

Anatomy of the Anterior Vagus Nerve: An Anatomic Description and its Application in Surgery

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Abstract

Objective: Anatomic study of human corpses in order to obtain specific measurements of the anterior vagus nerve for its application in the surgical field.

Methods: After analyzing the literature, dissections were performed on 15 human corpses, provided by the Universidad del Salvador. Descriptions were made of our observations.

Results: The most frequently found structure in esophageal hiatus was a plexus. The cardiac branch was present in 100% of the dissections. There were a constant number of gastric branches, between five and seven. The hepatic branch originated from the plexus in the majority of the cadavers. The distance between first and last branch points was variable. No relationship between the hepatic branch and left hepatic artery was observed.

Conclusions: The structure most commonly found in the esophageal hiatus was the terminal plexus of the anterior vagus nerve. The hepatic branch most frequently originated directly from this plexus, although in a considerable number of cases its origin was found either proximal or distal to this structure. We could not confirm the literature stating the relationship between the hepatic branch and the left hepatic artery through our studies. The number of gastric branches was constant. The distance between the first and last gastric branch was extremely variable, which can be explained by the anthropometric differences between the cadavers. No relationship was found between the number of gastric branches and the length of the main gastric branch.

Keywords: Vagus Nerve; Selective vagotomy; Stomach innervations; Peptic ulcer disease

Introduction

The vagus nerve is composed of both sensory and motor fibers. From the neck it penetrates into the mediastinum, and runs posterior to the pulmonary pedicle until it reaches the abdomen. Here it traverses the diaphragmatic hiatus along with the esophagus. Before reaching the abdomen, it forms the cardiac plexus and peri-esophageal plexus. The latter gives origin to the anterior and posterior vagus nerves.

The anterior vagus nerve descends in an oblique fashion towards the cardia or gastro-esophageal junction. At this point, it can continue either as an individual branch, as two terminal branches, or as a new plexus from which the terminal branches arise. These are: the principal gastric branch (Latarjet and Wertheimer's nerve), and the hepatic branch. The principal gastric branch descends along the lesser curvature, maintaining intimate contact with the anterior layer of the lesser omentum. Its direction then changes towards the pylorus. Five to seven rami branch off from this nerve to innervate the lesser curvature. The hepatic branch is also found within pars flaccida of the lesser omentum and makes its way to the hepatic hilum, between the liver's left lobe and caudate lobe [1-4].

Peptic ulcers have many means of being treated surgically. However, surgery is generally reserved for those patients who fail medical or endoscopic treatment; or those who suffer from a complication such as hemorrhage, perforation or gastric outlet obstruction [5-8].

The primary goal of vagotomy is to diminish gastric acid secretion. The decision to perform this technique, and the approach selected, are the primary concerns that emerge due to the lack of detailed descriptions and the high anatomic variability of this region. Even the principal authors on the subject have contrasting descriptions which only seed more insecurity and doubt.

The variability of this anatomy is a risk factor for post-operative complications. There is a risk of inadvertent nerve injuries that can alter the function of the pylorus and other abdominal organs. In contrast, a highly selective vagotomy may decrease complication rates, however recurrence rates increase substantially [9-11].

Peptic ulcers surgeries have a series of undesirable side effects and a possibility of therapeutic failure. We have investigated this topic further so as to provide a reliable description of the anatomy of the anterior vagus nerve in esophageal hiatus, which can later be applied to the surgical field.

This investigation was performed by dissection of 15 cadavers randomly chosen, of varying ages and sex. The esophageal hiatus was dissected, isolating the different structures, taking measurements and analyzing the results based on frequency of presentation of the anatomical variants.

Materials and Methods

The materials researched included 15 human cadavers, of both sexes. The dissections were performed over a period of 3 months, from June until August 2008. These were provided by the Department of

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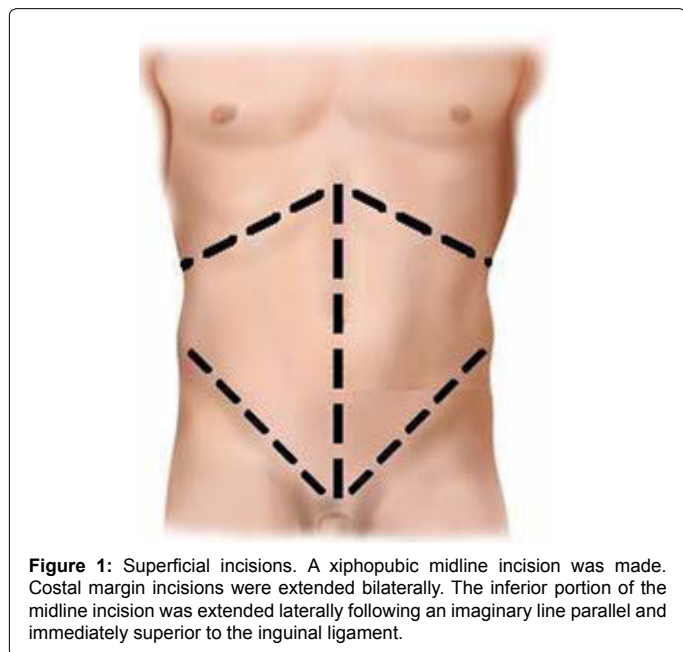
Anatomy of the School of Medicine of the Universidad del Salvador in Buenos Aires, Argentina. The cadavers were organized and labeled. Data obtained from each cadaver was registered on individualized charts.

