

and all of this tube is regarded as oesophagus, irrespective of its lining.

The lower centimetre or two of this tube is normally lined by columnar epithelium, previously called cardiac and regarded as gastric, but in this paper called junctional and regarded as oesophageal. Thus the view that the oesophagus is a tube lined only by squamous epithelium is rejected.

The cardia is defined as the lower sphincteric part of the oesophagus between the attachment of the phreno-oesophageal ligament and the oesophago-gastric junction.

Some changes in opinions about lesions involving the lower end of the oesophagus, which must follow if these new views on its anatomy are accepted, are indicated. In particular it is pointed out that all the literature about gastric epithelium in the oesophagus in cases of reflux oesophagitis becomes invalid because with the new outlook it is simply oesophageal epithelium in the oesophagus.

It is probably neither ectopic, nor congenital, nor permanent, nor in need of resection but meta-plastic and reversible.

I should like to thank Mr. N. R. Barrett for the elegant drawing on page 38.

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THE PHRENO-OESOPHAGEAL LIGAMENT IN HIATAL HERNIA REPAIR

Surgical opinions on the phreno-oesophageal ligament in hiatal hernia repair vary from those who ignore it (e.g., Sweet, 1948; Harrington, 1955) to those who regard its careful suture to the diaphragm under the edge of the hiatus as important (e.g., Allison, 1951; Clarebrough and Connell, 1959). Others acknowledge its existence but despise it. For instance, Tanner (1955) states that, in cases of hiatal hernia, "the phreno-oesophageal ligament . . . becomes infiltrated with fat and so stretched and tenuous that it becomes useless as a means of repair of the hernia," and Marchand (1959) states that it is "attenuated and inconspicuous when a hiatal hernia is present."

I have never found the phreno-oesophageal ligament inconspicuous, or useless as a means of repair, in these cases, and I agree with Allison and others that anchoring it below the diaphragm is a most important step in the operation. This paper is written to stress this point and to show how such opposite opinions may have arisen.

THE NORMAL ANATOMY OF THE LIGAMENT

The phreno-oesophageal ligament is a layer of fascia rich in elastic fibres which arises from the under surface of the oesophageal hiatus as a continuation of the subdiaphragmatic fascia, which in

turn corresponds to the fascia transversalis of the abdominal wall. It extends upwards in the hiatus in a conical fashion to be inserted into the adventitia of the oesophagus along a line about 2 cm. above the oesophago-gastric junction (at level A in Fig. 1). At this insertion its elastic fibres merge with those of the adventitia and extend both upwards and downwards for a centimetre or two. Elastic fibres also pass from the adventitia among the muscle bundles of the oesophageal wall as far as the submucosa. The attachment of the ligament to the oesophagus is therefore very firm indeed and appears to be designed to distribute any tension in it over a wide area of the oesophageal wall. The space, like a circular wedge, between the conical ligament laterally, the cylindrical oesophagus centrally, and the peritoneum below, is filled with extraperitoneal fat. This wedge of fat is constant and is not much affected by general emaciation.

The anatomical point to be stressed here is the site of attachment of the ligament to the oesophagus, about 2 cm. above the oesophago-gastric junction, where the oesophageal tube suddenly widens out into the stomach pouch and where the peritoneum is reflected from the stomach to the diaphragm (level B in Fig. 1). This observation was made in the last century (Laimer, 1883) and

