-pins, etcetera, are often found to lie crosswise in the esophagus, and it is imperative that one end be disengaged and the long axis of the object be made to correspond to that of the esophagus before traction for removal is made (Fig. 92). Should the intruder be grasped in the center and traction exerted, serious and perhaps fatal trauma might ensue.

[191] [FIG. 92.—The problem of the horizontally transfixed foreign body in the esophagus. The point, D, had caught as the bone, A, was being swallowed. The end, E, was forced down to C, by food or by blind attempts at pushing the bone downward. The wall, F, should be laterally displaced to J, with the esophagoscope, permitting the forceps to grasp the end, M, of the bone. Traction in the direction of the dart will disimpact the bone and permit it to rotate. The rotation forceps are used as at K.]

[FIG. 93.—Solution of the mechanical problem of the broad foreign body having a sharp point by version. If withdrawn with plain forceps as applied at A, the point B, will rip open the esophageal wall. If grasped at C, the point, D, will rotate in the direction of F and will trail harmlessly. To permit this version the rotation forceps are used as at H. On this principle flat foreign bodies with jagged or rough parts are so turned that the potentially traumatizing parts trail during withdrawal.]

The extraction of broad, flat foreign bodies having a sharp point or a rough place on part of their periphery is best accomplished by the method of rotation as shown in Fig. 93.

Extraction of Open Safety-pins from the Esophagus.—An open safety pin with the point down offers no particular mechanical difficulty in removal. Great care must be exercised, however, that it be not overridden or pushed upon, as either accident might result in perforation of the esophagus by the pin point. The coiled spring is to be sought, and when found, seized with the rotation forceps and the pin thus drawn into the esophagoscope to effect closure. An open safety-pin lodged point upward in the esophagus is one of the most difficult and dangerous problems. A roentgenogram should always be made in the plane showing the widest spread of the pin. It is to be remembered that the endoscopist can see but one portion of the pin at a time (except in cases of very small safety-pins) and that if he grasps the part first showing, which is almost invariably the keeper, fatal trauma will surely be inflicted when traction is made. It may be best to close the safety pin with the safety-pin closer, as illustrated in Fig. 37. For this purpose Arrowsmith's closer is excellent. In other cases it may prove best to disengage the point of the pin and to bring the pointed shaft into the esophagoscope with the Tucker forceps and withdraw the pin, forceps, and esophagoscope, with the keeper and its shaft sliding alongside the tube. The rounded end of the keeper lying outside the tube allows it to slip along the esophageal walls during withdrawal without inflicting trauma; however, should resistance be felt, withdrawal must immediately cease and the pin must be rotated into a different plane to release the keeper from the fold in which it has probably caught. The sense of touch will aid the sense of sight in the execution of this maneuver (Fig. 87). When the pin reaches the cricopharyngeal level the esophagoscope, forceps, and pin should be turned so that the keeper will be to the right, not so much because of the cricopharyngeal muscle as to escape the posteriorly protuberant cricoid cartilage. In certain cases in which it is found that the pointed shaft of a small safety pin has penetrated the esophageal wall, the pin has been successfully removed by working the keeper into the tube mouth, grasping the keeper with the rotation forceps or side-curved forceps, and pulling the whole pin into the tube by straightening it. This, however, is a dangerous method and applicable in but few cases. It is better to disengage the point by downward and inward rotation with the Tucker forceps.

Version of a Safety Pin.—A safety pin of very small size may be turned over in a direction that will cause the point to trail. An advancing point will puncture. This is a dangerous procedure with a large safety pin.

Endogastric Version.—A very useful and comparatively safe method is illustrated in Figs. 94 and 95. In the execution of this maneuver the pin is seized by the spring with a rotation forceps, and thus passed along with the esophagoscope into the stomach where it is rotated so that the spring is uppermost. It can then be drawn into the tube mouth so as to protect the tissues during withdrawal of the pin, forceps, and esophagoscope as one piece. Only very small safety-pins can be withdrawn through the esophagoscope.

Spatula-protected Method.—Safety-pins in children, point upward, when lodged high in the cervical esophagus may be readily removed with the aid of the laryngoscope, or esophageal speculum. The keeper end is grasped with the alligator forceps, while the spatular tip of the laryngoscope is worked under the point. Instruments and foreign body are then removed together. Often the pin point will catch in the light-chamber where it is very safely lodged. If the pin be then pulled upon it will straighten out and may be withdrawn through the tube.

[FIG. 94.—Endogastric version. One of the author's methods of removal of upward pointed esophageally lodged open safety-pins by passing them into stomach, where they are turned and removed. The first illustration (A) shows the rotation forceps before seizing pin by the ring of the spring end. (Forceps jaws are shown opening in the wrong diameter.) At B is shown the pin seized in the ring by the points of the forceps. At C is shown the pin carried into the stomach and about to be rotated by withdrawal. D, the withdrawal of the pin into the esophagoscope which will thereby close it. If withdrawn by flat-jawed forceps as at F, the esophageal wall would be fatally lacerated.]

Double pointed tacks and staples, when lodged point upward, must be turned so that the points trail on removal. This may be done by carrying them into the stomach and turning them, as described under safety-pins.

The extraction of foreign bodies of very large size from the esophagus is greatly facilitated by the use of general anesthesia, which relaxes the spasmodic contractions of the esophagus often occurring when attempt is made to withdraw the foreign body. General anesthesia, though entirely unnecessary for introduction of the esophagoscope, in any case may be used if the body is large, sharp, and rough, in order to prevent laceration through the muscular contractions otherwise incident to withdrawal.* In exceptional cases it may be necessary to comminute a large foreign body such as a tooth plate. A large smooth foreign body may be difficult to seize with forceps. In this case the mechanical spoon or the

author's safety-pin closer may be used.

* It must always be remembered that large foreign bodies are very prone to cause dyspnea that renders general anesthesia exceedingly dangerous especially in children.

[FIG. 95.—Lateral roentgenogram of a safety-pin in a child aged 11 months, demonstrating the esophageal location of the pin in this case and the great value of the lateral roentgenogram in the localization of foreign bodies. The pin was removed by the author's method of endogastric version. (Plate made by George C. Johnston)]

The extraction of meat and other foods from the esophagus at the level of the upper thoracic aperture is usually readily accomplished with the esophageal speculum and forceps. In certain cases the mechanical spoon will be found useful. Should the bolus of food be lodged at the lower level the esophagoscope will be required.

Extraction of Foreign Bodies from the Strictured Esophagus.—Foreign bodies of relatively small size will lodge in a strictured esophagus. Removal may be rendered difficult when the patient has an upper stricture relatively larger than the lower one, and the foreign body passing the first one lodges at the second. Still more difficult is the case when the second stricture is considerably below the first, and not concentric. Under these circumstances it is best to divulse the upper stricture mechanically, when a small tube can be inserted past the first stricture to the site of lodgement of the foreign body.

Prolonged sojourn of foreign bodies in the esophagus, while not so common as in the bronchi is by no means of rare occurrence. Following their removal, stricture of greater or less extent is almost certain to follow from contraction of the fibrous-tissue produced by the foreign body.

Fluoroscopic esophagoscopy is a questionable procedure, for the esophagus can be explored throughout by sight. In cases in which it is suspected that a foreign body, such as pin, has partially escaped from the esophagus, the fluoroscope may aid in a detailed search to determine its location, but under no circumstances should it be the guide for the application of forceps, because the transparent but vital tissues are almost certain to be included in the grasp.

[197] Complications and Dangers of Esophagoscopy for Foreign Bodies. Asphyxia from the pressure of the foreign body, or the foreign body plus the esophagoscope, is a possibility (Fig. 91). Faulty position of the patient, especially a low position of the head, with faulty direction of the esophagoscope may cause the tube mouth to press the membranous tracheo-esophageal wall into the trachea, so as temporarily to occlude the tracheal lumen, creating a very dangerous situation in a patient under general anesthesia. Prompt introduction of a bronchoscope, with oxygen and amyl nitrite insufflation and artificial respiration, may be necessary to save life. The danger is greater, of course, with chloroform than with ether anesthesia. Cocain poisoning may occur in those having an idiosyncrasy to the drug. Cocain should never be used with children, and is of little use in esophagoscopy in adults. Its application is more annoying and requires more time than the esophagoscopic removal of the foreign bodies without local anesthesia. Traumatic esophagitis, septic mediastinitis, cervical cellulitis, and, most dangerous, gangrenous esophagitis may be present, caused by the foreign body itself or ill-advised efforts at removal. Perforation of the esophagus with the esophagoscope is rare, in skillful hands, if the esophageal wall is sound. The esophageal wall, however, may be weakened by ulceration, malignant disease, or trauma, so that the possibility of making a false passage should always deter the endoscopist from advancing the tube beyond a visible point of weakening. To avoid entering a false passage previously created, is often exceedingly difficult, and usually it is better to wait for obliterative adhesive inflammation to seal the tissue layers together.

Treatment.—Acute esophagitis calls for rest in bed, sterile liquid food, and the administration of bismuth powder mentioned in the paragraph on contraindications. An ice bag applied to the neck may afford some relief. The mouth should be hourly cleansed with the following solution: Dakin's solution 1 part Cinnamon water 5 parts. Emphysema unaccompanied by pyogenic processes usually requires no treatment, though an occasional case may require punctures of the skin to liberate the air. Gaseous emphysema and pus formation urgently demand early external drainage, preferably behind the sternomastoid. Should the pleura be perforated by sudden puncture pyo-pneumothorax is inevitable. Prompt thoracotomy for drainage may save the patient's life if the mediastinum has not also been infected. Foreign bodies ulcerating through may reach the lung without pleural leakage because of the sealing together of the visceral and parietal pleurae. In the serious degrees of esophageal trauma, particularly if the pleura be perforated, gastrostomy is indicated to afford rest of the esophagus, and for alimentation. A duodenal feeding tube may be placed through an esophagoscope passed into the stomach in the usual way through the mouth, avoiding by ocular guidance the perforation into which a blindly passed stomach tube would be very likely to enter, with probably dangerous results.

[199] CHAPTER XX—PLEUROSCOPY

Foreign bodies in the pleural cavity should be immediately removed. The esophageal speculum inserted through a small intercostal incision makes an excellent pleuroscope, its spatular tip being of particular value in moving the lung out of the way. This otherwise dark cavity is thus brilliantly illuminated without the necessity of making a large flap resection, an important factor in those cases in which there is no infection present. The pleura and wound may be immediately closed without drainage, if the pleura is not infected. Excessive plus pressure or pus may require reopening. In one case in which the author removed a foreign body by pleuroscopy, healing was by first intention and the lung filled in a few days. Drainage tubes that have slipped up into the empyemic cavity are foreign bodies. They are readily removed with the retrograde esophagoscope even through the smallest fistula. The aspirating canal keeps a clear field while searching for the drain.

Pleuroscopy for Disease.—Most pleural diseases require a large external opening for drainage, and even here the pleuroscope may be of some use in exploring the cavities. Usually there are many adhesions and careful ray study may reveal one or more the breaking up of which will improve drainage to such an extent as to cure an empyema of long standing. Repeated severing of adhesions, aspiration and sometimes incision of the thickened visceral pleura may be necessary. The author is so strongly imbued with the idea that local examination under full illumination has so revolutionized the surgery of every region of the body to which it has been applied, that every accessible region should be thus studied. The pleural cavity is quite accessible with or without rib-resection, and there is practically no risk in careful pleuroscopy.

[201] CHAPTER XXI—BENIGN GROWTHS IN THE LARYNX

Benign growths in the larynx are easily and accurately removable by direct laryngoscopy; but perhaps no method has been more often misused and followed by most unfortunate results. It should always be remembered that benign growths are benign, and that hence they do not justify the radical work demanded in dealing with malignancy. The larynx should be worked upon with the same delicacy and respect for the normal tissues that are customary in dealing with the eye.

Granulomata in the larynx, while not true neoplasms, require extirpation in some instances.

Vocal nodules, when other methods of cure such as vocal rest, various vocal exercises, etcetera have failed may require surgical excision. This may be done with the laryngeal tissue forceps or with the author's vocal nodule forceps. Sessile vocal nodules may be cured by touching them with a fine galvanocautery point, but all work on the vocal cords must be done with extreme caution and nicety. It is exceedingly easy to ruin a fine voice.

Fibromata, often of inflammatory genesis, are best removed with the laryngeal grasping forceps, though the small laryngeal punch or tissue forceps may be used. If very large, they may be amputated with the snare, the base being treated with galvanocautery though this is seldom advisable. Strong traction should be avoided as likely to do irreparable injury to the laryngeal motility.

Cystomata may get well after simple excision or galvanopuncture of a part of the wall of the sac, but complete extirpation of the sac is often required for cure. The same is true of *adenomata.*

[202] Angiomata, if extensive and deeply seated, may require deep excision, but usually cure results from superficial removal. Usually no cauterization of the vessels at the base is necessary, either to arrest hemorrhage or to lessen the tendency to recurrence. A diffuse telangiectasis, should it require treatment, may be gently touched with a needle-pointed galvanocaustic electrode at a number of sittings. The galvanonocautery is a dangerous method to use in the larynx. Radium offers the best results in this latter form of angioma, applied either internally or to the neck.

Lymphoma, enchondroma and osteoma, if not too extensively involving the laryngeal walls, may be excised with basket punch forceps, but lymphoma is probably better treated by radium.* *True myxomata and lipomata* are very rare. *Amyloid tumors* are occasionally met with, and are very resistant to treatment. *Aberrant thyroid tumors* do not require very radical excision of normal base, but should be removed as completely as possible.

In a general way, it may be stated that with benign growths in the larynx the best functional results are obtained by superficial rather than radical, deep extirpation, remembering that it is easier to remove tissue than to replace it, and that cicatrices impair or ruin the voice and may cause stenosis.

* In a case reported by Delavan a complete cure with perfect restoration of voice resulted from

radium after I had failed to cure by operative methods. (Proceedings American Laryngological Association, 1921.)

[203] CHAPTER XXII—BENIGN GROWTHS IN THE LARYNX (Continued)

PAPILLOMATA OF THE LARYNX IN CHILDREN

Of all benign growths in the larynx papilloma is the most frequent. It may occur at any age of childhood and may even be congenital. The outstanding fact which necessarily influences our treatment is the tendency to recurrences, followed eventually in practically all cases by a tendency to disappearance. In the author's opinion multiple papillomata constitute a benign, self-limited disease. There are two classes of cases. 1. Those in which the growth gets well spontaneously, or with slight treatment, surgically or otherwise; and, 2, those not readily amenable to any form of treatment, recurrences appearing persistently at the old sites, and in entirely new locations. In the author's opinion these two classes of case represent not two different kinds of growths, but stages in the disease. Those that get well after a single removal are near the end of the disease. Papillomata are of inflammatory origin and are not true neoplasms in the strictest sense.

Methods of Treatment.—Irritating applications probably provoke recurrences, because the growths are of inflammatory origin. Formerly laryngostomy was recommended as a last resort when all other means had failed. The excellent results from the method described in the foregoing paragraph has relegated laryngostomy to those cases that come in with a severe cicatricial stenosis from an injudicious laryngofissure; and even in these cases cure of the stenosis as well as the papillomata can usually be obtained by endoscopic methods alone, using superficial scalping off of the papillomata with subsequent laryngoscopic bouginage for the stenosis. Thyrotomy for papillomata is mentioned only to be condemned. Fulguration has been satisfactory in the hands of some, disappointing to others. It is easily and accurately applied through the direct laryngoscope, but damage to normal tissues must be avoided. Radium, mesothorium, and the roentgenray are reported to have had in certain isolated cases a seemingly beneficial action. In my experience, however, I have never seen a cure of papillomata which could be attributed to the radiation. I have seen cases in which no effect on the growths or recurrence was apparent, and in some cases the growths seemed to have been stimulated to more rapid repullulations. In other most unfortunate cases I have seen perichondritis of the laryngeal cartilages with subsequent stenosis occurring after the roentgenotherapy. Possibly the disastrous results were due to overdosage; but I feel it a duty to state the unfavorable experience, and to call attention to the difference between cancer and papillomata. Multiple papillomata involve no danger to life other than that of easily obviated asphyxia, and it is moreover a benign self-limited disease that repullulates on the surface. In cancer we have an infiltrating process that has no limits short of life itself.

Endolaryngeal extirpation of papillomata in children requires no anesthetic, general or local; the growths are devoid of sensibility. If, for any reason, a general anesthetic is used it should be only in tracheotomized cases, because the growths obstruct the airway. Obstructed respiration introduces into general anesthesia an enormous element of danger. Concerning the treatment of multiple papillomata it has been my experience in hundreds of cases that have come to the Bronchoscopic Clinic, that repeated superficial removals with blunt non-cutting forceps (see Chapter I) will so modify the soil as to make it unfavorable for repullulation. The removals are superficial and do not include the subjacent normal tissue. Radical removal of a papilloma situated, for instance, on the left ventricular band or cord, can in no way prevent the subsequent occurrence of a similar growth at a different site, as upon the epiglottis, or even in the fauces. Furthermore, radical removal of the basal tissues is certain to impair the phonatory function. Excellent results as to voice and freedom from recurrence have always followed repeated superficial removal. The time required has been months or a year or two. Only rarely has a cure followed a single extirpation.

If the child is but slightly dyspneic, the obstructing part of the growth is first removed without anesthesia, general or local; the remaining fungations are extirpated subsequently at a number of brief seances. The child is thus not terrified, soon loses dread of the removals, and appreciates the relief. Should the child be very dyspneic when first seen, a low tracheotomy is immediately done, and after an interim of ten days, laryngoscopic removal of the growth is begun. Tracheotomy probably has a beneficial effect on the disease. Tracheal growths require the insertion of the bronchoscope for their removal.

Papillomata in the larynx of adults are, on the whole, much more amenable to treatment than similar growths in children. Tracheotomy is very rarely required, and the tendency to recurrence is less marked. Many are cured by a single extirpation. The best results are obtained by removal of the

growths with the laryngeal grasping-forceps, taking the utmost care to avoid including in the bite of the forceps any of the subjacent normal tissue. Radical resection or cauterization of the base is unwise because of the probable impairment of the voice, or cicatricial stenosis, without in anyway insuring against repullulation. The papillomata are so soft that they give no sensation of traction to the forceps. They can readily be "scalped" off without any impairment of the sound tissues, by the use of the author's papilloma forceps (Fig. 29). Cutting forceps of all kinds are objectionable because they may wound the normal tissues before the sense of touch can give warning. A gentle hand might be trusted with the cup forceps (Fig. 32, large size.)

Sir Felix Semon proved conclusively by his collective investigations that cancer cannot be caused by the repeated removals of benign growths. Therefore, no fear of causing cancer need give rise to hesitation in repeatedly removing the repullulations of papillomata or other benign growths. Indeed there is much clinical evidence elsewhere in the body, and more than a little such evidence as to the larynx, to warrant the removal of benign growths, repeated if necessary, as a prophylactic of cancer (Bibliography, 19).

[207] CHAPTER XXIII—BENIGN GROWTHS PRIMARY IN THE TRACHEOBRONCHIAL TREE

Extension of papillomata from the larynx into the cervical trachea, especially about the tracheotomy wound, is of relatively common occurrence. True primary growths of the tracheobronchial tree, though not frequent, are by no means rare. These primary growths include primary papillomata and fibromata as the most frequent, aberrant thyroid, lipomata, adenomata, granulomata and amyloid tumors. Chondromata and osteochondromata may be benign but are prone to develop malignancy, and by sarcomatous or other changes, even metaplasia. Edematous polypi and other more or less tumor-like inflammatory sequelae are occasionally encountered.

Symptoms of Benign Tumors of the Tracheobronchial Tree.—Cough, wheezing respiration, and dyspnea, varying in degree with the size of the tumor, indicate obstruction of the airway. Associated with defective aeration will be the signs of deficient drainage of secretions. Roentgenray examination may show the shadow of enchondromata or osteomata, and will also show variations in aeration should the tumor be in a bronchus.

Bronchoscopic removal of benign growths is readily accomplished with the endoscopic punch forceps shown in Figs. 28 and 33. Quick action may be necessary should a large tumor producing great dyspnea be encountered, for the dyspnea is apt to be increased by the congestion, cough, and increased respiration and spasm incidental to the presence of the bronchoscope in the trachea. General anesthesia, as in all cases showing dyspnea, is contraindicated. The risks of hemorrhage following removal are very slight, provided fungations on an aneurismal erosion be not mistaken for a tumor.

