THE SURGEON'S LIBRARY

THE HISTORY AND SURGICAL ANATOMY OF THE VAGUS NERVE

Lee J. Skandalakis, M.D., *Chicago, Illinois,* Stephen W. Gray, PH.D., *and* John E. Skandalakis, M.D., PH.D., F.A.C.S., *Atlanta, Georgia*

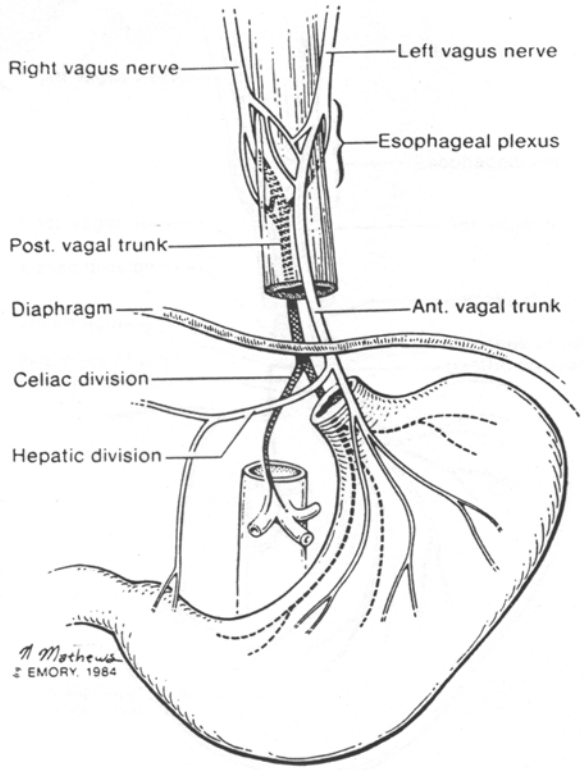

FIG. 2

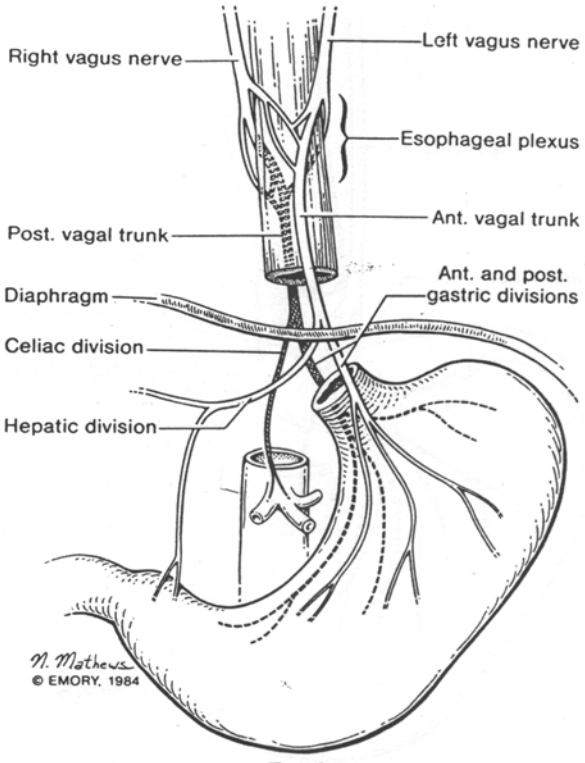

FIG. 3

FIG. 2. Two vagal elements (anterior and posterior trunks) enter the abdomen through the diaphragm.

FIG. 3. If the separation of vagal trunks is unusually high, four vagal elements (divisions) pass through the diaphragm. The vagal trunks are entirely within the thorax.

SURGICAL ANATOMY OF THE VAGUS NERVE

For the general surgeon, the surgical anatomy of the vagus nerve implies the anatomy of the esophageal plexus and structures distal to the plexus. This review would be incomplete without mentioning the origin of the vagus from the cranium and its course downward to the esophageal plexus (Fig. 1).