The dissection technique was determined beforehand based on analysis of our bibliography. A midline abdominal incision was made. This was extended from the xiphoid process to the symphysis pubis. The incision was then extended laterally following the costal margins and an imaginary line immediately superior to the inguinal ligaments (Figure 1).

Next, a horizontal incision was made 2 cm to the left of the lesser curvature at its most proximal point. The incision was extended distally, until the length of the principal nerve was entirely exposed. The anterior peritoneal layer of the lesser omentum was then reflected towards the liver, exposing the structures in the esophageal hiatus.

The measurements taken were the following:

- a. Structure in the esophageal hiatus (Figure 2): Three variants



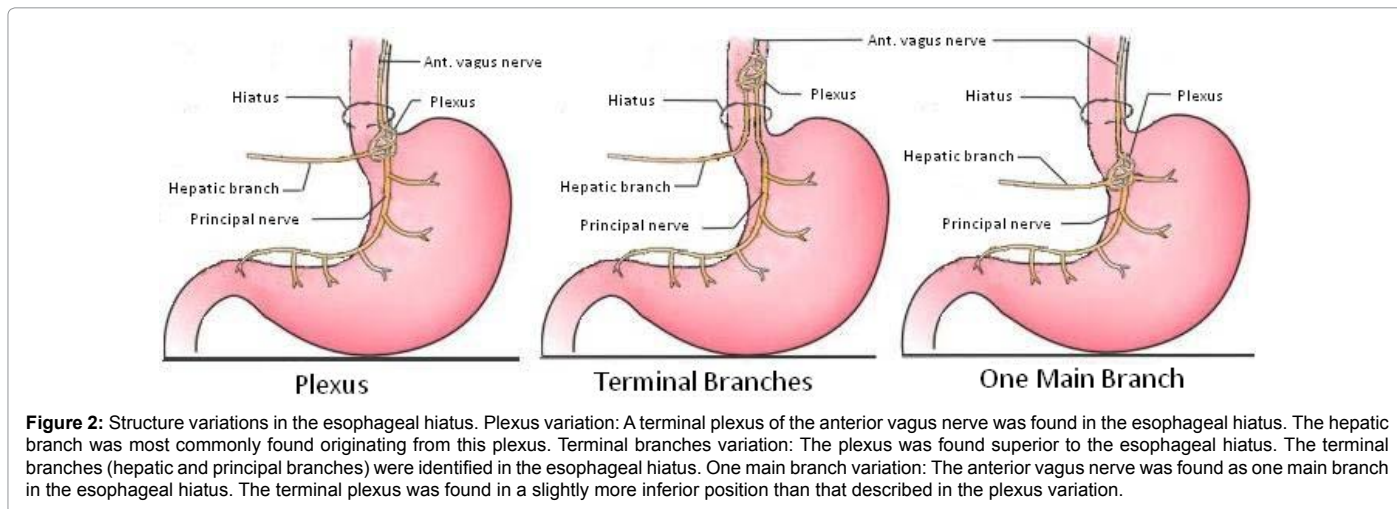
were. These were: a *plexus*, *one main branch*, or *terminal branches*. The *plexus* variant was visualized as anastomotic nerve fibers at the cardia. The *one main branch* variant was seen as a solitary branch through the esophageal hiatus which later formed a plexus distal to the cardia. The *terminal branches* variant were observed as two individual branches (principal nerve and hepatic nerve) which did not emerge from a plexus in the esophageal hiatus, the plexus was formed proximally in the thorax.

- b. Cardiac branch: The presence or absence of a branch which innervated the cardia.
- c. Distance from the hiatus to the point of cardiac nerve branching: Measurements were taken from the right edge of the esophagus as it crosses the diaphragm, to the origin of the cardiac branch.
- d. Total number of gastric branches: The number of gastric branches arising from the principal nerve of Latarjet, including the cardiac branch (first gastric branch).
- e. Origin of the hepatic branch: This branch originated either proximal, distal, or directly from the terminal plexus of the anterior vagus nerve.
- f. Distance between the first and last gastric branching point: The distance between the origin of the cardiac branch and the most distal point of the principal nerve was measured.
- g. Relationship between the left hepatic artery and the hepatic nerve: This relationship has been described when one encounters a replaced left hepatic artery arising as a branch of the left gastric artery.