Multiple papillomata when very numerous are best removed by the author's "coring" method. This consists in the insertion of an aspirating bronchoscope with the mechanical aspirator working at full negative pressure. The papillomata are removed like coring an apple; though the rounded edge of the bronchoscope does not even scratch the tracheal mucosa. Many of the papillomata are taken off by the holes in the bronchoscope. Aspiration of the detached papillomata into the lungs is prevented by the corking of the tube-mouth with the mass of papillomata held by the negative pressure at the canal inlet orifice.

CHAPTER XXIV—BENIGN NEOPLASMS OF THE ESOPHAGUS

As a result of prolonged inflammation edematous polypi and granulomata are not infrequently seen, but true benign tumors of the esophagus are rare affections. Keloidal changes in scar tissue may occur. Cases of retention, epithelial and dermoid cysts have been observed; and there are isolated reports of the finding of papillomata, fibromata, lipomata, myomata and adenomata. The removal of these is readily accomplished with the tissue forceps (Fig. 28), if the growths are small and projecting into the esophageal lumen. The determination of the advisability of the removal of keloidal scars would require careful consideration of the particular case, and the same may be said of very large growths of any kind. The extreme thinness of the esophageal walls must be always in the mind of the esophagoscopist if he would avoid disaster.

[210] CHAPTER XXV—ENDOSCOPY IN MALIGNANT DISEASE OF THE LARYNX

The general surgical rule applying to individuals past middle life, that benign growths exposed to irritation should be removed, probably applies to the larynx as well as to any other epithelialized structure. The facility, accuracy and thoroughness afforded by skilled, direct, laryngeal operation offers a means of lessening the incidence of cancer. To a much greater extent the facility, accuracy, and thoroughness contribute to the cure of cancer by establishing the necessary early diagnosis. Well-planned, careful, external operation (laryngofissure) followed by painstaking after-care is the only absolute cure so far known for malignant neoplasms of the larynx; and it is a cure only in those intrinsic cases in which the growth is small, and is located in the anterior two-thirds of the intrinsic area. By limiting operations strictly to this class of case, eighty-five per cent of cures may be obtained.* In determining the nature of the growth and its operability the limits of the usefulness of direct endoscopy are reached. It is very unwise to attempt the extirpation of intrinsic laryngeal malignancy by the endoscopic method, for the reason that the full extent of the growth cannot be appreciated when viewed only from above, and the necessary radical removal cannot be accurately or completely accomplished.

* The author's results in laryngofissure have recently fallen to 79 per cent of relative cures by thyrochondrotomy.

Malignant disease of the epiglottis, in those rare cases where the lesion is strictly limited to the tip is, however, an exception. If amputation of the epiglottis will give a sufficiently wide removal, this may be done en masse with a heavy snare, and has resulted in complete cure. Very small growths may be removed sufficiently widely with the punch forceps (Fig. 33); but piece meal removal of malignancy is to be avoided.

Differential Diagnosis of Laryngeal Growths in the Larynx of Adults.—Determination of the nature of the lesion in these cases usually consists in the diagnosis by exclusion of the possibilities, namely,

1. Lues.
2. Tuberculosis, including lupus.
3. Scleroma.
4. Malignant neoplasm.

In the Bronchoscopic Clinic the following is the routine procedure: 1. A Wassermann test is made. If negative, and there remains a suspicion of lues, a therapeutic test with mercury protoiodid is carried out by keeping the patient just under the salivation point for eight weeks; during which time no potassium iodid is given, lest its reaction upon the larynx cause an edema necessitating tracheotomy. If no improvement is noticed lues is excluded. If the Wassermann is positive, malignancy and the other possibilities are not considered as excluded until the patient has been completely cured by mercury, because, for instance, a leutic or tuberculous patient may have cancer; a tuberculous patient may have lues; or a leutic patient, tuberculosis. 2. Pulmonary tuberculosis is excluded by the usual means. If present the laryngeal lesion may or may not be tuberculous; if the laryngoscopic appearances are doubtful a specimen is taken. Lupoid laryngeal tuberculosis so much resembles lues that both the therapeutic test and biopsy may be required for certainty. 3. In all cases in which the diagnosis is not clear a specimen is taken. This is readily accomplished by direct laryngoscopy under local anesthesia, using the regular laryngoscope or the anterior commissure laryngoscope. The best forceps in case of large growths are the alligator punch forceps (Fig. 33). Smaller growths require tissue forceps (Fig. 28). In case of small growths, it is best to remove the entire growth; but without any attempt at radical extirpation of the base; because, if the growth prove benign it is unnecessary; if malignant, it is insufficient.

Inspection of the Party Wall in Cases of Suspected Laryngeal Malignancy.—When taking a specimen the party wall should be inspected by passing a laryngoscope or, if necessary, an esophageal speculum down through the laryngopharynx and beyond the cricopharyngeus. If this region shows infiltration, all hope of cure by operation, however radical, should be abandoned.

Radium and the therapeutic roentgenray have given good results, but not such as would warrant their exclusive use in any case of malignancy in the larynx operable by laryngofissure. With inoperable cases, excellent palliative results are obtained. In some cases an almost complete disappearance of the growth has occurred, but ultimately there has been recurrence. The method of application of the radium, dosage, and its screening, are best determined by the radiologist in consultation with the laryngologist. Radium may be applied externally to the neck, or suspended in the larynx; radium-containing needles may be buried in the growth, or the emanations, imprisoned in glass pearls or capillary tubes, may be inserted deeply into the growth by means of a small trocar and cannula. For all of these procedures direct laryngoscopy affords a ready means of accurate application. Tracheotomy is necessary however, because of the reactionary swelling, which may be so great as to close completely

the narrowed glottic chink. Where this is the case, the endolaryngeal application of the radium may be made by inserting the container through the tracheotomic wound, and anchoring it to the cannula.

The author is much impressed with Freer's method of radiation from the pyriform sinus in such cases as those in which external radiation alone is deemed insufficient.

The work of Drs. D. Bryson Delavan and Douglass M. Quick forms one of the most important contributions to the subject of the treatment of radium by cancer. (See Proceedings of the American Laryngological Association, 1922; also Proceedings of the Tenth International Otological Congress, Paris, 1922.)

[214] CHAPTER XXVI—BRONCHOSCOPY IN MALIGNANT GROWTHS OF THE TRACHEA

The trachea is often secondarily invaded by malignancy of the esophagus, thyroid gland, peritracheal or peribronchial glands. Primary malignant neoplasms of the trachea or bronchus have not infrequently been diagnosticated by bronchoscopy. Peritracheal or peribronchial malignancy may produce a compressive stenosis covered with normal mucosa. Endoscopically, the wall is seen to bulge in from one side causing a crescentic picture, or compression of opposite walls may cause a "scabbard" or pear shaped lumen. Endotracheal and endobronchial malignancy ulcerate early, and are characterized by the bronchoscopic view of a bleeding mass of fungating tissue bathed in pus and secretion, usually foul. The diagnosis in these cases rests upon the exclusion of lues, and is rendered certain by the removal of a specimen for biopsy. Sarcoma and carcinoma of the thyroid when perforating the trachea may become pedunculated. In such cases aberrant non-pathologic thyroid must be excluded by biopsy. Endothelioma of the trachea or bronchus may also assume a pedunculated form, but is more often sessile.

Treatment.—Pedunculated malignant growths are readily removed with snare or punch forceps. Cure has resulted in one case of the author following bronchoscopic removal of an endothelioma from the bronchus; and a limited carcinoma of the bronchus has been reported cured by bronchoscopic removal, with cauterization of the base. Most of the cases, however, will be subjects for palliative tracheotomy and radium therapy. It will be found necessary in many of the cases to employ the author's long, cane-shaped tracheal cannula (Fig. 104, A), in order to pipe the air down to one or both bronchi past the projecting neoplasm.

It has recently been demonstrated that following the intravenous injection of a suspension of the insoluble salt, radium sulphate, that the suspended particles are held in the capillaries of the lung for a period of one year. Intravenous injections of a watery suspension, and endobronchial injections of a suspension of radium sulphate in oil, have had definite beneficial action. While as yet, no relatively permanent cures of pulmonary malignancy have been obtained, the amelioration and steady improvement noted in the technic of radium therapy are so encouraging that every inoperable case should be thus treated, if the disease is not in a hopelessly advanced stage.

In a case under the care of Dr. Robert M. Lukens at the Bronchoscopic Clinic, a primary epithelioma of the trachea was retarded for 2 years by the use of radium applied by Dr. William S. Newcomet, radium-therapist, and Miss Katherine E. Schaeffer, technician.

[216] CHAPTER XXVII—MALIGNANT DISEASE OF THE ESOPHAGUS

Cancer of the esophagus is a more prevalent disease than is commonly thought. In the male it usually develops during the fourth and fifth decades of life. There is in some cases the history of years of more or less habitual consumption of strong alcoholic liquors. In the female the condition often occurs at an earlier age than in the male, and tends to run a more protracted course, preceeded in some cases by years of precancerous dysphagia.

Squamous-celled epithelioma is the most frequent type of neoplasm. In the lower third of the esophagus, cylindric cell carcinoma may be found associated with a like lesion in the stomach. Sarcoma of the esophagus is relatively rare (Bibliography 1, p. 449).

The sites of the lesion are those of physiologic narrowing of the esophagus. The middle third is most frequently involved; and the lower third, near the cardia, comes next in frequency. Cancer of the lower third of the esophagus preponderates in men, while cancer of the upper orifice is, curiously, more prevalent in women. The lesion is usually single, but multiple lesions, resulting from implantation

metastases have been observed (Bibliography 1, p. 391). Bronchoesophageal fistula from extension is not uncommon.

Symptoms.—Malignant disease of the esophagus is rarely seen early, because of the absence, or mildness, of the symptoms. Dysphagia, the one common symptom of all esophageal disease, is often ignored by the patient until it becomes so marked as to prevent the taking of solid food; therefore, the onset may have the similitude of abruptness. Any well masticated solid food can be swallowed through a lumen 5 millimeters in diameter. The inability to maintain the nutrition is evidenced by loss of weight and the rapid development of cachexia. When the stenosis becomes so severe that the fluid intake is limited, rapid decline occurs from water starvation. Pain is usually a late symptom of the disease. It may be of an aching character and referred to the vertebral region or to the neck; or it may only accompany the act of swallowing. Blood-streaked, regurgitated material, and the presence of odor, are late manifestations of ulceration and secondary infection. In some cases, constant oozing of blood from the ulcerated area adds greatly to the cachexia. If the recurrent laryngeal nerves are involved, unilateral or bilateral paralysis of the larynx may complicate the symptoms by cough, dyspnea, aphonia, and possibly septic pneumonia.

Diagnosis.—It has been estimated that 70 per cent of stenoses of the esophagus in adults are malignant in nature. This should stimulate the early and careful investigation of every case of dysphagia. When all cases of persistent dysphagia, however slight, are endoscopically studied, precancerous lesions may be discovered and treated, and the limited malignancy of the early stages may be afforded surgical treatment while yet there is hope of complete removal. Luetic and tuberculous ulceration of the esophagus are to be eliminated by suitable tests, supplemented in rare instances by biopsy. Aneurysm of the aorta must in all cases of dysphagia be excluded, for the dilated aorta may be the sole cause of the condition, and its presence contraindicates esophagoscopy because of the liability of rupture. Foreign body is to be excluded by history and roentgenographic study. Spasmodic stenosis of the esophagus may or may not have a malignant origin. Esophagoscopy and removal of a specimen for biopsy renders the diagnosis certain. It is to be especially remembered, however, that it is very unwise to bite through normal mucosa for the purpose of taking a specimen from a periesophageal growth. Fungations and polypoid protuberances afford safe opportunities for the removal of specimens of tissue.

The esophagoscopic appearances of malignant disease, varying with the stage and site of origin of the growth, may present as follows:—

1. Submucosal infiltration covered by perfectly normal membrane, usually associated with more or less bulging of the esophageal wall, and very often with hardness and infiltration.
2. Leucoplakia.
3. Ulceration projecting but little above the surface at the edges.
4. Rounded nodular masses grouped in mulberry-like form, either dark or light red in color.
5. Polypoid masses.
6. Cauliflower fungations.

In considering the esophagoscopic appearances of cancer, it is necessary to remember that after ulceration has set in, the cancerous process may have engrafted upon it, and upon its neighborhood, the results of inflammation due to the mixed infections. Cancer invading the wall from without may for a long time be covered with perfectly normal mucous membrane. The significant signs at this early stage are: 1. Absence of one or more of the normal radial creases between the folds. 2. Asymmetry of the inspiratory enlargement of lumen. 3. Sensation of hardness of the wall on palpation with the tube. 4. The involved wall will not readily be made to wrinkle when pushed upon with the tube mouth.

In all the later forms of lesions the two characteristics are (a) the readiness with which oozing of blood occurs; and (b) the sense of rigidity, or fixation, of the involved area as palpated with the esophagoscope, in contrast to the normally supple esophageal wall. Esophageal dilatation above a malignant lesion is rarely great, because the stenosis is seldom severely obstructive until late in the course of the disease.

Treatment.—The present 100 per cent mortality in cancer of the esophagus will be lowered and a certain percentage of surgical cures will be obtained when patients with esophageal symptoms are given the benefit of early esophagoscopic study. The relief or circumvention of the dysphagia requires early measures to prevent food and water starvation. *Bouginage* of a malignant esophagus to increase temporarily the size of the stenosed lumen is of questionable advisability, and is attended with the great risk of perforating the weakened esophageal wall.

Esophageal intubation may serve for a time to delay gastrostomy but it cannot supplant it, nor

obviate the necessity for its ultimate performance. The Charters-Symonds or Guisez esophageal intubation tube is readily inserted after drawing the larynx forward with the laryngoscope. The tube must be changed every week or two for cleaning, and duplicate tubes must be ready for immediate reinsertion. Eventually, a smaller, and then a still smaller tube are needed, until finally none can be introduced; though in some cases the tube can be kept in the soft mass of fungations until the patient has died of hemorrhage, exhaustion, complications or intercurrent disease.

Gastrostomy is always indicated as the disease progresses, and it should be done before nutrition is greatly impaired. Surgeons often hesitate thus to "operate on an inoperable case;" but it must be remembered that no one should be allowed to die of hunger and thirst. The operation should be done before inanition has made serious inroads. As in the case of tracheotomy, we always preach doing it early, and always do it late. If postponed too long, water starvation may proceed so far that the patient will not recover, because the water-starved tissues will not take up water put in the stomach.

Radiotherapy.—Radium and the therapeutic roentgenray are today our only effective means of retarding the progress of esophageal malignant neoplasms. No permanent cures have been reported, but marked temporary improvement in the swallowing function and prolongation of life have been repeatedly observed. The combination of radium treatment applied within the esophageal lumen and the therapeutic roentgenray through the chest wall, has retarded the progress of some cases.

The dosage of radium or the therapeutic ray must be determined by the radiologist for the particular individual case; its method of application should be decided by consultation of the radiologist and the endoscopist. Two fundamental points are to be considered, however. The radium capsule, if applied within the esophagus, should be so screened that the soft, irritating, beta rays, and the secondary rays, are both filtered out to prevent sloughing of the esophageal mucosa. The dose should be large enough to have a lethal effect upon the cancer cells at the periphery of the growth as well as in the center. If the dose be insufficient, development of the cells at the outside of the growth is stimulated rather than inhibited. It is essential that the radium capsule be accurately placed in the center of the malignant strictured area and this can be done only by visual control through the esophagoscope (Fig. 95)

Drs. Henry K. Pancoast, George E. Pfahler and William S. Newcomet have obtained very satisfactory palliative effects from the use of radium in esophageal cancer.

[221] CHAPTER XXVIII—DIRECT LARYNGOSCOPY IN DISEASES OF THE LARYNX

The diagnosis of laryngeal disease in young children, impossible with the mirror, has been made easy and precise by the development of direct laryngoscopy. No anesthetic, local or general, should be used, for the practised endoscopist can complete the examination within a minute of time and without pain to the patient. The technic for doing this should be acquired by every laryngologist. Anesthesia is absolutely contraindicated because of the possibility of the presence of diphtheria, and especially because of the dyspnea so frequently present in laryngeal disease. To attempt general anesthesia in a dyspneic case is to invite disaster (see Tracheotomy). It is to be remembered that coughing and straining produce an engorgement of the laryngeal mucosa, so that the first glance should include an estimation of the color of the mucosa, which, as a result of the engorgement, deepens with the prolongation of the direct laryngoscopy.

Chronic subglottic edema, often the result of perichondritis, may require linear cauterization at various times, to reduce its bulk, after the underlying cause has been removed.

Perichondritis and abscess, and their sequelae are to be treated on the accepted surgical precepts. They may be due to trauma, lues, tuberculosis, enteric fever, pneumonia, influenza, etc.

Tuberculosis of the larynx calls for conservatism in the application of surgery. Ulceration limited to the epiglottis may justify amputation of the projecting portion or excision of only the ulcerated area. In either case, rapid healing may be expected, and relief from the odynphagia is sometimes prompt. Amputation of the epiglottis is, however, not to be done if ulceration in other portions of the larynx coexist. The removal of tuberculomata is sometimes indicated, and the excision of limited ulcerative lesions situated elsewhere than on the epiglottis may be curative. These measures as well as the galvanocautery are easily executed by the facile operator; but their advisability should always be considered from a conservative viewpoint. They are rarely justifiable until after months of absolute silence and a general antituberculous regime have failed of benefit.

Galvanopuncture for laryngeal tuberculosis has yielded excellent results in reducing the large pyriform edematous swellings of the aryepiglottic folds when ulceration has not yet developed. Deep punctures at nearly a white heat, made perpendicular to the surface, are best. Care must be exercised

not to injure the cricoarytenoid joint. Fungating ulcerations may in some cases be made to cicatrize by superficial cauterization. Excessive reactions sometimes follow, so that a light application should be made at the first treatment.

Congenital laryngeal stridor is produced by an exaggeration of the infantile type of larynx. The epiglottis will be found long and tapering, its lateral margins rolled backward so as to meet and form a cylinder above. The upper edges of the aryepiglottic folds are approximated, leaving a narrow chink. The lack of firmness in these folds and the loose tissue in the posterior portion of the larynx, favors the drawing inward of the laryngeal aperture by the inspiratory blast. The vibration of the margins of this aperture produces the inspiratory stridor. Diagnosis is quickly made by the inspection of the larynx with the infant diagnostic laryngoscope. No anesthetic, general or local, is needed. Stridorous respiration may also be due to the presence of laryngeal papillomata, laryngeal spasm, thymic compression, congenital web, or an abnormal inspiratory bulging into the trachea of the posterior membranous tracheo-esophageal wall. The term "congenital laryngeal stridor" should be limited to the first described condition of exaggerated infantile larynx.

Treatment of congenital laryngeal stridor should be directed to the relief of dyspnea, and to increasing the nutrition and development of the infant. The insertion of a bronchoscope will temporarily relieve an urgent dyspneic attack precipitated by examination; but this rarely happens if the examination is not unduly prolonged. Tracheotomy may be needed to prevent asphyxia or exhaustion from loss of sleep; but very few cases require anything but attention to nutrition and hygiene. Recovery can be expected with development of the laryngeal structures.

Congenital webs of the larynx require incision or excision, or perhaps simply bouginage. Congenital goiter and congenital laryngeal paralysis, both of which may cause stertorous breathing, are considered in connection with other forms of stenosis of the air passages.

Aphonia due to cicatricial webs of the larynx may be cured by plastic operations that reform the cords, with a clean, sharp anterior commissure, which is a necessity for clear phonation. The laryngeal scissors and the long slender punch are often more useful for these operations than the knife.

[224] CHAPTER XXIX—BRONCHOSCOPY IN DISEASES OF THE TRACHEA AND BRONCHI

The indications for bronchoscopy in disease are becoming increasingly numerous. Among the more important may be mentioned:

1. Bronchiectasis.
2. Chronic pulmonary abscess.
3. Unexplained dyspnea.
4. Dyspnea unrelieved by tracheotomy calls for bronchoscopic search for deeper obstruction.
5. Paralysis of the recurrent laryngeal nerve, the cause of which is not positively known.
6. Obscure thoracic disease.
7. Unexplained hemoptysis.
8. Unexplained cough.
9. Unexplained expectoration.