Within the cranium, eight to ten vagal rootlets are associated with four nuclei of the medulla: the dorsal nucleus of the vagus, nucleus ambiguus, nucleus of the tractus solitarius and the spinal nucleus of the trigeminal nerve. The rootlets of the nerve unite to form a flat band which passes through the jugular foramen of the cranium with the spinal accessory and glossopharyngeal nerves. There are two swellings of the vagus nerve, one just within the cranium, the superior ganglion, and one just outside the cranium, the inferior ganglion.

Distal to the jugular fossa, the vagus nerve

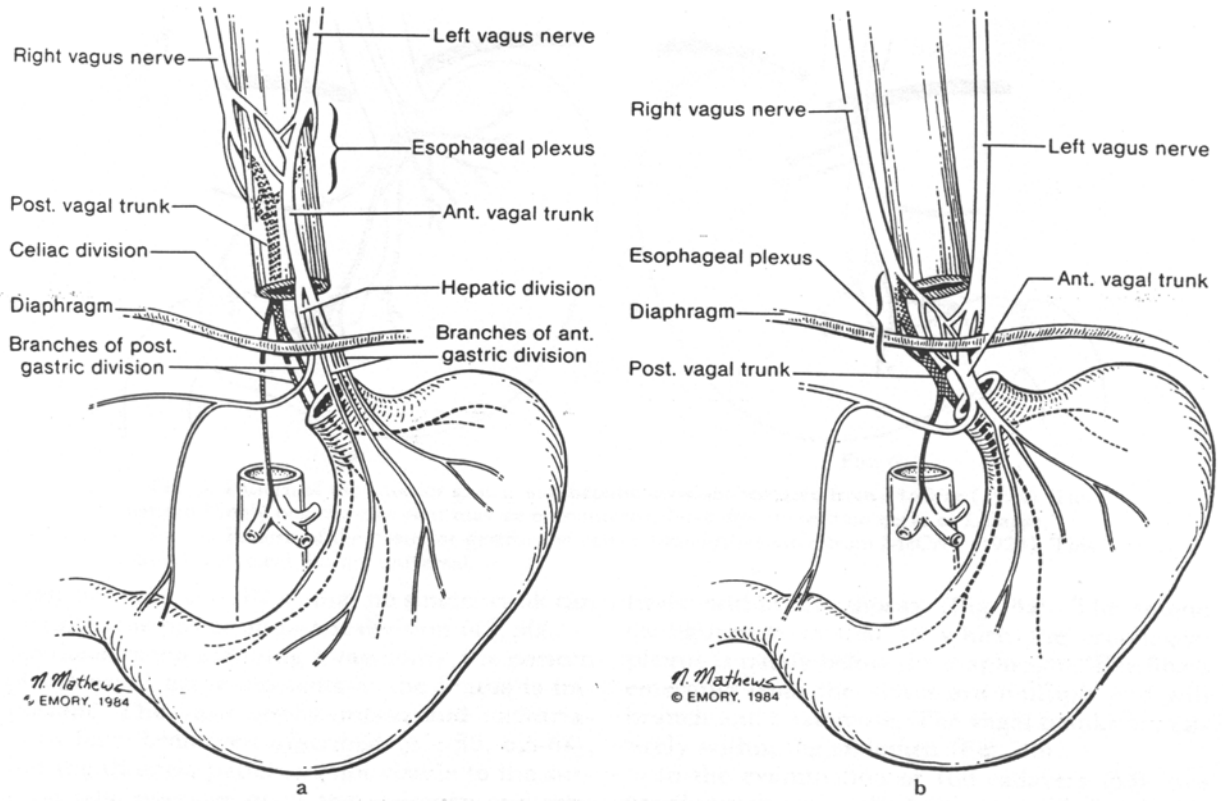

FIG. 4. In a few individuals, more than four vagal elements are present. a, Divisions that have already branched above the diaphragm. The vagal trunks are entirely within the thorax. b, At the other extreme, the esophageal plexus may extend below the diaphragm. The vagal trunks lie entirely within the abdomen.

descends through the neck in the carotid sheath with the internal jugular vein and the internal carotid artery (upper portion) or the common carotid artery (lower portion). Within the neck, each nerve gives rise to five branches: the pharyngeal nerve, a branch to the carotid body, superior laryngeal nerve, recurrent laryngeal nerve and the cardiac nerve. The right vagus nerve crosses the subclavian artery and enters the thorax, descending through the superior mediastinum to the right of the trachea and posterior to the root of the right lung. It continues on the posterior surface of the esophagus where it breaks up into the posterior esophageal plexus which also receives the left vagus nerve.