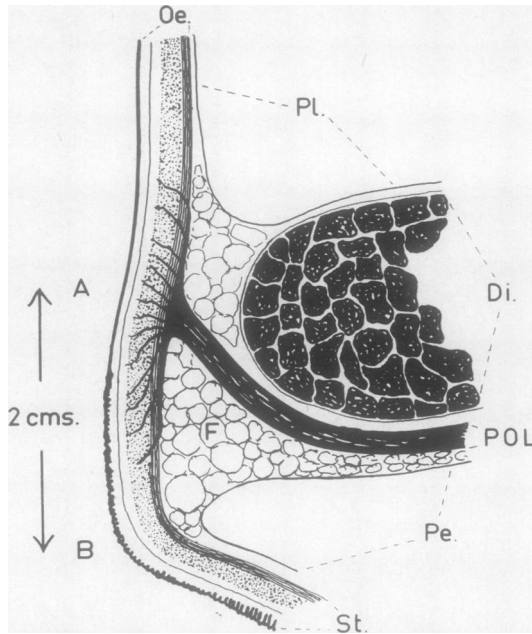


FIG. 1.—Diagram of the normal phreno-oesophageal ligament. The thickness of the ligament is exaggerated so that it will stand out clearly, and the way insertion merges with elastic fibres which pass through the muscular coat of the oesophagus is indicated by purely fanciful lines. A, Level of insertion of phreno-oesophageal ligament; B, level of oesophago-gastric junction; Di., diaphragm; F, extraperitoneal fat; Oe., oesophageal wall; Pe., peritoneum; Pl., pleura; POL, phreno-oesophageal ligament; St., stomach wall.

has been reaffirmed by Lerche (1950) and Hagarty (1959). It can be verified at operation or in the post-mortem room. Nevertheless, as far as I know, it has never been specially mentioned in surgical literature. The diagrams of the operation for repair of hiatal hernia given by Allison (1951) and Groves, Martinez, and Effler (1959) picture it as virtually at, or at least very near to, the oesophago-gastric junction. Marchand (1959) noticed that it could be palpated through the oesophageal wall with a finger up the oesophagus, and said that it extended "for about 1 cm. above the oesophago-gastric junction." Clarebrough and Connell (1959) noticed that the peritoneum and ligament near the cardia "veer away from each other," but they did not state how far. It would seem that there may be many surgeons who would be surprised to know that the distance is about 2 cm.

The level of the change from squamous to columnar epithelium in the oesophagus is variable. It usually occurs a little below the external attachment of the phreno-oesophageal ligament. The lower 1 to 2 cm. of the tube is therefore lined by

columnar epithelium. Because he accepted the view that the oesophagus is the part lined by squamous epithelium and tried to define the insertion of the ligament in terms of the squamo-columnar junction, Peters (1955) was led to state that "the insertion varies in relation to the oesophago-gastric junction; it is close to it, within a centimetre or two, and is usually proximal but sometimes virtually coincides with it." This suggests that the phreno-oesophageal attachment is variable. This is not so. It is the position of the squamo-columnar junction which varies.

THE LIGAMENT IN SLIDING HIATAL HERNIA

In a sliding hiatal hernia the attachment of the ligament to the oesophagus and the oesophago-gastric junction with its peritoneal reflection maintain their relationship to one another and simply slide together through the hiatus up into the chest. There is then a longer distance for the ligament to traverse from its origin under the hiatal margin to its insertion (Fig. 2). It must be stretched. Conversely, if it will not stretch the hernia cannot occur. Associated with this stretching it is, to a certain extent, attenuated, but not as much as would be expected from its increased area. It still remains as a definite, readily identifiable, fascial

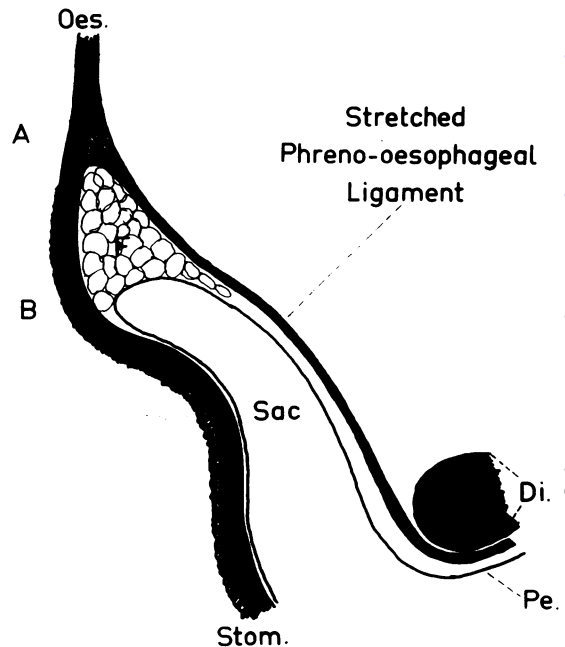


FIG. 2.—Finding hiatal hernia. A, Level of insertion of phreno-oesophageal ligament; B, level of oesophago-gastric junction; F, extraperitoneal fat; Di., diaphragm; Oes., oesophageal wall; Pe., peritoneum; Stom., stomach wall.