Contraindications to bronchoscopy in disease do not exist if the bronchoscopy is really needed. Serious organic disease such as aneurysm, hypertension, advanced cardiac disease, might render bronchoscopy inadvisable except for the removal of foreign bodies.

Bronchoscopic Appearances in Disease.—The first look should note the color of the bronchial mucosa, due allowance being made for the pressure of tubal contact, secretions, and the engorgement incident to continued cough. The carina trachealis normally moves slowly forward as well as downward during deep inspiration, returning quickly during expiration. Impaired movement of the carina indicates peritracheal and peribronchial pathology, the fixation being greatest in advanced cancer. In children and in the smaller tubes of the adult, the lengthening and dilatation of the bronchi during inspiration, and their shortening and contraction during expiration are readily seen.

Anomalies of the Tracheobronchial Tree.—Tracheobronchial anomalies are relatively rare. Congenital esophagotracheal and esophagobronchial fistulae are occasionally seen, and cases of cervicotracheal fistulae have been reported. Congenital webs and diverticula of the trachea are cited infrequently. Laryngoptosis and deviation of the trachea may be congenital. Substernal goitre, aneurysm, malignant growths, and various mediastinal adenopathies may displace the trachea from its normal course. The

emphysematous chest fixed in the deep voluntary inspiratory position produces in some cases an elevation of the superior thoracic aperture simulating laryngoptosis (Bibliography r, pp. 468, 594).

Compression Stenosis of the Trachea and Bronchi.—Compression of the trachea is most commonly caused by goiter, substernal or cervical, aneurysm, malignancy, or, in children, by enlarged thymus. Less frequently, enlarged mediastinal tuberculous, leukemic, leutic or Hodgkin's glands compress the airway. The left bronchus may be stenosed by pressure from a hypertrophied cardiac auricle. Compression stenosis of the trachea associated with pulmonary emphysema accounts for the dyspnea during attacks of coughing.

The endoscopic picture of compression stenosis is that of an elliptical or scabbard-shaped lumen when the bronchus is at rest or during inspiration. Concentric funnel-like compression stenosis, while rare, may be produced by annular growths.

Treatment of Compression Stenoses of the Trachea.—If the thymus be at fault, rapid amelioration of symptoms follows roentgenray or radium therapy. Tracheotomy and the insertion of the long cane-shaped cannula (Fig. 104) past the compressed area is required in the cases caused by conditions less amenable to treatment than thymic enlargement. Permanent cure depends upon the removability of the compressive mass. Should the bronchi be so compressed by a benign condition as to prevent escape of secretions from the subjacent air passages, bronchial intubation tubes may be inserted, and, if necessary, worn constantly. They should be removed weekly for cleansing and oftener if obstructed.

Influenzal Laryngotracheobronchitis.—Influenzal infection, not always by the same organism, sweeps over the population, attacking the air passages in a violent and quite characteristic way. Bronchoscopy shows the influenzal infection to be characterized by intense reddening and swelling of the mucosa. In some cases the swelling is so great as to necessitate tracheotomy, or intubation of the larynx; and if the edema involve the bronchi, occlusion may be fatal. Hemorrhagic spots and superficial erosions are commonly seen, and a thick, tenacious exudate, difficult of expectoration, lies in patches in the trachea. Infants may asphyxiate from accumulation of this secretion which they are unable to expel. The differential diagnosis from diphtheria is sometimes difficult. The absence of true membrane and the failure to find diphtheria bacilli in smears taken from the trachea are of aid but are not infallible. In doubtful cases, the administration of diphtheria antitoxin is a wise precaution pending the establishment of a definite diagnosis. The pseudomembrane sometimes present in influenzal tracheobronchitis is thinner and less pulpy than that of the earlier stages of diphtheria. The casts of the later stages do not occur in influenzal tracheobronchitis (Bibliography I, p. 480).

Edematous Tracheobronchitis.—This is chiefly observed in children. The most frequently encountered form is the epidemic disease to which the name "Influenza" has been given (q.v. supra). The only noticeable difference between the epidemic and the sporadic cases is in the more general susceptibility to the infective agent, which gives the influenzal form an appearance of being more virulently infective. Possibly the sporadic form is simply the attack of children not immunized by a previous attack during an epidemic.

There is another form of edematous tracheobronchitis often of great severity and grave prognosis, that results from the aspiration of irritating liquids or vapors, or of certain organic substances such as peanut kernels, watermelon seeds, etcetera. Tracheotomy should be done if marked dyspnea be present. Secretions can then be easily removed and medication in the form of oily solutions be instilled at will into the trachea. In the Bronchoscopic Clinic many children have been kept alive for days, and their lives finally saved by aspiration of thick, tough, sometimes clotted and crusted secretions, with the aspirating tube (Fig. 10). It is better in these cases not to pass the bronchoscope repeatedly. If, however, evidences of obstruction remain, after aspiration, it is necessary to see the nature of the obstruction and relieve it by removal, dilatation, or bronchial intubation as the case may require. It is all a matter of "plumbing" i.e., clearing out the "pipes," and maintaining a patulous airway.

Tracheobronchial Diphtheria.—Urgent dyspnea in diphtheria when no membrane and but slight lessening of the laryngeal airway is seen, calls for bronchoscopy. Many lives have been saved by the bronchoscopic removal of membrane obstructing the trachea or bronchi. In the early stages, pulpy masses looking like "mother" of vinegar are very obstructive. Later casts of membrane may simulate foreign bodies. The local application of diphtheria antitoxin to the trachea and bronchi has also been recommended. A preparation free from a chemical irritant should be selected.

Abscess of the Lung.—If of foreign-body origin, pulmonary abscess almost invariably heals after the removal of the object and a regime of fresh air and rest, without local measures of any kind. Acute pulmonary abscess from other causes may require bronchoscopic drainage and gentle dilatation of the swollen and narrowed bronchi leading to it. Some of these bronchi are practically fistulae. Obstructive granulations should be removed with crushing, not biting forceps. The regular foreign-body forceps are best for this purpose. Caution should be used as to removal of the granulations with which the abscess

"cavity" is filled in chronic cases. The term "abscess" is usually loosely applied to the condition of drowned lung in which the pus has accumulated in natural passages, and in which there is neither a new wall nor a breaking down of normal walls. Chronic lung-abscess is often successfully treated by weekly bronchoscopic lavage with 20 cc. or more of a warm, normal salt solution, a 1:1000 watery potassium permanganate solution, or a weak iodine solution as in the following formula: Rx. Monochlorphenol (Merck) .12 Lugol's solution 8.00 Normal salt solution 500.

Perhaps the best procedure is to precede medicinal applications by the clearing out of the purulent secretions by aspiration with the aspirating bronchoscope and the independent aspirating tube, the latter being inserted into passages too small to enter with the bronchoscope, and the endobronchial instillation of from 10 to 30 cc. of the medicament. The following have been used: Argyrol, 1 per cent watery solution; Silvol, 1 per cent watery solution; Iodoform, oil emulsion 10 per cent; Guaiacol, 10 per cent solution in paraffine oil; Gomenol, 20 per cent solution in oil; or a bismuth subnitrate suspension in oil. Robert M. Lukens and William F. Moore of the Bronchoscopic Clinic report excellent results in post-tonsillectomy abscesses from one tenth of one per cent phenol in normal salt solution with the addition of 2 per cent Lugol's solution. Chlorinated solutions are irritating, and if used, require copious dilution. Liquid petrolatum with a little oil of eucalyptus has been most often the medium.

Gangrene of the Lung.—Pulmonary gangrene has been followed by recovery after the endobronchial injection of oily solutions of gomenol and guaiacol (Guisez). The injections are readily made through the laryngoscope without the insertion of a bronchoscope. A silk woven catheter may be used with an ordinary glass syringe or a long-nozzled laryngeal syringe, or a bronchoscopic syringe may be used.

Lung-mapping by a roentgenogram taken promptly after the bronchoscopic insufflation of bismuth subnitrate powder or the injection of a suspension of bismuth in liquid petrolatum is advisable in most cases of pulmonary abscess before beginning any kind of treatment.

Bronchial Stenosis.—Stenosis of one or more bronchi results at times from cicatricial contraction following secondary infection of leutic, tuberculous or traumatic lesions. The narrowing resulting from foreign body traumatism rarely requires secondary dilatation after the foreign body has been removed. Tuberculous bronchial stenoses rarely require local treatment, but are easily dilated when necessary. Luetic cicatricial stenosis may require repeated dilatation, or even bronchial intubation. Endobronchial neoplasms may cause a subjacent bronchiectasis, and superjacent stenosis; the latter may require dilatation. Cicatricial stenoses of the bronchi are readily recognizable by the scarred wall and the absence of rings at or near the narrowing.

Bronchiectasis.—In most cases of bronchiectasis there are strong indications for a bronchoscopic diagnosis, to eliminate such conditions as foreign body, cicatricial bronchial stenosis, or endobronchial neoplasm as etiologic factors. In the idiopathic types considerable benefit has resulted from the endobronchial lavage and endobronchial oily injections mentioned under lung abscess. It is probable that if bronchoscopic study were carried out in every case, definite causes for many so-called "idiopathic" cases would be discovered. Lung-mapping as elsewhere herein explained is invaluable in the study of bronchiectasis.

Bronchial asthma affords a large field for bronchoscopic study. As yet, sufficient data to afford any definite conclusions even as to the endoscopic picture of this disease have not been accumulated. Of the cases seen in the Bronchoscopic Clinic some showed no abnormality of the bronchi in the intervals between attacks, others a chronic bronchitis. In cases studied bronchoscopically during an attack, the bronchi were found filled with bubbling secretions and the mucosa was somewhat cyanotic in color. The bronchial lumen was narrowed only as much as it would be, with the same degree of cough, in any patient not subject to asthma. The secretions were removed and the attack quickly subsided; but no influence on the recurrence of attacks was observed. It is essential that the bronchoscopic studies be made, as were these, without anesthesia, local or general, for it is known that the application of cocain or adrenalin to the larynx, or even in the nose, will, with some patients, stop the attack. When done without local anesthesia, allowance must be made for the reaction to the presence of the tube. In those cases in which other means have failed to give relief, the endobronchial application of novocain and adrenalin, orthoform, propaesin or anesthesin emulsion may be tried. Cures have been reported by this treatment. Argentic nitrate applied at weekly intervals has proven very efficient in some cases. Associated infective disease of the bronchial mucosa brings with it the questions of immunity, allergy, anaphylaxis, and vaccine therapy; and the often present defective metabolism has to be considered.

Autodrownage.—Autodrownage is the name given by the author to the drowning of the patient in his own secretions. Tracheobronchial secretions in excess of the amount required to moisten the inspired air, become, in certain cases, a mechanical menace to life, unless removed. The cough reflex, forced expiration, and ciliary action, normally remove the excess. When these mechanisms are impaired, as in profound asthenia, laryngeal paralysis, laryngeal or tracheal stenosis, etc.; and especially when in

addition to a mild degree of glottic stenosis or impaired laryngeal mobility, the secretions become excessive, the accumulation may literally drown the patient in his own secretions. This is illustrated frequently in influenza and arachidic bronchitis. Infants cannot expectorate, and their cough reflex is exceedingly ineffective in raising secretion to the pharynx; furthermore they are easily exhausted by bechic efforts; so that age may be cited as one of the most frequent etiologic factors in the condition of autodrownage. Bronchoscopic sponge-pumping (*q.v.*) and bronchoscopic aspiration are quite efficient and can save any patient not afflicted with conditions that are fatal by other pathologic processes.

Lues of the Tracheobronchial Tree.—Compared to laryngeal involvement, syphilis of the tracheobronchial tree is relatively rare. The lesions may be gummatous, ulcerative, or inflammatory, or there may be compressive granulomatous masses. Hemoptysis may have its origin from a luetic ulceration. Excision of fungations or of a portion of the margin of the ulceration for biopsy is advisable. The Wassermann and therapeutic tests, and the elimination of tuberculosis will be required for confirmation. Luetic stenoses are referred to above.

Tuberculosis of the Tracheobronchial Tree.—The bronchoscopic study of tuberculosis is very interesting, but only a few cases justify bronchoscopy. The subglottic infiltrations from extensions of laryngeal disease are usually of edematous appearance, though they are much more firm than in ordinary inflammatory edema. Ulcerations in this region are rare, except as direct extensions of ulceration above the cord. The trachea is relatively rarely involved in tuberculosis, but we may have in the trachea the pale swelling of the early stage of a perichondritis, or the later ulceration and all the phenomena following the mixed pyogenic infections. These same conditions may exist in the bronchi. In a number of instances, the entire lumen of the bronchus was occluded by cheesy pus and debris of a peribronchial gland which had eroded through. As a rule, the mucosa of tuberculosis is pale, and the pallor is accentuated by the rather bluish streak of vessels, where these are visible. Erosion through of peri-bronchial or peri-tracheal lymph masses may be associated with granulation tissue, usually of pale color, but occasionally reddish; and sometimes oozing of blood is noticed. A most common picture in tuberculosis is a broadening of the carina, which may be so marked as to obliterate the carina and to bulge inward, producing deformed lumina in both bronchi. Sometimes the lumina are crescentic, the concavity of the crescent being internal, that is, toward the median line. Absence of the normal anterior and downward movement of the carina on deep inspiration is almost pathognomonic of a mass at the bifurcation, and such a mass is usually tuberculous, though it may be malignant, and, very rarely, luetic. The only lesion visible in a tuberculous case may be cicatrices from healed processes. In a number of cases there has been a discharge of pus coming from the upper-lobe bronchus.

[Fig. 96.—The author's tampons for pulmonary hemostasis by bronchoscopic tamponade. The folded gauze is 10 cm. long; the braided silk cord 60 cm. long.]

Hemoptysis.—In cases not demonstrably tuberculous, hemoptysis may require bronchoscopic examination to determine the origin. Varices or unsuspected luetic, malignant, or tuberculous lesions may be found to be the cause. It is mechanically easy to pack off one bronchus with the author's packs (Fig. 96) introduced through the bronchoscope, but the advisability of doing so requires further clinical tests.

Angioneurotic Edema.—Angioneurotic edema manifests itself by a pale or red swollen mucosa producing stenosis of the lumen. The temporary character of the lesion and its appearance in other regions confirm the diagnosis.

Scleroma of the trachea is characterized by infiltration of the tracheal mucosa, which greatly narrows the lumen. The infiltration may be limited in area and produce a single stricture, or it may involve the entire trachea and even close a bronchial orifice. Drying and crusting of secretions renders the stenosis still more distressing. This disease is but rarely encountered in America but is not infrequent in some parts of Europe. Treatment consists in the prevention of crusts and their removal. Limited stenotic areas may yield to bronchoscopic bouginage. Urgent dyspnea calls for tracheotomy. Radium and roentgenray therapy have been advised, and cure has been reported by intravenous salvarsan treatment (see article by S. Shelton Watkins, on Scleroma in Surg. Gynecol. and Obst., July, 1921, p. 47).

Atrophic tracheitis, with symptoms quite similar to atrophic rhinitis is a not unusual accompaniment of the nasal condition. It may also exist without nasal involvement. On tracheoscopy the mucosa is thinned, pale and dry, and is covered with patches of thick mucilaginous secretion and crusts. Decomposition of secretion produces tracheal "ozena," while the accumulated crusts give rise to the sensation of a foreign body and may seriously interfere with respiration, making bronchoscopic removal imperative. The associated development of tracheal nodular enchondromata has been described. The internal administration of iodine and the intratracheal injection of bland oily solutions of menthol, guaiacol, or gomenol are helpful.

[235] CHAPTER XXX—DISEASES OF THE ESOPHAGUS

The more frequent causes of the one common symptom of esophageal disease, dysphagia, are included in the list given below. To avoid elaboration and to obtain maximum usefulness as a reminder, overlapping has not been eliminated.

1. Anomalies.
2. Esophagitis, acute.
3. Esophagitis, chronic.
4. Erosion.
5. Ulceration.
6. Trauma.
7. Stricture, congenital.
8. Stricture, spasmodic, including cramp of the diaphragmatic pinchcock.
9. Stricture, inflammatory.
10. Stricture, cicatricial.
11. Dilatation, local.
12. Dilatation, diffuse.
13. Diverticulum.
14. Compression stenosis.
15. Mediastinal tumor.
16. Mediastinal abscess.
17. Mediastinal glandular mass.
18. Aneurysm.
19. Malignant neoplasm.
20. Benign neoplasm.
21. Tuberculosis.
22. Lues.
23. Actinomycosis.
24. Varix.
25. Angioneurotic edema.
26. Hysteria.
27. Functional antiperistalsis.
28. Paralysis.
29. Foreign body in (a) pharynx, (b) larynx, (c) trachea, (d) esophagus.

[236] *Diagnosis*.—The swallowing function can be studied only with the fluoroscope; esophagoscopy for diagnosis, should therefore always be preceded by a fluoroscopic study of deglutition with a barium or other opaque mixture and examination of the thoracic organs to eliminate external pressure on the esophagus as the cause of stenosis. Complete physical examination and Wassermann reaction are further routine preliminaries to any esophagoscopy. Special laboratory tests are done as may be indicated. The physical examination is meant to include a careful examination of the lips, tongue, palate, pharynx, and a mirror examination of the larynx when age permits.

Indications for Esophagoscopy in Disease.—Any persistent abnormal sensation or disturbance of function of the esophagus calls for esophagoscopy. Vague stomach symptoms may prove to be esophageal in origin, for vomiting is often a complaint when the patient really regurgitates.

Contraindications to Esophagoscopy.—In the presence of aneurysm, advanced organic disease, extensive esophageal varicosities, acute necrotic or corrosive esophagitis, esophagoscopy should not be done except for urgent reasons, such as the lodgment of a foreign body; and in this case the esophagoscopy may be postponed, if necessary, unless the patient is unable to swallow fluids. Esophagoscopy should be deferred, in cases of acute esophagitis from swallowing of caustics, until sloughing has ceased and healing has strengthened the weak places. The extremes of age are not contraindications to esophagoscopy. A number of newborn infants have been esophagoscoped by the author; and he has removed foreign bodies from patients over 80 years of age.

Water starvation makes the patient a very bad surgical subject, and is a distinct contraindication to esophagoscopy. Water must be supplied by means of proctoclysis and hypodermoclysis before any endoscopic or surgical procedure is attempted. If the esophageal stenosis is not readily and quickly remediable, gastrostomy should be done immediately. *Rectal feeding* will supply water for a limited

time, but for nutrient purposes rectal alimentation is dangerously inefficient.

Preliminary examination of the pharynx and larynx with tongue depressor should always precede esophagoscopy, for any purpose, because the symptoms may be due to laryngeal or pharyngeal disease that might be overlooked in passing the esophagoscope. A high degree of esophageal stenosis results in retention in the suprajacent esophagus of the fluids which normally are continually flowing downward. The pyriform sinuses in these cases are seen with the laryngeal mirror to be filled with frothy secretion (Jackson's sign of esophageal stenosis) and this secretion may sometimes be seen trickling into the larynx. This overflow into the larynx and lower air passages is often the cause of pulmonary symptoms, which are thus strictly secondary to the esophageal disease.

ANOMALIES OF THE ESOPHAGUS

Congenital esophagotracheal fistulae are the most frequent of the embryonic developmental errors of this organ. Septic pneumonia from the entrance of fluids into the lungs usually causes death within a few weeks.

Imperforate esophagus usually shows an upper esophageal segment ending in a blind pouch. A lower segment is usually present and may be connected with the upper segment by a fistula.

Congenital stricture of the esophagus may be single or multiple, and may be thin and weblike, or it may extend over a third or more of the length of the esophagus. It may not become manifest until solids are added to the child's diet; often not for many months. The lodgment of an unusually large bolus of unmasticated food may set up an esophagitis the swelling of which may completely close the lumen of the congenitally narrow esophagus. It is not uncommon to meet with cases of adults who have "never swallowed as well as other people," and in whom cicatricial and spasmodic stenosis can be excluded by esophagoscopy, which demonstrates an obvious narrowing of the esophageal lumen. These cases are doubtless congenital.

Webs in the upper third of the esophagus are best determined by the passage of a large esophagoscope which puts the esophagus on the stretch. The webs may be broken by the insertion of a closed alligator forceps, which is then withdrawn with opened blades. Better still is the dilator shown in Fig. 26. This retrograde dilatation is relatively safe. A silk-woven esophagoscopic bougie or the metallic tracheal bougie may be used, with proper caution. Subsequent dilatation for a few times will be required to prevent a reproduction of the stenosis.