The left vagus nerve enters the thorax between the left common carotid and left subclavian arteries, behind the left branchiocephalic vein. It descends through the superior mediastinum, crossing the left side of the aortic arch and passing posteriorly to the root of the left lung. Descending on the anterior surface of the esophagus, its fibers join those of the right vagus nerve to form the esophageal plexus. This vagal plexus lies on the esophagus, usually between the level of the bifurcation of the trachea and the diaphragm, but it may occasionally extend below the diaphragm. Distally, the fibers of the plexus reunite to form the anterior and posterior vagal trunks. Each trunk divides to form two divisions.

From the anterior trunk the *hepatic division* passes to the right in the lesser omentum, branching before it enters the liver. One branch typically turns downward to innervate the pylo-

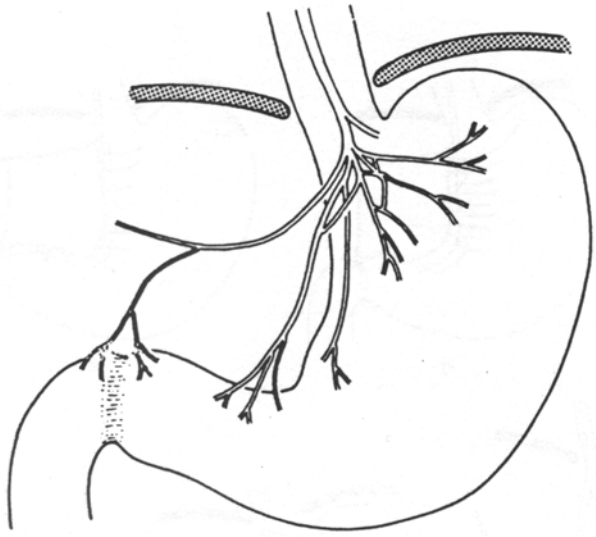

FIG. 5

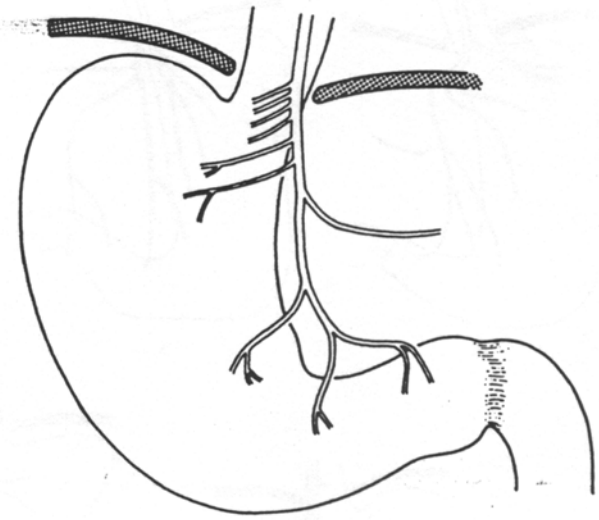

FIG. 6

FIG. 5. Pattern of the anterior gastric and hepatic divisions redrawn from McCrae (1924). This pattern is only one of many that may be encountered. Note that there is no nerve of Latarjet.

FIG. 6. Pattern of the posterior gastric and celiac divisions redrawn from McCrea (1924). This pattern is typical but not universal.

rus and the first part of the duodenum. The second division, the *anterior gastric division,* follows the lesser curvature of the stomach, giving from two to 12 branches to the anterior gastric wall.

The posterior vagal trunk divides into the *celiac division* passing to the celiac plexus, and the *posterior gastric division* with branches to the posterior gastric wall. Occasionally, the gastric branches arise serially so that no single trunk can be called the posterior gastric division (49, 50).