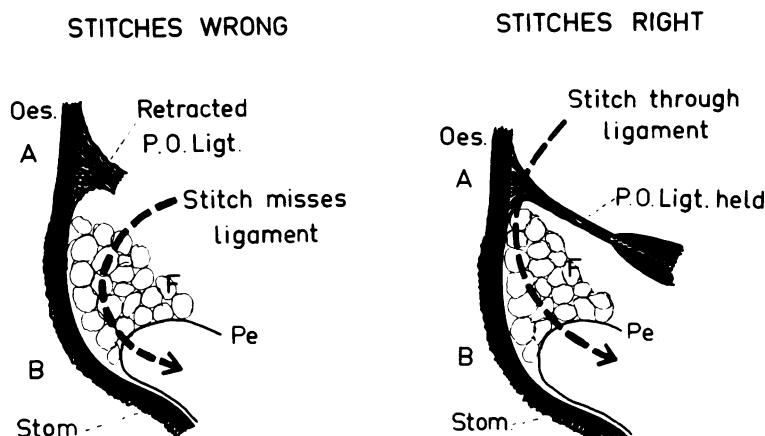


Fig. 3.—Anchoring phreno-oesophageal ligament. A, Level of insertion of phreno-oesophageal ligament; B, level of oesophago-gastric junction; F, extraperitoneal fat; Oes., oesophageal wall; Pe., peritoneum; P.O.Ligt., phreno-oesophageal ligament; Stom., stomach wall.

layer. In particular its attachment to the oesophageal adventitia remains sufficiently firm to hold stitches.

The ligament, being elastic, retracts when divided. The lower part goes down through the hiatus and the upper part up on to the oesophageal wall. If it is divided near the oesophagus the upper part may be taken right up into the adventitia of the oesophagus and vanish. It is then difficult to find again, especially if one looks for it less than 2 cm. above the oesophago-gastric junction. The peritoneum and extraperitoneal fat, which remain after division as a collar round the oesophago-gastric junction, will not hold stitches satisfactorily. Perhaps the surgeons who say the ligament will not hold stitches have, without realizing it, lost it when it retracted upwards after division (Fig. 3, first part). Unless precautions are taken to keep hold of it, the ligament is more likely to be missed when the abdominal approach is used. This probably accounts for the fact that most of the surgeons who ignore it favour the abdominal route for repair of the hernia.

HOLDING AND STITCHING THE LIGAMENT DURING HIATAL HERNIA REPAIR

The ligament should be divided with the sac at least 2 or 3 cm. from the oesophagus. I divide it near the upper margin of the hiatus. A small cut is made through the ligament, extraperitoneal fat, and peritoneum from above, or in the reverse order from below if the approach is abdominal, and the ligament or all three layers are grasped with straight artery forceps. The cut is then extended a centimetre or two and another forceps

applied, and so on until the whole sac is divided. Then the first halves of the anchoring stitches (No. 60 linen or similar non-absorbable suture) are passed and held untied, like slings, with the needle still attached. Each stitch passes through the attachment of the ligament to the oesophageal adventitia, the fat, and the peritoneum close to the stomach (Fig. 3, second part). They are placed $\frac{1}{2}$ to 1 cm. apart on the oesophageal wall and usually five are required. As each stitch catches the ligament at its insertion the corresponding holding forceps is removed and this part of it allowed to retract. The stitches are distributed radially from the level of the lesser omentum to the right, across the front and down the left side as far as the sac extends.