Treatment of Esophageal Anomalies.—Gastrostomy is required in the imperforate cases. Esophagoscopic bouginage is very successful in the cure of all cases of congenital stenosis. Any sort of lumen can be enlarged so any well masticated food can be swallowed. Careful esophagoscopic work with the bougies (Fig. 40) will ultimately cure with little or no risk of mortality. Any form of rapid dilatation is dangerous. Congenital stenosis, if not an absolute atresia, yields more readily to esophagoscopic bouginage than cicatricial stenosis.

RUPTURE AND TRAUMA OF THE ESOPHAGUS

These may be spontaneous or may ensue from the passage of an instrument, or foreign body, or of both combined, as exemplified in the blind attempts to remove a foreign body or to push it downwards. Digestion of the esophagus and perforation may result from the stagnation of regurgitated gastric juice therein. This condition sometimes occurs in profound toxic and debilitated states. Rupture of the thoracic esophagus produces profound shock, fever, mediastinal emphysema, and rapid sinking. Pneumothorax and empyema follow perforation into the pleural cavity. Rupture of the cervical esophagus is usually followed by cervical emphysema and cervical abscess, both of which often burrow into the mediastinum along the fascial layers of the neck. Lesser degrees of trauma produce esophagitis usually accompanied by fever and painful and difficult swallowing.

The treatment of traumatic esophagitis consists in rest in bed, sterile liquid food, and the administration of bismuth subnitrate (about one gramme in an adult), dry on the tongue every 4 hours. Rupture of the esophagus requires immediate gastrostomy to put the esophagus at rest and supply necessary alimentation. Thoracotomy for drainage is required when the pleural cavity has been involved, not only for pleural secretions, but for the constant and copious esophageal leakage. It is not ordinarily realized how much normal salivary drainage passes down the esophagus. The customary treatment of shock is to be applied. No attempt should be made to remove a foreign body until the traumatic lesions have healed. This may require a number of weeks. Decision as to when to remove the intruder is determined by esophagoscopic inspection.

Subcutaneous emphysema does not require puncture unless gaseous, or unless pus forms. In the latter event free external drainage becomes imperative.

ACUTE ESOPHAGITIS

This is usually of traumatic or cauterant origin. If severe or extensive, all the symptoms described under "Rupture of the Esophagus" may be present. The endoscopic appearances are unmistakable to anyone familiar with the appearance of mucosal inflammations. The pale, bluish pink color of the normal mucosa is replaced by a deep-red velvety swollen appearance in which individual vessels are invisible. After exudation of serum into the tissues, the color may be paler and in some instances a typical edema may be seen. This may diminish the lumen temporarily. Folds of swollen mucosa crowd into the lumen if the inflammation is intense. These folds are sometimes demonstrable in the roentgenogram by the bismuth or barium in the creases between which the prominence of the folds show as islands as beautifully demonstrated by David R. Bowen in one of the author's cases. If the inflammation is due to corrosives, a grayish exudate may be visible early, sloughs later.

ULCERATION OF THE ESOPHAGUS

Superficial erosions of the esophagus are by no means an uncommon accompaniment of the stagnation of food and secretions. From the irritation they produce, spastic stenosis may occur, thus constituting a vicious circle; the spasm of the esophagus increases the stagnation which in turn results in further inflammation and ultimate ulceration. Healing of such ulcers may result in cicatricial contraction and organic stenosis. Ulceration may follow trauma by instrument, foreign body, or corrosive.

DIFFERENTIAL DIAGNOSIS OF ULCER OF THE ESOPHAGUS

Simple ulcer requires the exclusion of lues, tuberculosis, epithelioma, endothelioma, sarcoma, and actinomycosis. Simple ulcer of the esophagus is usually associated with stenosis, spastic or organic.

Luetic ulcers commonly show a surrounding inflammatory areola, and they usually have thickened elevated edges, generally free from granulation tissue, with a pasty center not bleeding readily when sponged. The Wassermann reaction may contribute to the diagnosis; but if negative, a thorough and prolonged test with mercury is imperative. It must be remembered that a person with lues may have a simple, mixed, or malignant ulceration of the esophagus, or the three lesions may even be combined. It may be in some cases possible to demonstrate the treponema pallidum in scrapings taken from the ulcer.

The single *tuberculous ulcer* is usually pale, superficial, and granular in base. If it is a continuation from more extensive extra-esophageal tuberculous ulceration, pale cauliflower granulations may be present. Slight cicatrices may be seen. Tuberculosis in other organs can almost always be demonstrated by roentgenographic, physical, or laboratory studies. Tuberculin tests and animal injection with an emulsion of a specimen of tissue may be required. The specimen must be taken very superficially to avoid risk of perforation.

Sarcomatous ulcers do not differ materially in appearance from those of carcinoma, but they are much more rare.

Carcinomatous ulcer is usually characterized by the very vascular bright red zone, raised edges, fungations, granulation tissue that bleeds freely on the lightest touch, and above all, it is almost invariably situated on an infiltrated base which communicates a feeling of hardness to the pressure of sponges or the esophagoscope itself. A scar may be from the healing of an ulcer from stasis, or one of specific or precancerous character. It may be a cancerous process developing on the site of a scar, so that the presence of scar tissue does not absolutely negative malignancy. As a rule, however, scars are absent in cancer of the esophagus. The firm and sometimes prominent ridge of the crossing of the left bronchus must not be mistaken for infiltration, and the esophagoscopist must be familiar with the normal rigidity of the cricopharyngeus.

[242] Mixed infection gives to all esophageal ulceration a certain uniformity of appearance, so that laboratory studies of smears or histologic and bacteriologic study of tissue specimens taken from fungations or thickened edges are often required to confirm the endoscopic diagnosis. If the edges are thin and flat, the taking of a specimen involves some risk; fungations can be removed without risk; so can nodules, but care must be taken that projecting folds are not mistaken for nodules. It is always wise to push the therapeutic test with potassium iodid and especially mercury in any case of esophageal ulceration unassociated with stasis.

Treatment of Acute and Subacute Inflammation and Ulceration of the Esophagus.—Bismuth subnitrate in doses of about one gramme, given dry on the tongue and swallowed without water, has a local antiseptic and protective action. Its antiseptic power may be enhanced by the addition of calomel to the powder, in such amount as may be tolerated by the bowels. If pain be present the combination of

a grain or two of anesthesin or orthoform with the bismuth will be grateful. The local application of argyrol in 25 per cent watery solution is also of great value. The mouth and teeth are to be kept clean with a mouth wash of Dakin's solution, 1 part, to peppermint water, 6 parts. The esophagus must be placed at rest as far as possible by liquid diet or, if need be, by gastrostomy.

CHRONIC ESOPHAGITIS

This is usually a result of stagnation of food or secretion, and will be considered under spasmodic stenosis and diffuse dilatation of the esophagus.

A very marked case with local distress and pain extending through to the back was seen by the author in consultation with Dr. John B. Wright who had made the diagnosis. The patient was a sufferer from ankylostomiasis.

[243] COMPRESSION STENOSIS OF THE ESOPHAGUS

The esophagus may be narrowed by the pressure of any periesophageal disease or anomaly. The lesions most frequently found are:

1. Goiter, cervical or thoracic.
2. Malignancy of any of the intrathoracic viscera.
3. Aneurysm.
4. Cardiac and aortic enlargement.
5. Lymphadenopathies. Hodgkins' disease.
   Leukemia.
   Lues.
   Tuberculosis.
   Simple infective adenitis.
6. Lordosis.
7. Enlargement of the left hepatic lobe.

Endoscopically, compression stenosis of the esophagus is manifested by a slit-like crevice which occupies the place of the lumen and which does not open up readily before the advancing tube. The long axis of the slit is almost always at right angles to the compressive mass, if the esophageal wall be uninvolved. The covering mucosa may be normal or it may show signs of chronic inflammation. Malignant compressions are characterized by their hardness when palpated with the tube. Associated pressure on the recurrent laryngeal nerve often makes laryngeal paralysis coexistent. The nature of the compressive mass will require for its determination the aid of the roentgenologist, internist, and clinical laboratory. Compression by the enlarged left auricle has been observed a number of times. The presence of aneurysm is a distinct contraindication to esophagoscopy for diagnosis except in case of suspected foreign body.

Treatment of compressive stenosis of the esophagus depends upon the nature of the compressive lesion and is without the realm of endoscopy. In uncertain cases potassium iodid, and especially mercury, should always be given a thorough and prolonged trial; an occasional cure will result. Esophageal intubation is indicated in all conditions except aneurysm. Gastrostomy should be done early when necessary.

DIFFUSE DILATATION OF THE ESOPHAGUS

This is practically always due to stagnation ectasia, which is invariably associated with either organic or "spasmodic" stricture, existing at the time of observation or at some time prior thereto. The dilating effect of the repeatedly accumulated food results in a permanent enlargement, so that the esophagus acts as the reservoir of a large funnel with a very small opening. When food is swallowed the esophagus fills, and the contents trickle slowly through the opening. Gases due to fermentation increase the distension and cause substernal pressure, discomfort, and belching. A very large dilatation of the thoracic esophagus indicates spastic stenosis. Cicatricial stenoses do not result in such large dilatations and the dilatation above a malignant stenosis is usually slight, probably because of its relatively shorter duration.

The *treatment of diffuse esophageal dilatation* consists in dilating the "diaphragmatic pinchcock" that is, the hiatal esophagus. Chronic esophagitis is to be controlled by esophageal lavage, the regulation of the diet to liquefiable foods and the administration of bismuth subnitrate. The patient can be taught to do the lavage. The local esophagoscopic application of a small quantity of a 25 per cent watery solution of argyrol may be required for the static esophagitis. The redundancy probably never disappears; but functional and subjective cures are usually obtainable.

SPASMODIC STENOSIS OF THE ESOPHAGUS

Etiology.—The functional activity of the esophagus is dependent upon reflex action. The food is propulsed in a peristaltic wave by the same mechanism as, and through an innervation (Auerbach and Meissner plexus) similar to that which controls intestinal movements. The vagus also is directly concerned with the deglutitory act, for swallowing is impossible if both vagi are cut. Anything which unduly disturbs this reflex arc may serve as an exciting cause of spasmodic stenosis. Bolting of food, superficial erosions, local esophageal disease, or a small foreign body, may produce spasmodic stenosis. Spasm secondary to disease of the stomach, liver, gall bladder, appendix, or other abdominal organ is clinically well recognized. A perpetuating cause in established cases is undoubtedly "nerve cell habit," and in many cases there is an underlying neurotic factor. Shock as an exciting cause has been well exemplified by the number of cases of phrenospasm developing in soldiers during the World War.

Cricopharyngeal spasmodic stenosis usually presents the subjective symptom of difficulty in starting the bolus of food downward. Once started, the food passes into the stomach unimpeded. Regurgitation, if it occurs, is immediate. The condition consists in a tonic contraction, ahead of the bolus, of the circular fibers of the inferior constrictor known as the cricopharyngeus muscle, or in a failure of this muscle to relax so as to allow the bolus to pass. In either case the disorder may be secondary to an organic lesion. Local malignant disease or foreign bodies may be the cause. Globus hystericus, "lump in the throat," and the sense of constriction and choking during emotion are due to the same spasmodic condition.

Diagnosis.—At esophagoscopy there will be found marked exaggeration of the usual spasm which occurs at the cricopharyngeus during the introduction of the tube. The lumen may assume various shapes, or be so tightly closed that the folds form a mammilliform projection in the center. If the spasm gradually yields, and a full-sized esophagoscope passes without further resistance, it may be stated that the esophagus is of normal calibre, and a diagnosis of spasmodic stenosis can be made. Considerable experience is required to distinguish between normal and pathologic spasm in an unanesthetized individual. To the less experienced esophagoscopist, examination under ether anesthesia is recommended. Deep anesthesia will relax the normal cricopharyngeal reflex closure as well as any abnormal spasm, thus assisting in the differentiation between an organic stricture and one of functional character. Under deep general anesthesia, however, it is impossible to differentiate between the normal reflex and a spasmodic condition, since both are abolished. Many cases of intermittent esophageal stenosis supposed to be spasmodic are due to organic narrowness of lumen plus lodgement of food, obstructive in itself and in the esophagitis resulting from its presence. The organic narrowing, congenital or pathologic, is readily recognizable esophagoscopically.

Treatment.—The fundamental cause of the disturbance of the reflex should be searched for, and treated according to its nature. Purely functional cases are often cured by the passage of a large esophagoscope. Recurrences may require similar treatment.

[247] FUNCTIONAL HIATAL STENOSIS. HIATAL ESOPHAGISMUS. PHRENOSPASM, DIAPHRAGMATIC PINCHCOCK STENOSIS. (SO-CALLED CARDIOSPASM)

There is no sphincteric muscular arrangement at the cardiac orifice of the esophagus, so that spasmodic stenosis at this level is not possible and the term cardiospasm is, therefore, a misnomer. It was first demonstrated by the author that in so-called cardiospasm the functional closure of the esophagus occurred at the diaphragmatic level, and that it was due to the "diaphragmatic pinchcock." Anatomical studies have corroborated this finding by demonstrating a definite sphincteric mechanism consisting of muscle bands springing from the crura of the diaphragm and surrounding the esophagus at the under surface of the hiatus. An inspection of the cadaveric diaphragm from below will demonstrate an arrangement like double shears admirably adapted to this "pinchcock" action. Further confirmation is the fact that all dilatation of the esophagus incident to spasm at its lower extremity is situated above the diaphragm. In passing it may be stated that the pinchcock action, plus the kinking of the esophagus normally prevents regurgitation when a man with a full stomach "stands on his head" or inverts his body. For the upward escape of food from the stomach an involuntary co-ordinated antiperistaltic cycle is necessary. The dilatation resulting from phrenospasm may reach great size (Fig. 96a), and the capacity of the sac may be as much as two liters. While the esophagus is usually dilated, the stomach on the other hand is often contracted, largely from lack of distention by food, but possibly also because of a spastic state due to the same causes as the phrenospasm. Recently Mosher has demonstrated that hepatic abnormality may furnish an organic cause in many cases formerly considered spasmodic.

The *symptoms of hiatal esophagismus* are variable in degree. Substernal distress, with a feeling of

fullness and pressure followed by eructations of gas and regurgitation of food within a period of a quarter of an hour to several hours after eating, are present. If the esophageal dilatation be great, regurgitation may occur only after an accumulation of several days, when large quantities of stale food will be expelled. The general nutrition is impaired, and there is usually the history of weight loss to a certain level at which it is maintained with but slight variation. This is explained by the trickling of liquified food from the esophageal reservoir into the stomach as the spasm intermittently relaxes, this occurring usually before a serious state of inanition supervenes. At times the hiatal spasms are extremely violent and painful, the pain being referred from the xiphoid region to the back, or upward into the neck. Patients are often conscious of the times of patulency of the esophagus; they will know the esophagus to be open and will eat without hesitation, or will refuse food with the certain knowledge that it will not pass into the stomach. Periods of remission of symptoms for months and years are noted. The neurotic character of the lesion in some cases is evidenced by the occasionally sudden and startling cures following a single dilatation, as well as by the tendency to relapse when the individual is subject to what is for him undue nervous tension. In a very few cases, with patients of rather a stolid type, all neurotic tendencies seem to be absent.

The *diagnosis of hiatal esophagismus* requires the exclusion of local organic esophageal lesions. In the typical case with marked dilatation, the esophagoscopic findings are diagnostic. A white, pasty, macerated mucosa, and normally contracted hiatus esophageus which when found permits the large esophagoscope to pass into the stomach, will be recognized as characteristic by anyone who has seen the condition. In the cases with but little esophageal distension the diagnosis is confirmed by the constancy of the obstruction to a barium mixture at the phrenic level, while at esophagoscopy the usual resistance at the hiatus esophageus is found not to be increased, and no other local lesion is found as the esophagoscope enters the stomach. It is the failure of the diaphragmatic pinchcock to open, as in the normal deglutitory cycle, rather than a spasmodic tightness, that obstructs the food. The presence of organic stenosis at the hiatus may remove the case altogether from the spasmodic class, or a cicatricial or infiltrated narrowing may be the result of static esophagitis. A compressive stenosis due to hepatic abnormality may simulate spasmodic stenosis as shown by Mosher, who believes that 75 per cent of so-called cardiospasms are organic.

Treatment of hiatal esophagismus (so-called cardiospasm) consists in the over-dilatation of the "diaphragmatic pinchcock" or hiatus esophageus, and in proper remedial measures for the removal of the underlying neurosis. The simple passage of the esophagoscope suffices to cure some cases. Further dilatation by endoscopic guidance may be obtained by the introduction of Mosher's divulsor through the esophagoscope, by which accurate placement is obtained. The distension should not usually exceed 25 mm. Numerous water and air bags have been devised for stretching the hiatus, and excellent results have been obtained by their use. Possibly some of the cures have been due to the dilatation of organic lesions, or to the crowding back of an enlarged malposed, or otherwise abnormal left lobe of the liver, which Mosher has shown to be an etiologic factor.

Certain cases prove very obstinate of cure, and require esophageal lavage for the esophagitis, and feedings through the stomach tube to increase nutrition and to dilate the contracted stomach. Gastrostomy for feeding rarely becomes necessary, for a stomach tube can always be placed with the esophagoscope if it will not pass otherwise. Retrograde dilatation with the fingers through a gastrostomy opening has been done, but seems hardly warranted in view of the excellent results obtainable from above. Instructions should be given concerning the proper mastication of food, and during treatment the frequent partaking of small quantities of liquid foods is recommended. Liquids and foods should be neither hot nor cold. The neurologist should be consulted in cases deemed neurotic.

[96a.-Functional hiatal stenosis. Cramp of the diaphragmatic pinchcock (so-called cardiospasm).]

Endocrine imbalance should be investigated and treated, as urged by MacNab.

Esophageal antiperistalsis is the name given by the author to a heretofore undescribed disease associated with regurgitation of food from the esophagus, the food not having reached the stomach. It may be continuous or paroxysmal and may be of so serious a degree as to threaten starvation. The best treatment in severe cases is gastrostomy to put the esophagus at rest. Milder cases get well under liquid diet, rest in bed, endocrine therapy, cure of associated abdominal disease, etcetera.

[251] CHAPTER XXXII—DISEASES OF THE ESOPHAGUS (*Continued*)

CICATRICIAL STENOSIS OF THE ESOPHAGUS

Etiology.—The accidental swallowing of caustic alkali in solutions of lye or proprietary washing and cleansing powders, is the most frequent cause of cicatricial stenosis. Commercial lye preparations are about 95 per cent sodium hydroxide. The cleansing and washing powders contain from eight to fifty per cent of caustic alkali, usually soda ash, and are sold by grocers everywhere. The labels on their containers not only give no warning of the dangerous nature of the contents nor antidotal advice, but have such directly misleading statements as : "Will not injure the most delicate fabric," "Will not injure the hands," etc. Utensils used to measure or dissolve the powders are afterward used for drinking, without rinsing, and thus the residue of the powder remaining is swallowed in strong solution. At other times solutions of lye are drunk in mistake for water, coffee, or wine. These entirely preventable accidents would be rare if they were as conspicuously labelled "Poison" as is required by law in the case of these and any other poisons, when sold by druggists. The necessity for such labelling is even greater with the lye preparations because they go into the kitchen, whereas the drugs go to the medicine shelf, out of the reach of children. "Household ammonia," "salts of tartar" (potassium carbonate), "washing soda" (sodium carbonate), mercuric chloride, and strong acids are also, though less frequently, the cause of cicatricial esophageal stricture. Tuberculosis, lues, scarlet fever, diphtheria, enteric fever and pyogenic conditions may produce ulceration followed by cicatrices of the esophagus. Spasmodic stenosis with its consequent esophagitis and erosions, and, later, secondary pyogenic infection, may result in serious cicatrices. Peptic ulcer of the lower esophagus may be a cause. The prolonged sojourn of a foreign body is likely to result in cicatricial narrowing.

[FIG. 97.—Schematic illustration of a series of eccentric strictures with interstrictural sacculations, in the esophagus of a boy aged four years. The strictures were divulsed seriatim from above downward with the divulsor, the esophageal wall, D, being moved sidewise to the position of the dotted line by means of a small esophagoscope inserted through the upper stricture, A, after divulsion of the latter.]