Results

Table of results showing the different measurements obtained for each cadaver (Table 1).

Structure in the esophageal hiatus: The structure found in the esophageal hiatus had the following distribution: *Plexus* 67%, *Terminal branches* 20%, *One main branch* 13%. In the *plexus* variant, the terminal plexus of the anterior vagus nerve was observed as anastomotic nerve fibers at the cardia. The two terminal branches, the principal gastric nerve and the hepatic nerve, originated from this structure. The hepatic



Variables	Cadaver number						
	302	303	306	307	309	310	311
Structure in hiatus	T.B.	Plexus	T.B.	Plexus	Plexus	Plexus	Plexus
Cardiac branch	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Distance hiatus-cardiac branch (cm)	1.4	1.3	1.8	1.4	1.7	2.7	1.9
Total # gastric branches	5	5	6	7	6	6	5
Origin of hepatic nerve	Plexus	Plexus	Distal	Plexus	Proximal	Proximal	Plexus
Distance between first and last branch	12.3	10.3	10.7	5.5	8.2	8.4	4.6
Relationship between hepatic nerve and artery	No	No	No	No	No	No	No

Variables	Cadaver number							
	312	313	315	316	317	318	319	320
Structure in hiatus	M.B.	Plexus	M.B.	Plexus	T.B.	Plexus	Plexus	Plexus
Cardiac branch	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Distance hiatus-cardiac branch (cm)	1.9	1.6	2.1	2.2	1.2	2.4	1.4	2.4
Total # gastric branches	6	5	5	5	5	6	5	5
Origin of hepatic nerve	Plexus	Distal	Plexus	Distal	Plexus	Plexus	Proximal	Plexus
Distance between first and last branch	8.6	6.6	11.4	9.1	9.3	13.5	4.9	7.3
Relationship between hepatic nerve and artery	No	No	No	No	No	No	No	No

T.B. = Terminal branches; M.B. = Main branch

T.B. = Terminal Branches. M.B. = One Main branch. Origin of hepatic nerve: Plexus – directly from the terminal plexus; Distal – distal to the terminal plexus; Proximal – proximal to the terminal plexus.

Table 1: Table of results showing the different measurements obtained for each cadaver.

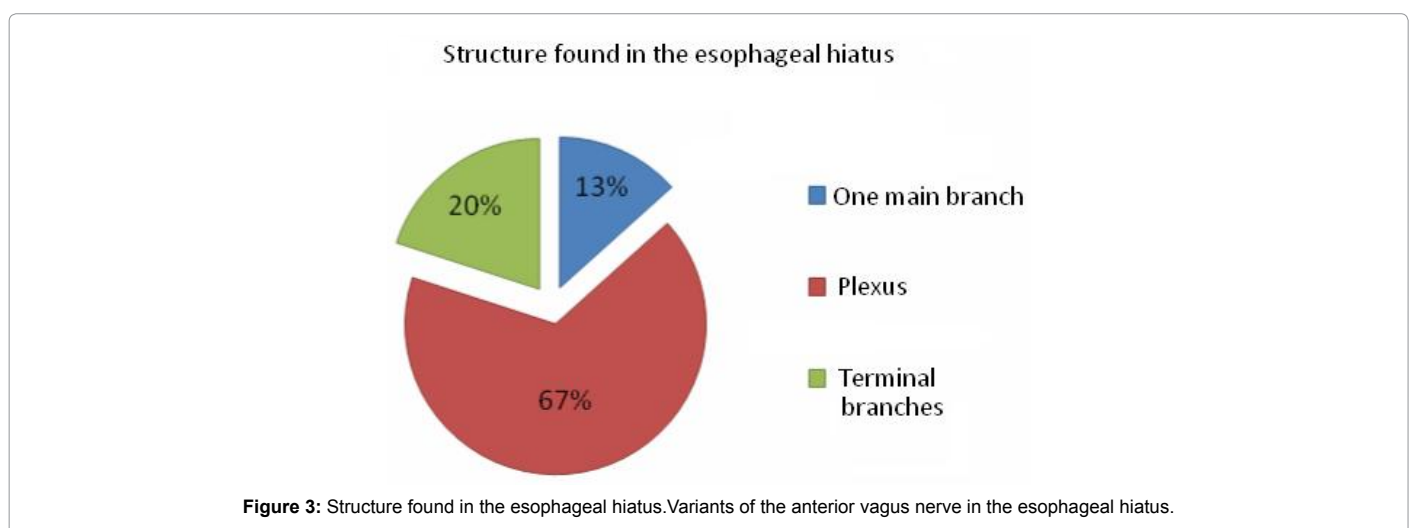


Figure 3: Structure found in the esophageal hiatus. Variants of the anterior vagus nerve in the esophageal hiatus.

nerve was found to originate both proximally and distally to the terminal plexus in different cadavers (Figure 2 and 3).