To the surgeon planning a vagotomy, the pattern of the vagal nerve elements at the hiatus is important. The basic configuration and its variations have been well described (43, 50, 62—64), but the thoracic pattern is not visible to the surgeon who operates upon the abdomen and who must proceed on the basis of nerve structure that appear, emerging through the hiatus with the esophagus.

"Vagal structures" entering the abdomen through the hiatus may be trunks, divisions, branches of divisions or portions of the esophageal plexus. *Two structures* (vagal trunks) at the histus is the simplest and most frequently encountered condition (Fig. 2). The esophageal plexus lies well above the hiatus and the anterior and posterior trunks separate into divisions well below the hiatus. The trunks are usually to the right of the midline. Among 100 cadavers examined in one study (63), 91 per cent of anterior and 86 per cent of posterior trunks were on the right. Emerging from the esophageal hiatus, the anterior vagal trunk lies closer to the esophagus than does the posterior trunk which lies closer to the aorta (63), although exceptions to this have been described (62).

Four structures (divisions) at the hiatus result from an unusually high esophageal plexus with separation of division occurring above the diaphragm. The vagal trunks lie entirely in the thorax (Fig. 3). *More than four structures* at the hiatus may be the result of a thoracic branching of one or both vagal divisions. The trunks are entirely within the thorax (Fig. 4a). The second

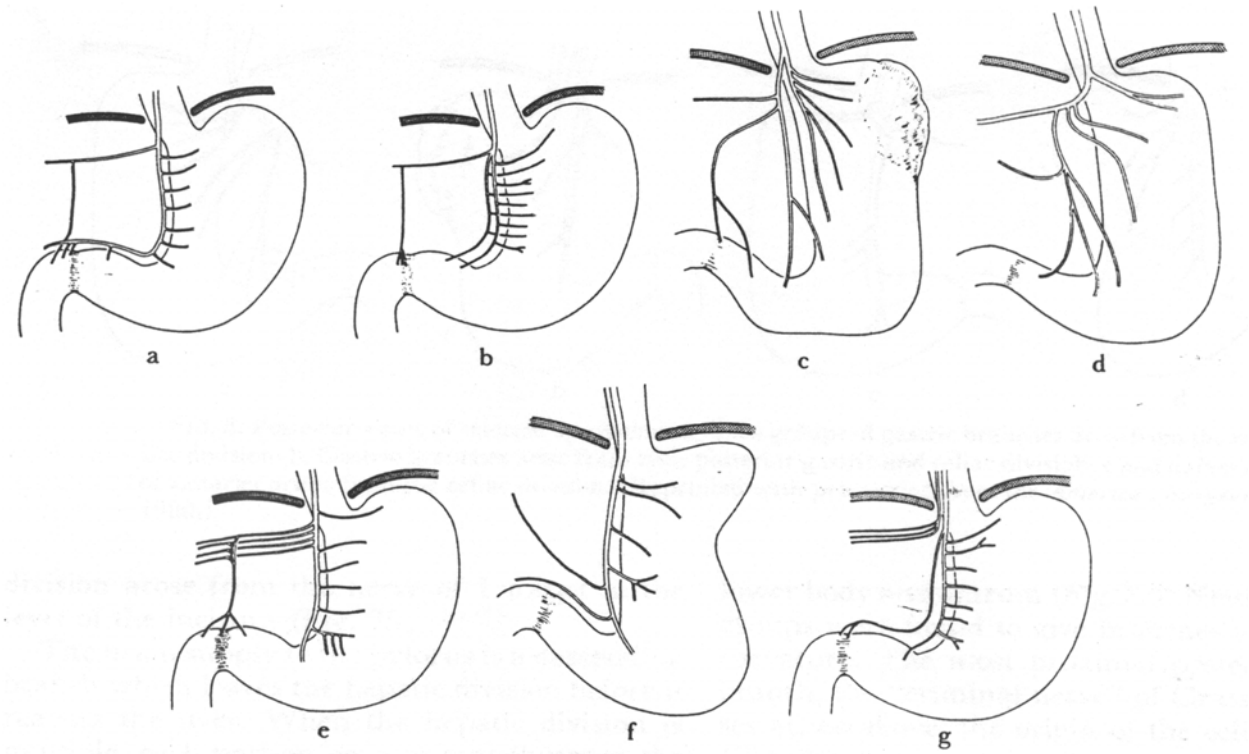

FIG. 7. The anterior views of several selected specimens. a, Innervation of the pylorus by the anterior gastric division and the pyloric branch of the hepatic division. b, The double nerve of Latarjet. c, No typical nerve of Latarjet is present. d, The gastric branches originate from the hepatic division. e, Multiple hepatic divisions are shown. f, Low origin of the hepatic division. g, The pyloric branch arises from the anterior gastric division. Reprinted with permission from the *American Surgeon*, 1980.