At the stage when the phreno-oesophageal halves of the five anchoring stitches are placed and the whole hiatal muscle sling is properly exposed, the oesophagus is drawn down to the most anterior part of the hiatus by traction on all five stitches together to see exactly where the second halves must be placed to make the oesophagus fit snugly in this part of the hiatus when they are tied. Then the second half of each stitch is passed through the appropriate part of the fascia and muscle of the abdominal surface of the hiatus near its edge, the needle removed, and the stitch still held as a sling. Access is easily obtained from the left chest through the hiatus by everting its edge. When all five are completed they are again drawn taut together. This reduces the hernia. A check is made to see that the oesophagus lies comfortably in the hiatus without torsion or distortion. Then the stitches are tied and cut one by one while the

untied ones are held taut by the assistant. The whole strain of keeping the hernia reduced should never fall on one stitch or it may pull out.

Finally, the right and left sides of the hiatal muscle sling are brought together posteriorly with stitches as described by Allison (1951) and the repair is complete.

DISCUSSION

In the method described, if the thoracic approach is being used and exploration of the abdomen is not indicated, there is no need to make an opening in the diaphragm and pass a sling round the oesophagus, down through the hiatus and up again through the diaphragmatic incision for traction to reduce the hernia as Allison described. This sling tends to slip down till it encircles the oesophagus just where the phreno-oesophageal ligament is inserted so that it is in the way of the first halves of the anchoring stitches and must be pushed up a little to allow them to be placed correctly. Also, even a small cut in the diaphragm is liable to damage branches of the left phrenic nerve, and it is a pity to paralyse any of this important muscle unnecessarily. Groves *et al.* (1959) recently described a similar method of transthoracic repair without opening the diaphragm except that they pull the second halves of the anchoring stitches through the hiatal muscle with stab forceps.

The anchoring stitches should pass through the actual insertion of the ligament immediately outside the oesophageal wall. On no account should any oesophageal muscle be included in them. The function of the muscular coat of the oesophagus in this region is not fully understood, but there is not the slightest doubt that it plays an important part in deglutition and the prevention of reflux. Sutures through it, particularly non-absorbable sutures, cannot fail to interfere with its action. It is therefore wrong, having lost or never found the phreno-oesophageal ligament, to try to get the firm bite for fixation below the diaphragm, which the peritoneum and fat do not give, by including oesophageal wall in the stitches. Such stitches can lead to post-operative discomfort and dissatisfied patients. I know of two cases in which a stitch transfixed not only the whole oesophageal wall but also a Ryle's tube in the lumen, because I was asked what to do when the Ryle's tube could not be pulled out two days later.

When the insertion of the phreno-oesophageal ligament is fixed as described to the under edge of the hiatus, not only the whole stomach but also the abdominal part of the oesophagus is returned

to the abdomen. The oesophago-gastric junction is neither distorted nor firmly fixed, because the stitches hold tightly only to the ligamentous insertion about 2 cm. above it. Its sphincteric and valvular mechanism is therefore given the best possible chance to function normally again. In fact, so long as an associated gastric or duodenal ulcer has not been missed, it always seems to recover its function and the relief of symptoms of reflux is complete.

It is not necessary to fix the gastric fundus. Indeed, it is unwise to do so. The whole stomach needs to be able to move freely with no attachments other than the normal omenta if its contractions are to continue without hindrance. Once the oesophago-gastric junction is permanently back in the abdomen the air in the stomach raises the fundus up under the dome of the diaphragm and restores the acute angle between it and the oesophagus. Stitches between oesophagus and fundus, or between fundus and diaphragm, achieve nothing but interference with gastric motility.

In the experience of different surgeons there is a wide variation in the number of oesophagi alleged to be too short for reduction of the hernia, and recent reports (e.g., Tanner, 1955; Burke, 1959) suggest that they are fewer than was originally thought. In 87 consecutive patients with hiatal hernia, including 13 with tough fibrous oesophageal strictures which were supposed to have led to considerable shortening, I have never been unable to reduce the hernia. An oesophagus really too short to allow reduction of a hiatal hernia must be an unusual finding. Doubtless I shall encounter one sooner or later.