Location of Cicatricial Esophageal Strictures.—The strictures are often multiple and their lumina are rarely either central or concentric (Fig. 97). In order of frequency the sites of cicatricial stenosis are: 1. At the crossing of the left bronchus; 2. In the region of the cricopharyngeus; 3. At the hiatal level. Stricture at the cardia has rarely been encountered in the Bronchoscopic Clinic. Stenosis of the pylorus has been noted, but is rare.

Prognosis.—Spontaneous recovery from cicatricial stenosis probably never occurs, and the mortality of untreated small lumen strictures is very high. Blind methods of dilatation are almost certain to result in death from perforation of the esophageal wall, because some pressure is necessary to dilate a stricture, and the point of the bougie, not being under guidance of the eye, is certain at sometime or other to be engaged in a pocket instead of in the stricture. Pressure then results in perforation of the bottom of the pocket (Fig. 98). This accident is contributed to by dilatation with the wrinkled, scarred floor which usually develops above the stricture. Rapid divulsion and internal esophagotomy are mechanically very easily and accurately done through the esophagoscope, and would yield a few prompt cures; but the mortality would be very high. Under certain circumstances, to be explained below, gentle divulsion of the proximal one of a series of strictures has to be done. With proper precautions and a gentle hand, the risk is slight. Under esophagoscopic bouginage the prognosis is favorable as to ultimate cure, the duration of the treatment varying with the number of strictures, the tightness, and the extent of the fibrous tissue-changes in the esophageal wall. Mortality from the endoscopic procedure is almost nil, and if gastrostomy is done early in the tightly stenosed cases, ultimate cure may be confidently expected with careful though prolonged treatment.

[FIG. 98.—Schema illustrating the mechanism of perforation by blind bouginage. On encountering resilient resistance the operator, having a false conception, pushes on the bougie. Perforation results because in reality the bougie is in a pocket of the suprastrictural eccentric dilatation.]

Symptoms.—Dysphagia, regurgitation, distress after eating, and loss of weight, vary with the degree of the stenosis. The intermittency of the symptoms is sometimes confusing, for the lodgment of relatively large particles of food often simulates a spasmodic stenosis, and in fact there is often an element of spasm which holds the foreign body in the strictured area until it relaxes. Static esophagitis results in a swelling of the esophageal walls and a narrowing of the lumen, so that swallowing is more or less troublesome until the esophagitis subsides.

Esophagoscopic Appearances of Cicatricial Stenosis.—The color of the cicatricial area is usually paler than the normal mucosa. The scars may be very white and elevated, or they may be flush with the normal mucosa, or even depressed. Occasionally the cicatrix is annular, but more often it is eccentric and involves only a part of the circumference of the wall. If the amount of scar tissue is small, the lumen maintains its mobility; opens and closes during respiration, cough, and vomiturition. Between two strictures there is often a pouch containing food remnants. It is rarely possible to see the lumen of the second stricture, because it is usually eccentric to the first. Stagnation of food results in superjacent dilatation and esophagitis. Erosions and ulcerations which follow the stagnation

esophagitis increase the cicatricial stenosis in their healing.

Differential Diagnosis.—When the underlying condition is masked by inflammation and ulceration, these lesions must be removed by frequent lavage, the administration of bismuth subnitrate with the occasional addition of calomel powder, and the limitation of the diet to strained liquids. The cicatricial nature of the stenosis can then be studied to better advantage. In most cases the cicatrices are unmistakably conspicuous. Spasmodic stenoses are differentiated by the absence of cicatrices and the yielding of the stenosis to gentle but continuous pressure of the esophagoscope. While it is possible that spasmodic stenosis may supplement cicatricial stenosis, it is certainly exceedingly rare. Nearly all of the occasions in which a temporary increase of the stenosis in a cicatricial case is attributed to an element of spasm, the real cause of the intermittency is not spasm but obstruction caused by food. This occurs in three ways: 1. Actual "corking" of the strictured lumen by a fragment of food, in which case intermittency may be due to partial regurgitation of the "corking" mass with subsequent sinking tightly into the stricture. 2. The "cork" may dissolve and pass on through to be later replaced by another. 3. Reactionary swelling of the esophageal mucosa due to stagnation. Here again the obstruction may be prolonged, or it may be quite intermittent, due to a valve-like action of the swollen mucosal surfaces or folds intermittently coming in contact. Cancerous stenosis is accompanied by infiltration of the periesophageal tissue, and usually by projecting bleeding fungations. Cancer may, however, develop on a cicatrix, favored no doubt by chronic inflammation in tissue of low resistance. Compression stenosis of the esophagus is characterized by the sudden transition of the lumen to a linear or crescentic outline, while the covering mucosa is normal unless esophagitis be present. The compressive mass can be detected by the sensation transmitted to the touch by the esophagoscope.

Treatment.—Blind bouginage should be discarded as an obsolete and very dangerous procedure. If the stenosis be so great as to interfere with the ingestion of the required amount of liquids, gastrostomy should be done at once and esophagoscopic treatment postponed until water hunger has been relieved. Gastrostomy aids in the treatment by putting the esophagus at rest, and by affording the means of maintaining a high degree of nutrition unhampered by the variability or efficiency of the swallowing function. Careful diet and gentle treatment will, however, usually avoid gastrostomy. The diet in the gastrostomy-fed patients should be as varied as in oral alimentation; even solids of the consistency of mashed potatoes, if previously forced through a wire gauze strainer, may be forced through the tube with a glass injector. Liquids and readily liquefiable foods are to be given the non-gastrostomized patient, solids being added when demonstrated that no stagnation above the stricture occurs. Thorough mastication and the slow partaking of small quantities at a time are imperative. Should food accumulation occur, the esophagus should be emptied by regurgitation, following which a glassful of warm sodium bicarbonate solution is to be taken, and this also regurgitated if it does not go through promptly. The esophagus is thus lavaged and emptied. In all these cases, whether being fed through the mouth or the gastrostomic tube, it is very important to remember that milk and eggs are not a complete dietary. A pediatrist should be consulted. Prof. Graham has saved the lives of many children by solving the nutritive problems in the cases at the Bronchoscopic Clinic. Fruit and vegetable juices are necessary. Vegetable soups and mashed fruits should be strained through a wire gauze coffee strainer. If the saliva is spat out by the child because it will not go through the stricture the child should be taught to spit the saliva into the funnel of the abdominal tube. This method of improving nutrition was discovered by Miss Groves at the Bronchoscopic Clinic.

Esophagoscopic bouginage with the author's silk-woven steel-shank endoscopic bougies (Fig. 40) has proven the safest and most successful method of treatment. The strictured lumen is to be centered in the esophagoscopic field, and three successively increasing sizes of bougies are used under direct vision. Larger and larger bougies are used at the successive treatments which are given at intervals of from four to seven days. No anesthesia, general or local, is used for esophagoscopic bouginage. The tightness of the grasping of the bougie by the stricture on withdrawal, determines the limitation of sizes to be used. When the upper stricture is dilated, lower ones in the series are taken seriatim. If concentric, two or more closely situated strictures may be simultaneously dilated. For the use of bougies of the larger sizes, the special esophagoscopes with both the light-carrier canal and the drainage canal outside the lumen of the tube are needed. Functional cure is obtained with a relatively small lumen at the point of stenosis. A lumen of 7 mm. will allow the passage of any well masticated food. It is unwise and unsafe to attempt to restore the lumen to its normal anatomic size. In cicatricial stricture cases it is advisable to examine the esophagus at monthly periods for a time after a functional cure has been obtained, in order that tendency to recurrence may be early detected.

Divulsion of an upper stricture may be deemed advisable in order to reach others lower down, especially in cases of multiple eccentric strictures (Fig. 97). This procedure is best done with the author's esophagoscopic divulser, accurately placed by means of the esophagoscope; but divulsion requires the utmost care, and a gentle hand. Even then it is not so safe as esophagoscopic bouginage.

Internal esophagotomy by the string-cutting instruments and esophagotome are relatively dangerous

methods, and perhaps yield in the end no quicker results than the slower and safe bouginage per tubam.

Electrolysis has been used with varying results in the treatment of cicatricial stenosis.

Thermic bouginage with electrically heated bougies has been found useful in some cases by Dean and Imperatori.

[258] *String-swallowing*, with the passage of olives threaded over the string has yielded good results in the hands of some operators. The string may be used to pull up dilators in increasing sizes, introduced through a gastrostomic fistula. The string stretched across the stomach from the cardia to the pylorus, is fished out with the author's pillar retractor, or is found with the retrograde esophagoscope (Fig. 43). The string is attached to a dilator (Fig. 35), and a fresh string is pulled in to replace the one pulled out. This is the safest of the blind methods. It is rarely possible to get a child under two years of age to swallow and tolerate a string. It is better after each treatment to draw the upper end of the string through the nose, as it is not so likely to be chewed off and is less annoying. With the esophagoscope, the string is not necessary, because the lumen of the stricture can be exposed to view by the esophagoscope.

Retrograde esophagoscopy through a gastrostomy wound offers some advantages over peroral treatment; but unless the gastrostomy is high, the procedure is undoubtedly more difficult. The approach to the lowest stricture from below is usually funnel shaped and free from dilatation and redundancy. It must be remembered the stricture seen from below may not be the same one seen from above. Roentgenray examination with barium mixture or esophagoscopes simultaneously in situ above and below are useful in the study of such cases.

Impermeable strictures of the cervical esophagus are amenable to external esophagotomy, with plastic reformation of the esophagus. Those in the middle third have not been successfully treated by surgical methods, though various ingenious operations for the formation of an extrathoracic esophagus have been suggested as means of securing relief. Impermeable strictures of the lower third can with reasonable safety be treated by the Brenneman method, which consists in passing the esophagoscope down to the stricture while the surgeon, inserting his finger up into the esophagus from the stomach, can feel the end of the esophagoscope. An incision through the tissue barrier is then made from below, passing the knife along the finger as a guide. A soft rubber stomach-tube is pulled up from below and left in situ, being replaced at intervals by a fresh one, pulled up from the stomach, until epithelialization of the new lumen is complete. Catheters are used in children. In replacing the catheter or stomach tube the fresh one is attached to the old one by stitching in a loop of braided silk. Frequent esophagoscopic bouginage will be required to maintain the more or less fistulous lumen until it is epithelialized, and in occasional cases, for a long time thereafter.

In cases of absolute atresia the saliva does not reach the stomach. No one realizes the quantity of normal salivary drainage, nor its importance in nutritive processes. Oral insalivation is of little consequence compared to esophagogastric drainage. Gastrostomized children with absolute atresia of the esophagus do not thrive unless they regurgitate the salivary accumulations into the funnel of the gastrostomic feeding tube. This has been abundantly proven by observations at the Bronchoscopic Clinic. My attention was first called to this clinical fact by Miss Frances Groves who has charge of these cases.

Intubation of the esophagus with soft rubber tubes has occasionally proven useful.

[260] CHAPTER XXXIII—DISEASES OF THE ESOPHAGUS (*Continued*)

DIVERTICULUM OF THE ESOPHAGUS

Diverticula may, and usually do, consist in a pouching by herniation, of the whole thickness of the esophageal wall; or they may be herniations of the mucosa between the muscular layers. They are classified according to their etiology, as traction and pulsion diverticula.

[FIG. 99.—Traction diverticulum of the esophagus rendered visible in the roentgenogram by a swallowed opaque mixture. Case of H. W. Dachtler, Am. Journ. Roentgenology.]

Traction diverticulum of the esophagus (Fig. 99) is a rare condition, usually occurring in the thorax, and as a rule constituting a one-sided enlargement of the gullet rather than a true pouch formation. It is supposed to be formed by the pulling during cough, respiration, and swallowing, on localized adhesions of the esophagus to periesophageal structures, such as inflammatory peribronchial glands.

Diagnosis is often incidental to examination of the gastrointestinal tract for other conditions, because traction diverticula usually cause no symptoms. Unless a very large esophagoscope be used, a traction diverticulum may easily be overlooked in the mucosal folds. Careful lateral search, however, will reveal the dilatation, and the localized periesophageal fixation may be demonstrated. The subdiverticular esophagus is readily followed, its lumen opening during inspiration unless very close to the diaphragm, which is very rare. Perhaps most cases will be discovered by the roentgenologist. It has been said that traction diverticula are more readily demonstrated in the roentgenologic examination, if the patient be placed with pelvis elevated.

Pulsion diverticulum of the esophagus is an acquired hernia of the mucosa between the circular and oblique fibers of the inferior constrictor muscle of the pharynx. A congenital anatomic basic factor in etiology probably exists. The pouching develops in the middle part of the posterior wall, between the orbicular and oblique fibers of the cricopharyngeus muscle, at which point there is a gap, leaving the mucosa supported only by a not very resistant fascia (Fig. 100). When small, the sac is in the midline, but with increase in size, it presents either to the right or the left side, commonly the latter. The sac may be very small, or it may be sufficiently large to hold a pint or more, and to cause the neck to bulge when filled. When large, the pouch extends into the mediastinum. It will be seen that anatomically the pulsion diverticulum has its origin in the pharynx; the symptoms, however, are referable to the esophagus and the subdiverticular esophagus is stenosed by compression of the pouch; therefore, it is properly classified as an esophageal disease.

[FIG. 100.—Schema illustrative of the etiology of pressure diverticula. O, oblique fibers of the cricopharyngeus attached to the thyroid cartilage, T. The fundiform fibers, F, encircle the mouth of the esophagus. Between the two sets of fibers is a gap in the support of the esophageal wall, through which the wall herniates owing to the pressure of food propelled by the oblique fibers, O, advance of the bolus being resisted by spasmodic contraction of the orbicular fibers, F.]

Etiology.—Pressure diverticula occur after middle life, and more often in men than in women. The hasty swallowing of unmasticated food, too large a bolus, defective or artificial teeth, flaccidity of tissues, and spasm of the cricopharyngeus muscle, are etiologic factors. Cicatricial stenosis below the level of the inferior constrictor is a contributory cause in some cases.

Prognosis.—After the pouch is formed, it steadily increases in size, since the swallowed food first fills and distends the sac before the overflow passes down the esophagus. When a pendulous sac becomes filled with food, it presses on the subdiverticular esophagus, and produces compression stenosis; so that there exists a "vicious circle." The enlargement of the sac produces increasing stenosis with consequent further distension of the pouch. This explains the clinically observed fact, that unless treated, pulsion diverticula increase progressively in size, and consequently in distressing symptoms. The sac becomes so large in some cases as to contribute to the occurrence of cerebral apoplexy by interference with venous return. Practically all cases can be cured by radical operation. The operative mortality varies with the age, state of nutrition, and general health of the patient. In general it may be said to have a mortality of at least 10 per cent, largely due to the fact that most cases are poor surgical subjects. Recurrences after radical operation are due to a persistence of the original causes, i.e., bolting of food; stenosis, spasmodic or organic, of the esophageal lumen; and weakness in the support of the esophageal wall, which, unsupported, has little strength of its own.

Symptoms.—Dysphagia, regurgitation, a gurgling sound and subjective bubbling sensation on swallowing, sour odor to the breath, and cough, are the chief symptoms. With larger pouches, emaciation, pressure sensation in the neck and upper mediastinum, and the presence of a mass in the neck when the sac is filled, are present. Tracheal compression by the filled pouch may produce dyspnea. The sac may be emptied by pressure on the neck, this means of relief being often discovered by the patient. The sac sometimes spontaneously empties itself by contraction of its enveloping muscular layer, and one of the most annoying symptoms is the paroxysm of coughing, waking the patient, when during the relaxation of sleep the sac empties itself into the pharynx and some of its contents are aspirated into the larynx. There are no pathognomonic symptoms. Those recited are common to other forms of esophageal stenosis, and are urgent indications for diagnostic esophagoscopy.

Diagnosis.—Roentgenray study with barium mixtures, is the first step in the diagnosis (Fig. 101). This is to be followed by diagnostic esophagoscopy. Malignant, spasmodic, cicatricial, and compression stenosis are to be excluded by esophagoscopic appearances. Aneurysm is to be eliminated by the usual means. The Boyce sign is almost invariably present, and is diagnostic. It is elicited by telling the patient to swallow, which action imprisons air in the sac. The imprisoned air is forced out by finger-pressure on the neck, over the sac. The exit of the air bubble produces a gurgling sound audible at the open mouth of the patient.

Esophagoscopic Appearances in Pulsion Diverticulum.—The esophagoscope will without difficulty enter the mouth of the sac which is really the whole bottom of the pharynx, and will be arrested by the blind end of the pouch, the depth of which may be from 4 to 10 cm. In some cases the bottom of the pouch is in the mediastinum. The walls are often pasty, and may be eroded, or ulcerated, and they may show vessels or cicatrices. On withdrawing the tube and searching the anterior wall, the subdiverticular slit-like opening of the esophagus will be found, though perhaps not always easily. The esophageal speculum will be found particularly useful in exposing the subdiverticular orifice, and through this a small esophagoscope may be passed into the esophagus, thus completing the diagnosis. Care must be exercised not to perforate the bottom of the diverticular pouch by pressure with the esophagoscope or esophageal speculum. The walls of the sac are surprisingly thin.

[FIG. 101.—Pulsion diverticulum filled with bismuth mixture in a man of fifty years.]

Treatment of Pulsion Diverticulum.—If the pouch is small, the subdiverticular esophageal orifice may be dilated with esophagoscopic bougies, thus overcoming the etiologic factor of spastic or organic stenosis. The redundancy remains, however, though the symptoms may be relieved. Cutting the common wall between the esophagus and the sac by means of scissors passed through the endoscopic tube, has been successfully done by Mosher.

Various methods of external operation have been devised, among which are: (1) Freeing the sac through an external cervical incision and suturing its fundus upward against the pharynx, which has proved successful in some cases. (2) Inversion of the sac into the pharynx and suture of the mouth of the pouch. In a case so treated the pouch was blown out again during a fit of sneezing eight months after operation. (3) Plication of the walls of the sac by catgut sutures, as in the Matas obliterative operation for aneurysm. (4) Freeing and removing the sac, with suture of the esophageal wound. (5) Removal of the sac by a two-stage operation, in which method the initial step is the deliverance of the sac into the cervical wound, where it remains surrounded by gauze packing until adhesions have walled off the mediastinum. The work is completed by cutting off the sac and either suturing the esophageal wound or touching it with the cautery, and allowing it to heal by granulation. External exposure and amputation of the sac has been more frequently done than any other operation. Unless the pouch is large, it is extremely difficult to find after the surgeon has exposed the esophagus, for the reasons that at operation it is empty and that when the adhesions about it are removed the walls of the sac contract. After removal, the sac is disappointingly small as compared with its previous size in the roentgenogram, which shows it distended with opaque material. It has been the chagrin of skilled surgeons to find the diverticulum present functionally and roentgenographically precisely the same as before the performance of the very trying and difficult operation. The time of operation may be shortened at least by one-half by the aid of the esophagoscopist in the Gaub-Jackson operation. Intratracheally insufflated ether is the anesthesia of choice. After the surgeon has exposed the esophagus by dissection, the endoscopist introduces the esophagoscope into the sac, and delivers it into the wound, while the surgeon frees it from adhesions. The esophagoscope is now withdrawn from the pouch and entered into the esophagus proper, below the diverticulum, while the surgeon cuts off the hernial sac and sutures the esophagopharyngeal wound over the esophagoscope. The presence of the esophagoscope prevents too tight suture and possible narrowing of the lumen (Fig. 102).

[FIG. 102.—Schematic representation of esophagoscopic aid in the excision of a diverticulum in the Gaub-Jackson operation. At A the esophagoscope is represented in the bottom of the pouch after the surgeon has cut down to where he can feel the esophagoscope. Then the esophagoscopist causes the pouch to protrude as shown by the dotted line at B. After the surgeon has dissected the sac entirely loose from its surroundings, traction is made upon the sac as shown at H and the esophagoscope is inserted down the lumen of the esophagus as shown at C. The esophagoscope now occupies the lumen which the patient will need for swallowing. It only remains for the surgeon to remove the redundancy, without risk of removing any of the normal wall. The esophagoscope here shown is of the form squarely cut off at the end. The standard form of instrument with slanted end will serve as well.]