configuration is that in which the esophageal plexus is partly below the diaphragm. The fibers emerging from the hiatus are multiple and will branch and anatomose. The vagal trunks are entirely within the abdomen (Fig. 4b).

In the examination of 100 cadavers (63), two vagal structures at the hiatus were found in 88, four vagal structures in seven and more than four in five. In the last group, two were the result of thoracic branching of divisions, while three had portions of the plexus at the hiatus. Accessory vagal nerves above the plexus have not been reported but the existence of accessory vagal trunks below the plexus have been mentioned (64) but have not been confirmed (63).

In summary, the level of the esophageal vagal plexus and the level of the separation of vagal trunks into divisions control the pattern of vagal structures at the hiatus. The plexus may be "high," entirely within the thorax, or "low," extending through the hiatus. The truncal bifurcation may be "high," within the thorax, or "low," within the abdomen. Variation of the level of the diaphragm has been suggested (62) to explain the position, but this is not embryologically defensible (63).

That fibers of the vagus nerve are distributed to the walls of the stomach was known to Galen and Vesalius, but the discovery of the action of the nerve on gastric secretion and possible therapeutic vagal section forced attention to the detailed anatomy of the nerves and their branches. The first of the modern

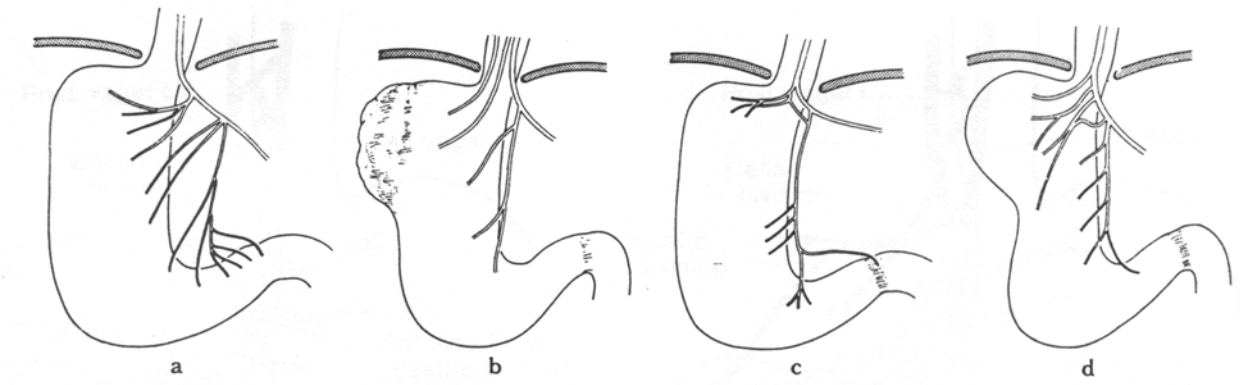

FIG. 8. Posterior views of selected specimens. a, Two groups of gastric branches arise from the celiac division. b, Gastric branches arise from both posterior gastric and celiac division. c and d, Nerve of Latarjet arises from the celiac division. (Reprinted with permission from the *American Surgeon*, 1980.)

studies was done in 1922 (38) on dogs, preparatory to operations on human patients (37). In 1924, anatomic studies up to that time were reviewed (65) and the distribution of nerves found in seven cadavers was described (Figs. 5 and 6). This work was followed by a number of studies of the vagal anatomy (32, 43, 49, 50, 56, 66—69).