The oesophagus is normally under longitudinal stretch and surrounded by mobile mediastinal aerolar tissue which does not impede its up-and-down movement, though its vascular attachments do to some extent. When a sliding hiatal hernia occurs the distance between pharynx and stomach is diminished and the oesophagus becomes shorter because it is under less stretch. Its normal stretched, elastic state usually prevents the appearance of redundant length, so it is, in fact, shorter. Its musculo-elastic wall is, however, still normal, and, from the surgical point of view, it is not a short oesophagus. No more than normal tension will restore its original length. Thus the radiological and surgical conceptions of short oesophagus are not the same and the surgeon need take little notice of the radiological diagnosis of short oesophagus.

Some true, organic shortening occurs when oesophagitis leads to a fibrous stricture, but it is usually less than it appears to be. If the diseased

part of the oesophagus in these cases is completely freed by dividing all the fibrous mediastinal attachments which have resulted from peri-oesophagitis, the normal part of the tube is nearly always sufficiently elastic to allow the hernia to be reduced without undue tension. I am sure that placing the anchoring stitches from the insertion of the phreno-oesophageal ligament to the under surface of the hiatal muscle as described and tightening them all together is an important factor in making an oesophagus which is apparently short lengthen sufficiently for good repair of the hernia. Bringing the oesophagus through the anterior part of the hiatus is also important, i.e., always placing the hiatal stitches behind the oesophagus, never at the sides or in front, because the plane of the hiatus is tilted forwards very little from the vertical so that the most anterior part is also the highest.

There is another condition which has been called "short oesophagus." Those who believe that only the part of the tube lined by squamous epithelium can rightly be called oesophagus consider that a state of short oesophagus exists when columnar epithelium extends further than usual up the tube, whether the tube itself is shortened or not. In the previous paper I have explained why I do not recognize reduction in the length of the part of the tube lined by squamous epithelium as a type of short oesophagus.

SUMMARY

The insertion of the phreno-oesophageal ligament into the oesophagus is at a level about 2 cm. above the oesophago-gastric junction.

The fixation of this insertion to the lower edge of the hiatus is an essential step in the repair of a hiatal hernia. A method of doing this is described.

Neither the wall of the oesophagus nor of the stomach should be included in any stitches used in the repair.

Repair by the method described makes an oesophagus too short to allow restoration of the stomach to the abdomen a rare finding.

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THE TREATMENT OF FIBROUS STRICTURE OF THE OESOPHAGUS ASSOCIATED WITH HIATAL HERNIA

When a patient with a sliding hiatal hernia develops dysphagia, this symptom may be due to inflammatory hyperaemia and oedema in the oesophagus, to oesophageal muscular incoordination or spasm, or to the laying down circumferentially of dense, contracted fibrous tissue in the mucosa, the mucosa and submucosa, or all layers of the oesophageal wall. These changes can occur separately or together. In this paper a stricture is regarded as fibrous when there is convincing evidence at oesophagoscopy and at operation of the presence of circumferential fibrosis in the oesophagus sufficient in itself to cause significant oesophageal obstruction whether the other factors are also present or not. These fibrous strictures complicating sliding hiatal hernias are difficult to treat satisfactorily, and an extraordinarily wide range of procedures has been

suggested—a sure sign that the best solution to the problem has yet to be found.

Most authors favour some sort of resection (Allison, 1951; Allison, Wooler, and Gunning, 1957; Barrett, 1952, 1957; Belsey, 1953; Ellis, 1956; Ellis, Andersen, and Clagett, 1956; Lindskog and Kline, 1957; MacLean and Wangenstein, 1956; Mustard, 1957; Sweet, Robbins, Gephart, and Wilkins, 1954; Tanner, 1955; Wooler, 1956), but few agree on what is to be removed or how best to reconstitute the alimentary canal afterwards. Many variations of resection of oesophagus, or stomach, or both, with all sorts of anastomoses which may or may not involve the jejunum or colon, have been advocated. Sometimes no stomach, sometimes the upper part of it, sometimes the lower part, sometimes the upper and lower parts leaving a portion of the greater curvature in