After-care.—Feeding may be carried on by the placing of a small nasal feeding tube into the stomach at the time of operation. Gastrostomy for feeding as a preliminary to the esophageal operation has been suggested, and is certainly ideal from the viewpoint of nutrition and esophageal rest. The decision of its performance may perhaps be best made by the patient himself. Should leakage through the neck occur, the fistula should be flushed by the intake of sterile water by mouth. Oral sepsis should, of course, be treated before operation and combated after operation by frequent brushing of the teeth and rinsing of the mouth with Dakin's solution, one part, to ten parts of peppermint water. A postoperative barium roentgenogram should be made in every case as a matter of record and to make certain the proper functioning of the esophagus.

PARALYSIS OF THE ESOPHAGUS

The passage of liquids and solids through the esophagus is a purely muscular act, controlled, after the propulsive usually voluntary start given to the bolus by the inferior constrictor, by a reflex arc having connection with the central nervous system through the vagus nerve. Gravity plays little or no part in the act of deglutition, and alone will not carry food or drink to the stomach. Paralysis of the esophagus may be said to be motor or sensory. It is rarely if ever unassociated with like lesions of contiguous organs.

Motor paralysis of the esophagus is first manifested by inability to swallow. This is associated with the accumulation of secretion in the pyriform sinuses (the author's sign of esophageal stenosis) which overflows into the larynx and incites violent coughing. Motor paralysis may affect the constrictors or the esophageal muscular fibers or both.

Sensory paralysis of the esophagus by breaking the continuity of the reflex arc, may so impair the peristaltic movements as to produce aphagia. The same filling of the pyriform sinuses will be noted, but as the larynx is usually anesthetic also, it may be that no cough is produced when secretions overflow into it.

Etiology.—1. Toxic paralysis as in diphtheria.
2. Functional paralysis as in hysteria.
3. Peripheral paralysis from neuritis.
4. Central paralysis, usually of bulbar origin.

Embolism or thrombosis of the posterior cerebral artery is a reported cause in two cases. Lues is always to be excluded as the fundamental factor in the groups 3 and 4. Esophageal paralysis is not uncommon in myasthenia gravis.

Esophagoscopic findings are those of absence of the normal resistance at the cricopharyngeus, flaccidity and lack of sensation of the esophageal walls, and perhaps adherence of particles of food to the folds. The hiatal contraction is usually that normally encountered, for this is accomplished by the diaphragmatic musculature. In paralysis of sensation, the reflexes of coughing, vomiturition and vomiting are obtunded.

Diagnosis.—Hysteria must not be decided upon as the cause of dysphagia, until after esophagoscopy has eliminated paralysis. Dysphagia after recent diphtheria should suggest paralysis of the esophagus. The larynx, lips, tongue, and pharynx also, are usually paralyzed in esophageal paralysis of bulbar origin. The absence of the cricopharyngeal resistance to the esophagoscope passed without anesthesia, general or local, is diagnostic.

Treatment.—The internist and neurologist should govern the basic treatment. Nutrition can be maintained by feeding with the stomach-tube, which meets no resistance to its passage. Should this be contraindicated by ulceration of the esophagus, gastrostomy should be done.

LUES OF THE ESOPHAGUS

Esophageal syphilis is a rather rare affection, and may show itself as a mucous plaque, a gumma, an ulceration, or a cicatrix. Cicatricial stenosis developing late in life without history of the swallowing of escharotics or ulcerative lesions is strongly suggestive of syphilis, though the late manifestation of a congenital stenosis is a possibility.

Esophagoscopic appearances of lues are not always characteristic. As in any ulcerative lesion, the inflammatory changes of mixed infections mask the basic nature. The mucous plaque has the same appearance as one situated on the velum, and gummata resemble those seen in the mucosa elsewhere. There is nothing characteristic in luetic cicatrices.

The diagnosis of luetic lesions of the esophagus, therefore, depends upon the history, presence of luetic lesions elsewhere, the serologic reaction, therapeutic test, examination of tissue, and the demonstration of the treponema pallidum. The therapeutic test by prolonged saturation of the system with mercury is imperative in all suspected cases and no other negative result should be deemed sufficient.

The treatment of luetic esophagitis is systemic, not local. Luetic cicatrices contract strongly, and are very resistant to treatment, so that esophagoscopic bouginage should be begun as early as possible after the healing of a luetic ulceration, in order to prevent stenosis. A silk-woven endoscopic bougie placed in position by ocular guidance, and left *in situ* for from half to one hour daily, may prevent

severe contraction, if used early in the stage of cicatrization. Prolonged treatment is required for the cure of established luetic cicatricial stenosis. If gastrostomy has been done retrograde bouginage (Fig. 35) may be used.

TUBERCULOSIS OF THE ESOPHAGUS

Esophageal tuberculosis is not commonly met, but is probably not infrequently associated with the dysphagia of tuberculous laryngitis. It may rarely occur as a primary infection, but usually the esophagus is involved in an extension from a tuberculous process in the larynx, mediastinal lymphatics, pleura, bronchi, or lungs.

Primary lesions appear as superficial erosions or ulcerations, with a surrounding yellowish granular zone, or the granules may alone be present. The mucosa in tuberculous lesions is usually pallid, the absence of vascularity being marked. Invasion from the periesophageal organs produces more or less localized compression and fixation of the esophagus. The character of open ulceration is modified by the mixed infections. Healed tuberculous lesions, sometimes resulting from the evacuation of tuberculous mediastinal lymph nodes into the esophagus may be encountered. The local fixation and cicatricial contraction may be the site of a traction diverticulum. Tuberculous esophago-bronchial fistulae are occasionally seen.

Diagnosis, to be certain, requires the demonstration of the tubercule bacilli and the characteristic cell accumulation of the tubercle in a specimen of tissue removed from the lesion. Actinomycosis must be excluded, and the possibility of mixed luetic and tuberculous lesions is to be kept in mind. Post-tuberculous cicatrices have no recognizable characteristics.

Treatment.—The maintenance of nutrition to the highest degree, and the institution of a strict antituberculous regime are demanded. Local applications are of no avail. Gastrostomy for feeding should be done if dysphagia be severe, and has the advantage of putting the esophagus at rest. The passage of a stomach-tube for feeding purposes may be done, but it is often painful, and is dangerous in the presence of ulceration. Pain is not marked if the lesion be limited to the esophagus, though if it is present orthoform, anesthesin, or apothesin, in powder form, swallowed dry, may prove helpful.

VARIX AND ANGIOMA OF THE ESOPHAGUS

These lesions are sometimes the cause of esophageal hemorrhage, the regurgitated blood being bright red, and alkaline in reaction, in contradistinction to the acid "coffee ground" blood of gastric origin. Esophageal varices may coexist with the common dilatation of the venous system in which the veins of the rectum, scrotum, and legs are most conspicuously affected. Cirrhosis and cancer of the liver may, by interference with the portal circulation, produce dilatation of the veins in the lower third of the esophagus. Angioma of the esophagus is amenable to radium treatment.

ACTINOMYCOSIS OF THE ESOPHAGUS

Esophageal actinomycosis has been autoptically discovered. Its diagnosis, and differentiation from tuberculosis, would probably rest upon the microscopic study of tissue removed esophagoscopically, though as yet no such case has been reported.

ANGIONEUROTIC EDEMA

Angioneurotic edema involving the esophagus, may produce intermittent and transient dysphagia. The lesions are rarely limited to the esophagus alone; they may occur in any portion of the gastrointestinal, genitourinary, or respiratory tracts, and concomitant cutaneous manifestations usually render the diagnosis clear. The treatment is general.

DEVIATION OF THE ESOPHAGUS

Deviation of the esophagus may be marked in the presence of a deformed vertebral column, though dysphagia is a very uncommon symptom. The lack of esophageal symptoms in deviation of spinal production is probably explained by the longitudinal shortening of the spine which accompanies the deflection. Compression stenosis of the esophagus is commonly associated with deviations produced by a thoracic mass.

[PLATE IV

A, Gastroscopic view of a gastrojejunostomy opening drawn patulous by the tube mouth. (Gastrojejunostomy done by Dr. George L. Hays.) B, Carcinoma of the lesser curvature. (Patient

afterward surgically explored and diagnosis verified by Dr. John J. Buchanan.) C, Healed perforated ulcer. (Patient referred by Dr. John W. Boyce.)

Drawn from a case of postdiphtheric subglottic stenosis cured by the author's method of direct galvanocauterization of the hypertrophies. A, Immediately after removal of the intubation tube; hypertrophies like turbinals are seen projecting into the subglottic lumen. B, Five minutes later; the masses have now closed the lumen almost completely. The patient became so cyanotic that a bronchoscope was at once introduced to prevent asphyxia. C, The left mass has been cauterized by a vertical application of the incandescent knife. D, Completely and permanently cured after repeated cauterizations. Direct view; recumbent patient.

PHOTOPROCESS REPRODUCTIONS OF THE AUTHOR'S OIL-COLOR DRAWINGS FROM LIFE]

[273] CHAPTER XXXV—GASTROSCOPY

The stomach of any individual having a normal esophagus and normal spine can be explored with an open-tube gastroscope. The adult size esophagoscope being 53 cm. long will reach the stomach of the average individual. Longer gastroscopes are used, when necessary, to explore a ptosed stomach. Various lens-system gastroscopes have been devised, which afford an excellent view of the walls of the air-inflated stomach. The optical system, however, interferes with the insertion of instruments, so that the open-tube gastroscope is required for the removal of gastric foreign bodies, the palpation of, or sponging secretions from, gastric lesions. The open-tube gastroscope may be closed with a window plug (Fig. 6) having a rubber diaphragm with a central perforation for forceps, when it is desired to inflate the stomach.

Technic.—Relaxation by general anesthesia permits lateral displacement of the dome of the diaphragm along with the esophagus, and thus makes possible a wider range of motion of the distal end of the gastroscope. All of the recent gastroscopies in the Bronchoscopic Clinic, however, have been performed without anesthesia. The method of introduction of the gastroscope through the esophagus is precisely the same as the introduction of the esophagoscope (q.v.). It should be emphasized that with the lens-system gastroscopes, the tube should be introduced into the stomach under direct ocular guidance, without a mandrin, and the optical apparatus should be inserted through the tube only after the stomach has been entered. Blind insertion of a rigid metallic tube into the esophagus is an extremely dangerous procedure.

The descriptions and illustrations of the stomach in anatomical works must be disregarded as cadaveric. In the living body, the empty stomach is usually found, on endoscopic inspection, to be a collapsed tube of such shape as to fit whatever space is available at the particular moment, with folds and rugae running in all directions, the impression given as to form being strikingly like searching among a mass of earth worms or boiled spaghetti. The color is pink, under proper illumination, if no food is present. Poor illumination may make the color appear deep crimson. If food is present, or has just been regurgitated, the color is bright red. To appreciate the appearance of gastritis, the eye must have been educated to the endoscopic appearances under a degree of illumination always the same. The left two-thirds of the stomach is most easily examined. The stomach wall can be pushed by the tube into almost any position, and with the aid of gentle external abdominal manipulation to draw over the pylorus it is possible to examine directly almost all of the gastric walls except the pyloric antrum, which is reachable in relatively few cases. A lateral motion of from 10 to 17 cm. can be imparted to the gastroscope, provided the diaphragmatic musculature is relaxed by deep anesthesia. The stomach is explored by progressive traverse. That is, after exploring down to the greater curvature, the tube-mouth is moved laterally about 2 centimeters, and the withdrawing travel explores a new field. Then a lateral movement affords a fresh field during the next insertion. This is repeated until the entire explorable area has been covered. Ballooning the stomach with air or oxygen is sometimes helpful, but the distension fixes the stomach, lessens the mobility of the arch of the diaphragm, and thus lessens the lateral range of gastroscopic vision. Furthermore, ballooning pushes the gastric walls far away from the reach of the tube-mouth. A window plug (Fig. 6) is inserted into the ocular end of the gastroscope for the ballooning procedure.

[275] Like many other valuable diagnostic means, gastroscopy is very valuable in its positive findings. Negative results are entitled to little weight except as to the explorable area.

The gastroscopist working in conjunction with the abdominal surgeon should be able to render him invaluable assistance in his work on the stomach. The surgeon with his gloved hand in the abdomen, by manipulating suspected areas of the stomach in front of the tube-mouth can receive immediately a report of its interior appearance, whether cancerous, ulcerated, hemorrhagic, etc.

Lens-system ballooning gastroscopy may possibly afford additional information after all possible data from open-tube gastroscopy has been obtained. Care must be exercised not to exert an injurious degree of air-pressure. The distended portion of the stomach assumes a funnel-like form ending at the apex in a depression with radiating folds, that leads the observer to think he is looking at the pylorus. The foreshortening produced by the lens system also contributes to this illusion. The best lens-system gastroscope is that of Henry Janeway, which combines the open-tube and the lens system.

Gastroscopy for Foreign Bodies.—The great majority of foreign bodies that reach the stomach unassisted are passed per rectum, provided the natural protective means are not impaired by the administration of cathartics, changes in diet, etcetera. This, however, does not mean that esophageal foreign bodies should be pushed into the stomach by blind methods, or by esophagoscopy, because a swallowed object lodged in the esophagus can always be returned through the mouth. Foreign bodies in the stomach and intestines should be fluoroscopically watched each second day. If an object is seen to lodge five days in one location in the intestines, it should be removed by laparotomy, since it will almost certainly perforate. Certain objects reaching the stomach may be judged too large to pass the pylorus and intestinal angles. These should be removed by gastroscopy when such decision is made. It is to be remembered that gastric foreign bodies may be regurgitated and may lodge in the esophagus, whence they are easily removed by esophagoscopy. The double-planed fluoroscope of Manges is helpful in the removal of gastric foreign bodies, but there is great danger of injury to the stomach walls, and even the peritoneum, unless forceps are used with the utmost caution.

[277] CHAPTER XXXVI—ACUTE STENOSIS OF THE LARYNX

Etiology.—Causes of a relatively sudden narrowing of the lumen of the larynx and subjacent trachea are included in the following list. Two or more may be combined.

1. Foreign body.
2. Accumulation of secretions or exudate in the lumen.
3. Distension of the tissues by air, inflammatory products, serum, pus, etc.
4. Displacement of relatively normal tissues, as in abductor paralysis, congenital laryngeal stridor, etcetera.
5. Neoplasms.
6. Granulomata.

Edema of the larynx may be at the glottic level, or in the supraglottic or subglottic regions. The loose cellular tissue is most frequently concerned in the process rather than the mucosal layer alone. In children the subglottic area is very vascular, and swelling quickly results from trauma or inflammation, so that acute stenosis of the larynx in children commonly has its point of narrowing below the cords. Dyspnea, and croupy, barking, cough with no change in the tone or pitch of the speaking voice are characteristic signs of subglottic stenosis. Edema may accompany inflammation of either the superficial or deep structures of the larynx. The laryngeal lesion may be primary, or may complicate general diseases; among the latter, typhoid fever deserves especial mention.

Acute laryngeal stenosis complicating typhoid fever is frequently overlooked and often fatal, for the asthenic patient makes no fight for air, and hoarseness, if present, is very slight. The laryngeal lesion may be due to cordal immobility from either paralysis or inflammatory arytenoid fixation, in the absence of edema. Perichondritis and chondritis of the laryngeal cartilages often follow typhoid ulceration of the larynx, chronic stenosis resulting.

Laryngeal stenosis in the newborn may be due to various anomalies of the larynx or trachea, or to traumatism of these structures during delivery. The normal glottis in the newborn is relatively narrow, so that even slight encroachment on its lumen produces a serious degree of dyspnea. The characteristic signs are inspiratory indrawing of the supraclavicular fossae, the suprasternal notch, the epigastrium, and the lower sternum and ribs. Cyanosis is seen at first, later giving place to pallid asphyxia when cardiac failure occurs. Little air is heard to enter the lungs, during respiratory efforts and the infant, becoming exhausted by the great muscular exertion, soon ceases to breathe. Paralytic stenosis of the larynx sometimes follows difficult forceps deliveries during which stretching or compression of the recurrent nerves occur.

Acute laryngeal stenosis in infants, from laryngeal perichondritis, may be a delayed result of traumatism to the laryngeal cartilages during delivery. The symptoms usually develop within four weeks after birth. Lues and tuberculosis are possible factors to be eliminated by the usual methods.

Surgical Treatment of Acute Laryngeal Stenosis.—Multiple puncture of acute inflammatory edema,

while readily performed with the laryngeal knife used through the direct laryngoscope, is an uncertain measure of relief. Tracheotomy, if done low in the neck, will completely relieve the dyspnea. By its therapeutic effect of rest, it favors the rapid subsidence of the inflammation in the larynx and is the treatment to be preferred. Intubation is treacherous and unreliable except in diphtheritic cases; but in the diphtheritic cases it is ideal, if constant skilled watching can be had.

[279] CHAPTER XXXVII—TRACHEOTOMY

Indications.—Tracheotomy is indicated in dyspnea of laryngotracheal origin. The cardinal signs of this form of dyspnea are:

1. Indrawing at the suprasternal notch.
2. Indrawing around the clavicles.
3. Indrawing of the intercostal spaces.
4. Restlessness.
5. Choking and waking as soon as the aid of the voluntary respiratory muscles ceases in falling to sleep.
6. Cyanosis is a dangerously late symptom.

As a therapeutic measure in diseases of the larynx its place has been thoroughly established. Marked improvement of the laryngeal lesions has been observed to follow tracheotomy in advanced laryngeal tuberculosis, and in cancer of the larynx. It has proven, in some cases, a useful adjunct in the treatment of luetic laryngitis, though it cannot be regarded as indicated, in the absence of dyspnea. Perichondritis and other inflammations are benefited by tracheotomy. A marked therapeutic effect on multiple laryngotracheal papillomata in children has been noted by the author in hundreds of cases.

Tracheotomy for foreign body is no longer indicated either for the removal of the intruder, or for the insertion of the bronchoscope. Tracheotomy may be urgently indicated for foreign body dyspnea, but not for foreign body removal.

Subcutaneous rupture of the trachea from external trauma may produce dyspnea and generalized emphysema, both of which will be relieved by tracheotomy.

[280] *Acromegalic stenosis of the larynx* is a rare but urgent indication for tracheotomy.

Contraindications.—There are no contraindications to tracheotomy for dyspnea.

The instruments required for an orderly tracheotomy are:

Headlight
Scalpels
2 Retractors
Trousseau dilator
6 Hemostats
Scissors (dissecting)
Tracheal cannulae (six sizes)
Curved needles
Needle holder
Hypodermic syringe for local anesthesia
No. 1 plain catgut ligatures
Linen tape
Gauze sponges

These are sterilized and kept in a sterile copper box ready for instant use. Beside the patient's bed following the tracheotomy the following sterile materials are placed:

Sterile gloves
1 Hemostat
Sterile new gauze
Trousseau dilator
Scissors
Duplicate tracheotomy tube
Silver probe
Basin of Bichloride of mercury solution, 1 : 10,000

Tracheotomy is one of the oldest operations known to surgery, yet strange to say, it is probably more often improperly performed today, and more often followed by needless mortality, than any other

operation. The two chief preventable sequelae are death from improper routine surgical care and wrongly fitted tube, and stenosis from too high an operation. The classical descriptions of crico-thyroidotomy and high and low tracheotomy have been handed down to generations of medical students without revision. Every medical graduate has been taught that there are two kinds of tracheotomy, high and low, the low operation being very difficult, the high operation very easy. When he is suddenly called upon to do an emergency tracheotomy, this erroneous teaching is about all that remains in the dim recesses of his memory; consequently he makes sure of doing the operation high enough, and goes in through the larynx, usually dividing the cricoid cartilage, the only complete ring in the trachea. As originally made the distinction between high and low as applied to tracheotomy referred to operations above and below the isthmus of the thyroid gland, in a day when primitive surgery attached too much importance to operations upon the thyroid gland. The isthmus is entitled to absolutely no consideration whatever in deciding the location at which to incise so vital a structure as the trachea. Students are taught different short skin incisions for these two operations, and it is no wonder that they, as did their predecessors, find tracheotomy a difficult, bloody, and often futile operation. The trachea is searched for at the bottom of a short, deep wound filled with blood, the source of which is difficult to find and impossible to control.