ANTERIOR GASTRIC DIVISIONS

The separation of the anterior vagal trunk into anterior gastric and hepatic divisions is usually found on the surface of the distal esophagus at the gastroesophageal junction. In most instances, a major branch of the anterior gastric division forms the principal anterior nerve of the lesser curvature, the nerve of Latarjet. It lies 0.5 to 1.0 centimeter from the lesser curvature and can be traced to the level of the incision in most instances and as far as the first part of the duodenum in six specimens (67) (Fig. 7a). In the rare instances in which the nerve is doubled (Fig. 7b), the longer of the two has been called the antral nerve, but it probably extends beyond the antrum.

Occasionally, there is no true nerve of Látarjet. Instead, the antrum is supplied by a fan of gastric branches arising from the anterior vagal trunk proximal to the origin of the hepatic division (Fig.7c), or from the hepatic division itself (Fig. 7d). Such branches may be present even when there is a well defined nerve of Laterjet (67).

HEPATIC DIVISION

The hepatic division of the anterior trunk leaves the stomach to pass between the leaflets of the avascular portion of the gastrohepatic ligament. If there is an aberrent left hepatic artery, the hepatic nerve lies just above the artery. It has been accurately reported (68) that, within 1 centimeter above or below an imaginary transverse line at the level of the angle of His, one will usually encounter the following structures from above downward: the bifurcation of the anterior and posterior vagal trunks, the beginning of the hepatic division, the beginning of the celiac division, the bifurcation of the left gastric artery and an aberrant left hepatic artery when present. The hepatic division is often (23 instances) found in multiple closely parallel branches (Fig. 7e). In some instances, the hepatic division clearly receives contributions from both the anterior and

posterior vagal trunks. The hepatic division may arise from the nerve of Latarjet, at or below, the lesser curvature. In one specimen, the hepatic division arose from the nerve of Latarjet at the level of the incisura (Fig. 7f) .

The usual supply to the pylorus is a descending branch which leaves the hepatic division before it reaches the liver. When the hepatic division is multiple, each portion usually contributes to the pyloric branch (Fig. 7e). Occasionally, the pyloric branch arises from the anterior gastric division, passing diagonally to the pylorus or following the lesser curvature (Fig. 7g). This is not a double nerve of Latarjet; it gives off no branches to the stomach wall. Anastomoses between the anterior nerve of Latarjet and the pyloric branch have been observed (67, 69).

POSTERIOR GASTRIC AND CELIAC DIVISIONS

The posterior gastric and celiac divisions usually separate below the diaphragm. In general, these posterior divisions are less variable than are the anterior divisions. In most instances, the celiac division follows the left gastric artery while the posterior gastric division forms the posterior nerve of Latarjet. Generally, the posterior gastric division terminates slightly higher on the lesser curvature and has fewer large branches than does the anterior gastric division. In three instances, the posterior nerve reached the pylorus, but rarely, if ever, did it extend as far as the duodenum. The most frequent pattern of the posterior gastric division is similar to that which has been previously described (65) (Fig. 6). This is Jackson's Type 1 (49). In a number of instances, the gastric branches fall into superior and inferior groups (67) (Figs. 8a). The superior group may arise from the posterior vagal trunk at, or above, the level of the diaphragm (Fig. 8b). The inferior group of branches may arise from the posterior nerve of Latarjet and supply only the lower body and antrum (Fig. 8c). Neither of these groups were found to give branches to the lesser curvature. The most proximal posterior gastric branch, the "criminal nerve" of Grassi (60), arises at, or above, the origin of the celiac division (Fig. 8d).

When the posterior nerve of Latarjet is absent, branches arising from the celiac division turn medially to innervate the lesser curvature and antrum (Fig. 8a). These are the Types 4 and 6 of Jackson's classification (49).

CELIAC DIVISION

Of the four vagal divisions, the celiac division is the largest. It lies in the gastropancreatic peritoneal fold. In almost all instances, it is single and leads to the celiac plexus. It may follow the left gastric artery, the right crus of the diaphragm or take an intermediate position in the triangle bounded by the left gastric artery, the right crus of the diaphragm and the right margin of the stomach. The nerve lies closer to the artery than to the crus in 80 per cent of specimens (49).