Tracheotomic cannulae should be made of sterling silver. German silver plated with pure silver is good enough for temporary use, but the plating soon wears off under the galvanic action set up between the two metals. Aluminum becomes roughened by boiling and contact with secretions, and causes the formation of granulations which in time lead to stenosis. Hard rubber tubes cannot be boiled, the walls are so thick as to leave too little lumen, and the rubber is irritating to the tissues. All tracheotomy tubes should be fitted with pilots. Many of the tubes furnished to patients have no pilots to facilitate the introduction, and the tubes are inserted with somewhat the effect of a cheese tester, and with great pain and suffering on the part of the patient. Most of the the tubes in the shops are too short to allow for the swelling of the tissues of the neck following the operation. They may reach the trachea at the time of the operation, but as soon as the reactionary swelling occurs, the end of the tube is pulled out (Fig. 103) of the tracheal incision; the air hissing along the tube is considered by the attendant to indicate that the tube is still in place, and the increasing dyspnea and accelerated respiratory rate are attributed to supposed pneumonia or edema of the lungs, under which erroneous diagnosis the patient is buried. In all cases in which it is reported that in spite of tracheotomy the dyspnea was only temporarily relieved, the fault is the lack of a "plumber." That is, an attendant who will make sure that there is at all times a clear airway all the way down to the lungs. With a bronchoscope and aspirator he will see that the airway is clear. To begin with, a proper sized cannula must be selected. The series of different sized, full curved tubes, one of which is illustrated in Fig. 104, will under all conditions reach the trachea. If the tube seems to be too long in any given case, it will usually be found that the tracheotomy has been done too high, and a lower one should be done at once. If the operation has not been done too high, and the cannula is too long, a pad of gauze under the shield will take up the surplus length. In cases of tracheal compression from new growth, thymus or other such cases, in which the ordinary tube will not pass the obstruction, the author's long cane-shaped cannula (see Fig. 104) can be inserted past the obstruction, and if necessary into either bronchus. The fenestrum placed in the cannula in many of the older tubes, with the supposed function of allowing partial breathing through the larynx, is a most pernicious thing. A properly fitted tube should not take up more than half of the cross section of the trachea, and should allow the passage of sufficient air for free laryngeal breathing when it is completely corked. The fenestrum is, moreover, rarely so situated that air can pass through it; the fenestral edges act as a constant irritant to the wound, producing bleeding and granulation tissue.

[FIG. 103.—Schema showing thick pad of gauze dressing, filling the space, A, and used to hold out the author's full-curved cannula when too long, prior to reactionary swelling, and after subsidence of the latter. At the right is shown the manner in which the ordinary cannula of the shops permits a patient to asphyxiate, though some air is heard passing through the tracheal opening, H, after the cannula has been partially withdrawn by swelling of the tissues, T.]

[FIG. 104.—The author's tracheotomic cannulae. A, shows cane-shaped cannula for use in intrathoracic compressive or other stenoses. B, shows full curved cannula for regular use. Pilots are made to fit the outer cannula; the inner cannula not being inserted until after withdrawal of the pilot.]

Anesthesia.—No dyspneic patient should be given a general anesthetic; because any patient dyspneic enough to need a tracheotomy for dyspnea is depending largely upon the action of the accessory respiratory muscles. When this action is stopped by beginning unconsciousness, respiration ceases. If the trachea is not immediately opened, artificial respiration instituted, and oxygen insufflated, the patient dies on the table. Skin infiltration along the line of incision with a very weak cocaine solution (1/10 of 1 per cent), apothesine (2 per cent), novocaine, Schleich's fluid or other local anesthetic, suffices to render the operation painless. The deeper structures have little sensation and do not require

infiltration. It has been advocated that an interannular injection of cocaine solution with a hypodermic syringe be done just prior to incision of the trachea for the purpose of preventing cough after the incision of the trachea and the insertion of the cannula. It would seem, however, that this introduces the risk of aspiration pneumonia and pulmonary abscess, by permitting the aspiration and clotting of blood in small bronchi, followed by subsequent breaking down of the clots. As the author has so often said, "The cough reflex is the watch dog of the lungs," and if not drugged asleep by local or general anesthesia can safely be relied upon to prevent all possibility of the blood or the pus which nearly always is present in acute or chronic conditions calling for tracheotomy, being aspirated into the deeper air-passages. Cocaine in any form, by any method, and in any dosage, is dangerous in very young children.

Technic.—The patient should be placed in the recumbent position, with the extended head held in the midline by an assistant. The shoulders, not the neck, should be slightly raised with a sand bag. The head should be somewhat lower than the feet, to lessen the danger of aspiration of blood. A midline incision dividing the skin and fascia is made from the thyroid notch to just above the suprasternal notch. The cricoid is now located, and the deeper dissection is continued from below this point. The ribbon muscles are separated with dissecting scissors or knife, and held apart with retractors. If the isthmus of the thyroid gland is in the way, it may be retracted upward; if large, however, it should be divided and ligated, for it is apt to slip over the tracheal incision afterward, and render difficult the quick finding of the incision during after-care. This covering of the tracheal incision by the slipping back of the drawn-aside thyroidal isthmus is one of the most frequent avoidable causes of mortality, because it deflects the cannula off into the tissues when it is replaced after cleaning during the early postoperative period. The corrugated surface of the trachea can be felt, and its exact location can be determined by the index finger. If the tracheotomy is proceeding in an orderly manner, all bleeding points should be caught and tied with plain catgut (No. 1) before the trachea is opened. Because of distension of vessels during cough, all but the tiniest vessels should be ligated. Side-cut veins are particularly treacherous. They should be freed of tissue, cut across and the divided ends ligated.

The *incision in the trachea* should be as low as possible, and should never be made through the first ring. The incision should be through the third, fourth and fifth rings. Only in cases of laryngoptosis will it be necessary to incise the trachea higher than this. The incision must be made in the midline, and in the long axis of the trachea, and care must be exercised that the point of the knife does not perforate the posterior tracheal wall. Stab incisions are always to be avoided. If the incision in the trachea is found to be of insufficient length, the original incision must be found and elongated. A second incision must not be made, for the portion of cartilage between the two incisions will die and will almost certainly make a site of future tracheal stenosis. The cricoid should never be cut, for stenosis is almost sure to follow the wearing of a cannula in this position. A Trousseau dilator should now be inserted in the tracheal incision, its blades gently separated. With the tracheal lumen thus opened, a cannula of proper size is introduced with absolute certainty of its having entered the trachea. A quadruple-folded square of gauze in the form of a pad about four inches square is moistened with mercuric chloride solution (1:10,000) and is slit from the lower border to its midpoint. This pad is slipped from above downward under the tape holder of the cannula, the slit permitting the tubal part of the cannula to reach the central part of the pad (Fig. 108), and completely covers the wound. No attempt should be made to suture the skin wound, for this tends to form a pocket in which lodge the bronchial secretions that escape alongside the tube, resulting in infection of the wound. Furthermore it renders the daily changing of the tube much more difficult. In fact it prevents the attendant from being certain that the tube is actually placed in the trachea. Suturing of the skin to the trachea should never be done, for the sutures soon tear out and often set up a perichondritis of the tracheal cartilages, with resulting difficult decannulation.

[FIG. 105.—Schema of practical gross anatomy to be memorized for emergency tracheotomy. The middle line is the safety line, the higher the wider. Below, the safety line narrows to the vanishing point VP. The upper limit of the safety line is the thyroid notch until the trachea is bared, when the limit falls below the first tracheal ring. In practice the two-dark danger lines are pushed back with the left thumb and middle finger as shown in Fig. 106, thus throwing the safety line into prominence. This is generally known as Jackson's tracheotomic triangle.]

[FIG. 106.—Schema showing the author's method of rapid tracheotomy. First stage. The hands are drawn ungloved for the sake of clearness. The upper hand is the left, of which the middle finger (M) and the thumb are used to repress the sterno-cleido-mastoid muscles, the finger and thumb being close to the trachea in order to press backward out of the way the carotid arteries and the jugular vein. This throws the trachea forward into prominence, and one deep slashing cut will incise all of the soft tissues down to the trachea.]

Emergency Tracheotomy.—Stabbing of the cricothyroid membrane, or an attempted stabbing of the trachea, so long taught as an emergency tracheotomy, is a mistake. The author's "two stage, finger

guided" method is safer, quicker, more efficient, and not likely to be followed by stenosis. To execute this promptly, the operator is required to forget his textbook anatomy and memorize the schema (Fig. 105). The larynx and trachea are steadied by the thumb and middle finger of the left hand, which at the same time push back the important nerves and vessels which parallel the trachea, and render the central safety line more prominent (Fig. 106). A long incision is now made from the thyroid notch almost to the suprasternal notch, and deep enough to reach the trachea. This completes the first stage.

[FIG. 107.—Illustrating the author's method of quick tracheotomy. Second stage. The fingers are drawn ungloved for the sake of clearness. In operating the whole wound is full of blood, and the rings of the trachea are felt with the left index which is then moved slightly to the patient's left, while the knife is slid down along the left index to exactly the middle line when the trachea is incised.]

Second stage. The entire wound is full of blood and the trachea cannot be seen, but its corrugations can be very readily felt by the tip of the free left index finger. The left index finger is now moved a little to the patient's left in order that the knife shall come precisely in the midline of the trachea, and three rings of the trachea are divided from above downward (Fig. 107). The Trousseau dilator should now be inserted, the head of the table should be lowered, and the patient should be turned on the side to allow the blood to run away from the wound. If respiration has ceased, a cannula is slipped in, and artificial respiration is begun. Oxygen insufflation will aid in the restoration of respiration, and a pearl of amyl nitrite should be crushed in gauze and blown in with the oxygen. In all such cases, excessive pressure of oxygen should be avoided because of the danger of producing ischemia of the lungs. Hope of restoring respiration should not be abandoned for half an hour at least. One of the author's assistants, Dr. Phillip Stout, saved a patient's life by keeping up artificial respiration for twenty minutes before the patient could do his own breathing.

The *after-care* of the tracheotomic wound is of the utmost importance. A special day and night nurse are required. The inner tube of the cannula must be removed and cleaned as soon as it contains secretion. Secretion coughed out must be wiped away quickly, but gently, before it is again aspirated. The gauze dressing covering the wound must be changed as soon as soiled with secretions from the wound and the air-passages. Each fresh pad should be moistened with very weak bichloride of mercury solution (1:10,000). The outer tube must be changed every twenty-four hours, and oftener if the bronchial secretion is abundant. Student-physicians who have been taught my methods and who have seen the cases in care of our nurses have often expressed amazement at the neglect unknowingly inflicted on such cases elsewhere, in the course of ordinary routine surgery. It is not unusual for a patient to be sent to the Bronchoscopic Clinic who has worn his cannula without a single changing for one or two years. In some cases the tube had broken and a portion had been aspirated into the trachea.

[FIG. 108.—Method of dressing a tracheotomic wound. A broad quadruple, in-folded pad of gauze is cut to its centre so that it can be slipped astride of the tube of the cannula back of the shield. No strings, ravellings or strips of gauze are permissible because of the risk of their getting down into the trachea.]

If the respiratory rate increases, instead of attributing it to pulmonary complications, the entire cannula should be removed, the wound dilated with the Trousseau forceps, the interior of the trachea inspected, and all secretions cleaned away. Then the tracheal mucosa below the wound should be gently touched with a sterile bent probe, to induce cough to rid the lower air passages of accumulated secretions. In many cases it is a life-saving procedure to insert a sterile long malleable aspirating tube to remove secretions from the lower air-passages. When all is clear, a fresh sterile cannula which has been carefully inspected to see that its lumen has been thoroughly cleaned, is inserted, and its tapes tied. Good "plumbing," that is, the maintenance at all times of a clear, clean passage in all the "pipes," natural and artificial, is the reason why the mortality in the Bronchoscopic Clinic has been less than half of one per cent, while in ordinary routine surgical care in all hospitals collectively it ranges from 10 to 20 per cent.

Bronchial Aspiration.—As mentioned above, bronchial aspiration is often necessary. When the patient is unable to get up secretions, he will, as demonstrated by the author many years ago, "drown in his own secretions." In some cases bronchoscopic aspiration is required (Peroral Endoscopy, p. 483). Occasionally, very thick secretions will require removal with forceps. Pus may become very thick and gummy from the administration of morphin. Opiates do not lessen pus formation, but they do lessen the normal secretions that ordinarily increase the quantity and fluidity of the pus. When to this is added the dessicating effect of the air inhaled through the cannula, unmoistened by the upper air-passages, the secretions may be so thick as to form crusts and plugs that are equivalent to foreign bodies and require removal with forceps. Diphtheritic membrane in the trachea may require removal with bronchoscope and forceps. Thinner secretions may be removed by sponge-pumping. In most cases, however, secretions can be brought up through an aspirating tube, connected to a bronchoscopic aspirating syringe (Fig. 11), an ordinary aspirating bottle, or preferably, a mechanical aspirator such as that

shown in Fig. 12. In this, combined with bronchoscopic oxygen insuflation (q.v.), we have a life-saving measure of the highest efficiency in cases of poisoning by chlorine and other irritant and asphyxiating gases. An aspirating tube for insertion into the deeper air passages should be of copper, so that it can be bent to the proper curve to reach into the various parts of the tracheobronchial tree, and it should have a removable copper-wire core to prevent kinking, and collapse of the lumen. The distal end should be thickened, and also perforated at the sides, to prevent drawing-in of the mucosa and trauma thereto. A rubber tube may be used, but is not so satisfactory. The one shown in Fig. 10 I had made by Mr. Pilling, and it has proved very satisfactory.

Decannulation.—When the tracheal incision is placed below the first ring, no difficulty in decannulation should result from the operation per se. When by temporarily occluding the cannula with the finger it is evident that the laryngeal aperture has regained sufficient size to allow free breathing, a smaller-sized tracheotomic tube should be substituted to allow free passage of air around the cannula in the trachea. In doing this, the amount of secretion and the handicap of impaired glottic mobility in the expulsion of thick secretions must be borne in mind. Babies labor under a special handicap in their inefficient bechic expulsion and especially in their small cannulae which are so readily occluded. If breathing is not free and quiet with the smaller tube; the larger one must be replaced. If, however, there is no trouble with secretions, and the breathing is free and quiet, the inner cannula should be removed, and the external orifice of the outer cannula firmly closed with a rubber cork. If the laryngeal condition has been acute, decannulation can usually be safely done after the patient has been able to sleep quietly for three nights with a corked cannula. If free breathing cannot be obtained when the cannula is corked, the larynx is stenosed, and special work will be required to remove the tube. Children sometimes become panic stricken when the cannula is completely corked at once and they are forced to breathe through the larynx instead of the easier shortcut through the neck. In such a case, the first step is partially to cork the cannula with a half or two-thirds plug made from a pure rubber cord fashioned in the desired shape by grinding with an emery wheel (Fig. 112). Thus the patient is gradually taught to use the natural air-way, still feeling that he has an "anchor to windward" in the opening in the cannula. When some swelling of the laryngeal structures still exists, this gradual corking has a therapeutic effect in lessening the stenosis by exercising the muscles of abduction of the cords and mobilizing the cricoarytenoid articulation during the inspiratory effort. The forced respiration keeps the larynx freed from secretions, which are more or less purulent and hence irritating. After removing the cannula, in order that healing may proceed from the bottom upward, the wound should be dressed in the following manner: A single thickness of gauze should be placed over the wound and the front of the neck, and a gauze wedge firmly inserted over this to the depths of the tracheotomic wound, all of this dressing being held in place by a bandage. If the skin-wound heals before the fibrous union of the tracheal cartilages is complete, exuberant granulations are apt to form and occlude the trachea, perhaps necessitating a new tracheotomy for dyspnea.

It is so important to fix indelibly in the mind the cardinal points concerning tracheotomy that I have appended to this chapter the teaching notes that I have been for years giving my classes of students and practitioners, hundreds of whom have thanked me for giving them the clear-cut conception of tracheotomy that enabled them, when their turn came to do an emergency tracheotomy, to save human life.

RESUME OF TRACHEOTOMY

Instruments.
Headlight
Sandbag
Scalpel
Hemostats
Small retractors
Tenaculum
Tracheotomic cannulae (proper kind)
Long.
Half area cross-section trachea.
Proper curve: Radius too short will press ant. tracheal wall; too long, post. wall.
Sterling Silver
Tracheobronchial aspirator.
Probe.
Tapes for cannulae
Trousseau dilator
Sponges
Infiltration syringe and solution

Oxygen tank.

Indications: Laryngeal dyspnea.
(Indrawing guttural and clavicular fossae and at epigastrium.
Pallor. Restlessness. Drowning in his own secretions.)

Do it early. Don't wait for cyanosis.
[294] Never use general anesthesia on dyspneic patient.
Forget about "high" and "low" distinctions until trachea is exposed.
Memorize Jackson's tracheotomic triangle.
Patient recumbent, sand bag under shoulders or neck. Nose to zenith.
Infiltration, _Intra_dermatic.
Incise from Adam's apple to guttural fossa.
Hemostasis.
Keep in middle line.
Feel for trachea.
Expose isthmus of thyroid gland.
Draw it upward or downward or cut it.
Ligature, torsion, etc. before incising trachea.
Hold trachea with tenaculum.
Incise trachea below first ring.
Avoid cutting cricoid or first ring. Cut 3 rings vertically. Don't hack. Don't cut posterior wall which almost touches the anterior wall during cough. Spread carefully, with Trousseau dilator.
Insert cannula; *see* it enter tracheal lumen; remove pilot; tie tapes.
Don't suture wound. Dress with large squares.
Don't give morphine.
Decannulation by corking partially, after changing to smaller cannula.
Do not remove cannula permanently until patient sleeps without indrawing with corked cannula.

RESUME OF EMERGENCY TRACHEOTOMY

The following notes should be memorized.
1. Essentials: Knife and pair of hands (but full equipment better).
[295] 2. Don't do a laryngotomy, or stabbing.
3. "Two stage, finger guided" operation better.
4. Sand bag or substitute.
5. Press back danger lines with left thumb and middle finger, making safety line and trachea prominent.
6. Memorize Jackson's tracheotomic triangle.
7. Incise exactly in middle line from Adam's apple to sternum.
8. Feel for tracheal corrugations with left index in pool of blood, following trachea with finger downward from superficial Adam's apple.
9. Pass knife along index and incise trachea (not too deeply, may cut posterior wall).
10. Don't mind bleeding; but keep middle line and keep head straight; keep head low; don't bother about thyroid gland.
11. Don't expect hiss when trachea is cut if patient has stopped breathing.
12. Start artificial respiration.
13. Amyl nitrite. Oxygen.
14. Practice palpation of the neck until the tracheal landmarks are familiar.
15. Practice above technic, up to point of incision, at every opportunity.
16. *Jackson's tracheotomic triangle*: A triangulation of the front of the neck intended to facilitate a proper emergency tracheotomy.
Apex at suprasternal notch.
Sides anterior edge sternomastoids.
Base horizontal line lower edge cricoid.

RESUME OF AFTER-CARE OF A TRACHEOTOMIC CASE

1. Always bear in mind that tracheotomy is not an ultimate object. The ultimate object is to pipe air down into the lungs. Tracheotomy is only a means to that end. 2. Sterile tray beside bed should contain duplicate (exact) tracheotomy tube, Trousseau dilator, hemostat, thumb forceps, silver probe, scissors, scalpel, probe-pointed curved bistoury. Sterile gloves ready. 3. Special nursing necessary for safety. 4. Laxative. 5. Sponge away secretions before they are drawn in. 6. Cover wound with wide large gauze square slit so it fits around cannula under the tape holder. Pull off ravelings. Keep wet with 1 : 10,000 Bichloride solution. 7. Change dressing every hour or oftener. 8. Abundance of fresh air, temperature preferably about 70 degrees. 9. *Nurse should remove inner cannula as often as needed and clean it with pipe cleaner before boiling.* 10. Outer cannula should be changed every day by the surgeon or long-experienced tracheotomy nurse. A pilot should be used and care should be taken not to injure the cut ends of the tracheal cartilage. 11. A sterile, bent probe may be inserted downward in the trachea with both cannulae out to excite cough if necessary to expel secretions. An aspirating tube should be used, when necessary. 12. A patient with a properly fitted cannula free of secretions breathes noiselessly. Any sound demands immediate attention. 13. If the respiratory rate increase it is much more likely to be due to obstruction in, malposition of, or shortness of the cannula than to lung complications. 14. Be sure that: (a) The cannula is clear and clean. (b) The cannula is long enough to reach well down into the trachea. A cannula that was long enough when the operation was done may be too short after the cervical tissues swell. (c) The distal end of the cannula actually is deeply in the trachea. The only way to be sure is, when inserting the cannula, to spread the wound and the tracheal incision with a Trousseau dilator, then *see* the interior of the tracheal lumen and *see* the cannula enter therein. 15. If after attending to the above mentioned details there are still signs of obstructive dyspnea, a bronchoscopy should be done for finding and removal of the obstruction in the trachea or main bronchi. 16. If all the "pipes," natural and instrumental, are clear there can be no such thing as obstructive dyspnea. 17. Pneumonia and pulmonary edema may exist before tracheotomy, but they are rare sequelae. 18. Decannulation, in cases of tracheotomy done for temporary conditions should not be attempted until the patient has slept at least 3 nights with his cannula tightly corked. A properly fitted cannula (i.e. one not larger than half the area of cross section of the trachea) permits the by-passage of plenty of air. A partial cork should be worn for a few days first for testing and "weaning" a child away from the easier breathing through the neck. In cases of chronic laryngeal stenosis a prolonged test is necessary before attempting decannulation. 19. A tracheotomic case may be aphonic, hence unable to call for help. 20. The foregoing rules apply to the post-operative periods. After the wound has healed and a fistula is established, the patient, if not a child, may learn to care for his own cannula. [298] 21. Do not give cough-sedatives or narcotics. The cough reflex is the watch dog of the lungs.

NOTES ON NURSING TRACHEOTOMIZED PATIENTS

Bedside tray should contain:
Duplicate cannula
Scalpel
Trousseau dilator
Hemostat
Dressing forceps
Sterile vaseline
Scissors
Tape
Probe
Gauze sponges
Gauze squares
Probe-pointed curved bistoury.

1. Room should be abundantly ventilated, as free from dust and lint as possible, and the air should be moistened by steam in winter.
2. Keep mouth clean. Tooth brush. Rinse alcohol 1:10.
3. Sponge away secretion after the cough before drawn in.
4. Remove inner cannula (not outer) as often as needed. Not less often than every hour. Replace immediately. Never boil a cannula until you have thoroughly cleaned it.
5. Obstruction of cannula calling for cleaning indicated by:
   Blue or ashy color.
   Indrawing at clavicles, sternal notch, epigastrium.
   Noisy breathing. (Learn sound.)
6. Surgeon (in our cases) will change outer cannula once daily or oftener.
7. Duplicate cannulae.
8. Be careful in cleaning cannulae not to damage.

9. Watch for loose parts on cannula.
10. Change dressing (in our cases) as often as soiled. Not less often than every hour. Large squares. Never narrow strips.
11. Watch color of lips and ears and face.
[299] 12. Report at once if food or water leaks through wound. (Coughing and choking).
13. Never leave a tracheotomized patient unwatched during the first days or weeks, according to case.
14. Remember Trousseau dilator or hemostat will spread the tracheal wound or fistula when cannula is out.
15. Remember life depends on a clear cannula if the patient gets no air through the mouth.
16. Remember it takes very little to clog the small cannula of a child.
17. Remember a tracheotomized patient cannot call for help.
18. Decannulation. Testing by corking partially. Watch corks not too small, or broken. Attach them by braided silk thread. Pure rubber cord ground down makes best cork.

[300] CHAPTER XXXVIII—CHRONIC STENOSIS OF THE LARYNX AND TRACHEA

The various forms of laryngeal stenosis for which tracheotomy or intubation has been performed, and the difficulties encountered in restoring the natural breathing, may be classified into the following types:

1. Panic
2. Spasmodic
3. Paralytic
4. Ankylotic (arytenoid)
5. Neoplastic
6. Hyperplastic
7. Cicatricial
   (a) Loss of cartilage
   (b) Loss of muscular tissue
   (c) Fibrous

Panic.—Nothing so terrifies a child as severe dyspnea; and the memory of previous struggles for air, together with the greater ease of breathing through the tracheotomic cannula than through even a normal larynx, incites in some cases so great a degree of fear that it may properly be called panic, when attempts at decannulation are made. Crying and possibly glottic spasm increase the difficulties.

Spasmodic stenosis may be associated with panic, or may be excited by subglottic inflammation. Prolonged wearing of an intubation tube, by disturbing the normal reciprocal equilibrium of the abductors and adductors, is one of the chief causes. The treatment for spasmodic stenosis and panic is similar. The use of a special intubation tube having a long antero-posterior lumen and a narrow neck, which form allows greater action of the musculature, has been successful in some cases. Repeated removal and replacement of the intubation tube when dyspnea requires it may prove sufficient in the milder cases. Very rarely a tracheotomy may be required; if so, it should be done low. The wearing of a tracheotomic cannula permits a restoration of the muscle balance and a subsidence of the subglottic inflammation. Corking the cannula with a slotted cork (Fig. 111) will now restore laryngeal breathing, after which the tracheotomic cannula may be removed.

[PLATE V—PHOTOPROCESS REPRODUCTIONS OF THE AUTHOR'S OIL-COLOR DRAWINGS FROM LIFE—LARYNGEAL AND TRACHEAL STENOSES:

1, Indirect view, sitting position; postdiphtheric cicatricial stenosis permanently cured by endoscopic evisceration. (See Fig. 5.) 2, Indirect view, sitting position; posttyphoid cicatricial stenosis. Mucosa was very cyanotic because cannula was re-moved for laryngoscopy and bronchoscopy. Cured by laryngostomy. (See Fig. 6.) 3, Indirect view, sitting position; posttyphoid infiltrative stenosis, left arytenoid destroyed by necrosis. Cured by laryngostomy; failure to form adventitious band (Fig. 7) because of lack of arytenoid activity. 4, Indirect view, recumbent position; posttyphoid cicatricial stenosis. Cured of stenosis by endoscopic evisceration with sliding punch forceps. Anterior commissure twice afterward cleared of cicatricial tissue as in the other case shown in Fig. 15. Ultimate result shown in Fig. 8. 5, Same patient as Fig. 1; sketch made two years after decannulation and plastic. 6,

Same patient as Fig. 2; sketch made four years after decannulation and plastic. 7, Same patient as Fig. 3; sketch made three years after decannulation and plastic. 8, Same patient as Fig. 4; sketch made one year after decannulation, fourteen months after clearing of the anterior commissure to form adventitious cords. 9, Direct view, recumbent patient; web postdiphtheric (?) or congenital (?). "Rough voice" since birth, but larynx never examined until stenosed after diphtheria. Web removed and larynx eviscerated with punch forceps; recurrence of stenosis (not of web). Cure by laryngostomy. This view also illustrates the true depth of the larynx which is often overlooked because of the misleading flatness of laryngeal illustrations. 10, Direct laryngoscopic view; postdiphtheric hypertrophic subglottic stenosis. Cured by galvanocauterization. 11, Direct laryngoscopic view; postdiphtheric hypertrophic supraglottic stenosis. Forceps excision; extubation one month later; still well after four years. 12, Bronchoscopic view of posttracheotomic stenosis following a "plastic flap" tracheotomy done for acute edema. 13, Direct laryngoscopic view; anterolateral thymic compression stenosis in a child of eighteen months. Cured by thymopexy. 14, Indirect laryngoscopic (mirror) view; laryngostomy rubber tube in position in treatment of post-typhoid stenosis. 15, Direct view; posttyphoid stenosis after cure by laryngostomy. Dotted line shows place of excision for clearing out the anterior commissure to restore the voice. 16, Endoscopic view of posttracheotomic tracheal stenosis from badly placed incision and chondrial necrosis. Tracheotomy originally done for influenzal tracheitis. Cured by tracheostomy.]

Paralysis.—Bilateral abductor laryngeal paralysis causes severe stenosis, and usually tracheotomy is urgently required. In cadaveric paralysis both cords are in a position midway between abduction and adduction, and their margins are crescentic, so that sufficient airway remains. Efforts to produce the cadaveric position of the cords by division or excision of a portion of the recurrent laryngeal nerves, have been failures. The operation of *ventriculocordectomy* consists in removing a vocal cord and the portion or all of the ventricular floor by means of a punch forceps introduced through the direct laryngoscope. Usually it is better to remove only the portion of the floor anterior to the vocal process of the arytenoid. In some cases monolateral ventriculocordectomy is sufficient; in most cases, however, operation on both sides is needed. An interval of two months between operations is advisable to avoid adhesions. In almost all cases, ventriculocordectomy will result in a sufficient increase in the glottic chink for normal respiration. The ultimate vocal results are good. Evisceration of the larynx, either by the endoscopic or thyrotomic method, usually yields excellent results when no lesion other than paralysis exists. Only too often, however, the condition is complicated by the results of a faultily high tracheotomy. A rough, inflexible voice is ultimately obtained after this operation, especially if the arytenoid cartilage is unharmed. In recent bilateral recurrent paralysis, it may be worthy of trial to suture the recurrent to the pneumogastric. Operations on the larynx for paralytic stenosis should not be undertaken earlier than twelve months from the inception of the condition, this time being allowed for possible nerve regeneration, the patient being made safe and comfortable, meanwhile, by a low tracheotomy.

Ankylosis.—Fixation of the crico-arytenoid joints with an approximation of the cords may require evisceration of the larynx. This, however, should not be attempted until after a year's lapse, and should be preceded by attempts to improve the condition by endoscopic bouginage, and by partial corking of the tracheotomic cannula.

Neoplasms.—Decannulation in neoplastic cases depends upon the nature of the growth, and its curability. Cicatricial contraction following operative removal of malignant growths is best treated by intubational dilatation, provided recurrence has been ruled out. The stenosis produced by benign tumors is usually relieved by their removal.

Papillomata.—Decannulation after tracheotomy done for papillomata should be deferred at least 6 months after the discontinuance of recurrence. Not uncommonly the operative treatment of the growths has been so mistakenly radical as to result in cicatricial or ankylotic stenoses which require their appropriate treatments. It is the author's opinion that recurrent papillomata constitute a benign self-limited disease and are best treated by repeated superficial removals, leaving the underlying normal structures uninjured. This method will yield ultimately a perfect voice and will avoid the unfortunate complications of cicatricial hypertrophic and ankylotic stenosis.

Compression Stenosis of the Trachea.—Decannulation in these cases can only follow the removal of the compressive mass, which may be thymic, neoplastic, hypertrophic or inflammatory. Glandular disease may be of the Hodgkins' type. Thymic compression yields readily to radium and the roentgenray, and the tuberculous and leukemic adenitides are sometimes favorably influenced by the same agents. Surgery will relieve the compression of struma and benign neoplasms, and may be indicated in certain neoplasms of malignant origin. The possible coexistence of laryngeal paralysis with tracheal compression is frequently overlooked by the surgeon. Monolateral or bilateral paralysis of the larynx is by no means an uncommon postoperative sequel to thyroidectomy, even though the recurrent nerves have been in no way injured at operation. Probably a localized neuritis, a cicatricial traction, or inclusion of a nerve trunk accounts for most of these cases.

Hyperplastic and cicatricial chronic stenoses preventing decannulation may be classified etiologically as follows:

1. Tuberculosis
2. Lues
3. Scleroma
4. Acute infectious diseases
   (a) Diphtheria
   (b) Typhoid fever
   (c) Scarlet fever
   (d) Measles
   (e) Pertussis
5. Decubitus
   (a) Cannular
   (b) Tubal
6. Trauma
   (a) Tracheotomic
   (b) Intubational
   (c) Operative
   (d) Suicidal and homicidal
   (e) Accidental (by foreign bodies, external violence, bullets, etc.)

Most of the organic stenoses, other than the paralytic and neoplastic forms, are the result of inflammation, often with ulceration and secondary changes in the cartilages or the soft tissues.

[304] *Tuberculosis*.—In the non-cicatricial forms, galvanocaustic puncture applied through the direct laryngoscope will usually reduce the infiltrations sufficiently to provide a free airway. Should the pulmonary and laryngeal tuberculosis be fortunately cured, leaving, however, a cicatricial stenosis of the larynx, decannulation may be accomplished by laryngostomy.

Lues.—Active and persistent antiluetic medication must precede and accompany any local treatment of luetic laryngeal stenosis. Prolonged stretching with oversized intubation tubes following excision or cauterization may sometimes be successful, but laryngostomy is usually required to combat the vicious contraction of luetic cicatrices.

Scleroma is rarely encountered in America. Radiotherapy has been advocated and good results have been reported from the intravenous injection of salvarsan. Radium may be tried, and its application is readily made through the direct laryngoscope.

Diphtheria.—Chronic postdiphtheritic stenosis may be of the panic, spasmodic or, rarely, the paralytic types; but more often it is of either the hypertrophic or cicatricial forms. Only too frequently the stenosis should be called posttracheotomic rather than postdiphtheritic, since decannulation after the subsidence of the acute stenosis would have been easy had it not been for the sequelae of the faulty tracheotomy. Prolonged intubation may induce either a supraglottic or subglottic tissue hyperplasia. *The supraglottic type* consists in an edematous thickening around the base of the epiglottis, sometimes involving also the glossoepiglottic folds and the ventricular bands. An improperly shaped or fitted tube is the usual cause of this condition, and a change to a correct form of intubation tube may be all that is required. Excessive polypoid tissue hypertrophy should be excised. The less redundant cases subside under galvanocaustic treatment, which may be preceded by tracheotomy and extubation, or the intubation tube may be replaced after the application of the cautery. The former method is preferable since the patient is far safer with a tracheotomic cannula and, further, the constant irritation of the intubation tube is avoided. *Subglottic hypertrophic stenosis* consists in symmetrical turbinal-like swellings encroaching on the lumen from either side. Cautious galvanocauterant treatment accurately applied by the direct method will practically always cure this condition. Preliminary tracheotomy is required in those cases in which it has not already been done, and in the cases in which a high tracheotomy has been done, a low tracheotomy must be the first step in the cure. Cicatricial types of postdiphtheritic stenosis may be seen as webs, annular cicatrices of funnel shape, or masses of fibrous tissue causing fixation of the arytenoids as well as encroachment on the glottic lumen. (See color plates.)

As a rule, when a convalescent diphtheritic patient cannot be extubated two weeks after three negative cultures have been obtained the advisability of a low tracheotomy should be considered. If a convalescent intubated patient cough up a tube and become dyspneic a low tracheotomy is usually preferable to forcing in an oversized intubation tube.

Typhoid Fever.—Ulcerative lesions in the larynx during typhoid fever are almost always the result of

mixed infection, though thrombosis of a small vessel, with subsequent necrosis is also seen. If the ulceration reaches the cartilage, cicatricial stenosis is almost certain to follow.

Trauma.—The chief traumatic factors in chronic laryngeal stenosis are: (a) prolonged presence of a foreign body in the larynx (b) unskilled attempts at intubation and the wearing of poorly fitting intubation tubes; (c) a faulty tracheotomy; (d) a badly fitting cannula; (e) war injuries; (f) attempted suicide; (g) attempted homicide; (h) neglect of cleanliness and care of either intubation tubes or tracheotomic cannulae allowing incrustation and roughening which traumatize the tissues at each movement of the ever-moving larynx and trachea.

Treatment of Cicatricial Stenosis.—A careful direct endoscopic examination is essential before deciding on the method of treatment for each particular case. Granulations should be removed. Intubated cases are usually best treated by tracheotomy and extubation before further endoscopic treatment is undertaken. A certain diagnosis as to the cause of the condition must be made by laboratory and therapeutic tests, supplemented by biopsy if necessary. Vigorous antiluetic treatment, especially with protiodide of mercury, must precede operation in all luetic cases. Necrotic cartilage is best treated by laryngostomy. Intubational dilatation will succeed in some cases.

[FIG. 109.—Schema showing the author's method of laryngostomy. The hollow upward metallic branch (N) of the cannula (C) holds the rubber tube (R) back firmly against the spur usually found on the back wall of the trachea. Moreover, the air passing up through the rubber tube (R) permits the patient to talk in a loud whisper, the external orifice of the cannula being occluded most of the time with the cork (K). The rubber tubing, when large sizes are reached may extend down to the lower end of the cannula, the part C coming out through a large hole cut in the tubing at the proper distance from the lower end.]

Laryngoscopic bouginage once weekly with the laryngeal bougies (Fig. 42) will cure most cases of laryngeal stenosis. For the trachea, round, silk-woven, or metallic bougies (Fig. 40) are better.

[307] *Laryngostomy* consists in a midline division of the laryngeal and tracheal cartilages as low as the tracheotomic fistula, excision of thick cicatricial tissue, very cautious incision of the scar tissue on the posterior wall, if necessary, and the placing of the author's laryngostomy tube for dilatation (Fig. 109). Over the upward branch of the laryngostomy tube is slipped a piece of rubber tubing which is in turn anchored to the tape carrier by braided silk thread. Progressively larger sizes of rubber tubing are used as the laryngeal lumen increases in size under the absorptive influence of the continuous elastic pressure of the rubber. Several months of wearing the tube are required until dilatation and epithelialization of the open trough thus formed are completed. Painstaking after-care is essential to success. When dilatation and healing have taken place, the laryngostomy wound in the neck is closed by a plastic operation to convert the trough into a trachea by supplying an anterior wall.

Intubational treatment of chronic laryngeal stenosis may be tried in certain forms of stenosis in which the cicatrices do not seem very thick. The tube is a silver-plated brass one of large size (Fig. 110). A post which screws into the anterior surface of the tube prevents its expulsion. Over the post is slipped a block which serves to keep open the tracheal fistula. Detailed discussion of these operative treatments is outside the scope of this work, but mention is made for the sake of completeness. Before undertaking any of the foregoing procedures, a careful study of the complete descriptions in Peroral Endoscopy is necessary, and a practical course of training is advisable.

[FIG. 110.—The author's retaining intubation tube for treatment of chronic laryngeal stenosis. The tube (A) is introduced through the mouth, then the post (B) is screwed in through the tracheal wound. Then the block (C) is slid into the wound, the square hole in the block guarding the post against all possibility of unscrewing. If the threads of the post are properly fitted and tightly screwed up with a hemostat, however, there is no chance of unscrewing and gauze packing is used instead of the block to maintain a large fistula. The shape of the intubation tube has been arrived at after long clinical study and trials, and cannot be altered without risk of falling into errors that have been made and eliminated in the development of this shape.]

[309] CHAPTER XXXIX—DECANNULATION AFTER CURE OF LARYNGEAL STENOSIS

In order to train the patient to breathe again through the larynx it is necessary to occlude the cannula. This is best done by inserting a rubber cork in the inner cannula. At first it may be necessary to make a slot in the cork so as to permit some air to enter through the tube to supplement the insufficient supply obtainable through the insufficiently patulous glottis, new corks with smaller grooves being substituted as laryngeal breathing becomes easier. Corking the cannula is an excellent orthopedic treatment in certain cases where muscle atrophy and partial inflammatory fixation of the cricoarytenoid joints are

etiological factors in the stenosis. The added pull of the posterior cricoarytenoid muscles during the slight effort at inspiration restores their tone and increases the mobility of all the attached structures. By no other method can panic and spasmodic stenosis be so efficiently cured.

[FIG. 111.—Illustration of corks used to occlude the cannula in training patients to breathe through the mouth again, before decannulation. The corks allow air leakage, the amount of which is regulated by the use of different shapes. A smaller and still smaller air leak is permitted until finally an ungrooved cork is tolerated. A central hole is sometimes used instead of a slot. A, one-third cork; B, half cork; C, three-quarter cork; D, whole cork.]

Following the subsidence of an acute laryngeal stenosis, it is my rule to decannulate after the patient has been able to breathe through the larynx with the cannula tightly corked for 3 days and nights. This rule does not apply to chronic laryngeal stenosis, for while the lumen under ordinary conditions might be ample, a slight degree of inflammation might render it dangerously small. In these cases, many weeks are sometimes required to determine when decannulation is safe. A test period of a few months is advisable in most cases of chronic laryngeal stenosis. Recurrent contractions after closure of the wound are best treated by endoscopic bouginage. The corks are best made of pure rubber cord, cut and ground to shape, and grooved, if desired, on a small emery wheel (Fig. 112). The ordinary rubber corks and those made of cork-bark should not be used because of their friability, and the possible aspiration of a fragment into the bronchus, where rubber particles form very irritant foreign bodies.

[FIG. 112.—This illustration shows the method of making safe corks for tracheotomic cannulae by grinding pure rubber cord to shape on an emery wheel. After grinding the taper, if a partial cork is desired, a groove is ground on the angle of the wheel. If a half-cork is desired half of the cork is ground away on the side of the wheel. Reliable corks made in this way are now obtainable from Messers Charles J. Pilling and Son.]

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