When we observed the *terminal branches* variant, we identified the principal gastric nerve and hepatic nerve in the hiatus. We found that the plexus originated proximally in the thorax. The principal nerve always originated from the plexus, while the hepatic nerve origin was found either proximal or distal to this structure.

We infrequently found *one main branch* in the esophageal hiatus. This branch was found in the hiatus with the terminal plexus forming more distally than usual.

Cardiac branch

The cardiac branch was found in 100% of the dissections, and it was always the first branch.

Distance from the hiatus to the cardiac branch

The mean distance between the hiatus and the cardiac branch was

1.83 cm. The smallest distance was 1.2 cm, the largest distance was 2.7 cm (range was 1.5 cm). The standard deviation was ± 0.46 cm.

Total number of gastric branches

The total number of gastric branches was between 5 and 7, the most common being 5 branches (5 branches - 60% of cases; 6 branches - 33% of cases; 7 branches - 7% of cases).

Origin of the hepatic branch

The origin of the hepatic branch had the following distribution: 60% from the plexus, 20% proximal to the plexus, and 20% distal to the plexus.

Distance between the first and last gastric branch

The mean distance between the first and last gastric branch was 8.71 cm. The smallest distance found was 4.6 cm, the largest distance was 13.5 cm (range was 8.9 cm). The standard deviation was ± 2.65 cm.

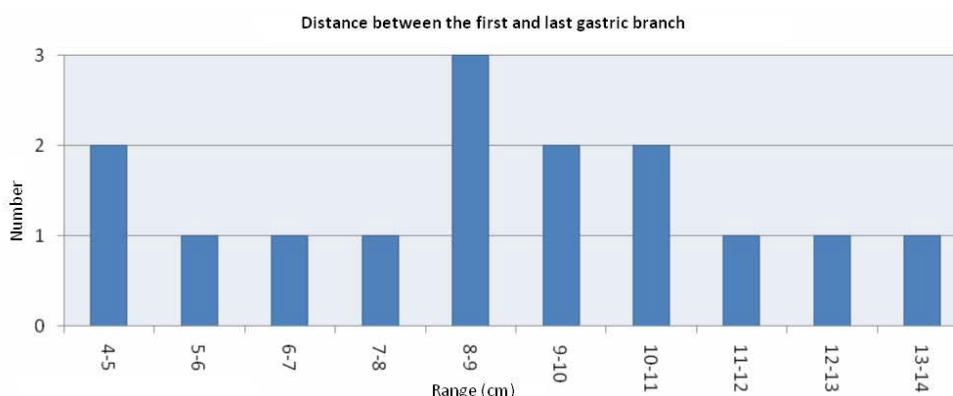


Figure 4: Distance between the first and last gastric branch. Length of the principal nerve of Latarjet.

Values between 8 and 11 cm were predominant (Figure 4).

Relationship between the left hepatic artery and the hepatic nerve

No relationship between the left hepatic artery and the hepatic nerve was found during our dissections.

Discussion

After an extensive bibliographic search we found few scientific papers oriented towards the subject at hand. However, we identified and analyzed the most relevant literature.

The classical descriptions [3,4,12] refer to the existence of a periesophageal plexus, which according to Gorostarzu [2], is found 2 to 6 cm above the diaphragm, and will give rise to the anterior vagus nerve. In our dissections we found that this nerve later forms a terminal plexus, from which several collateral gastric rami originate, as well as two terminal branches: the principal gastric nerve of Latarjet and the hepatic nerve [13]. We discovered that in 67% of cases, the terminal plexus is found in the esophageal hiatus. In 20% of cases, it is found above the diaphragm, and in 13% found distal to the hiatus. This concurs with Gorostarzu's description, although his findings suggest that the formation of the terminal plexus was most commonly found distal to the hiatus. Hovelaque [12] describes that the branches of the anterior vagus nerve begin separating in the esophageal hiatus, but never form a plexus.

According to Hovelaque [12] and Johnston [14], the cardiac branch is a consistent finding. Johnston describes a technique for selective vagotomy starting with an incision 6 cm to the left of the angle of His, extending parallel to the lesser curvature to a point 6 cm proximal to the pylorus. Using a similar technique we were able to successfully dissect this region exposing all of the gastric branches. Of note, there is also a branch of the posterior vagus nerve specifically destined to innervate the cardia, the criminal nerve of Grassi. It is important to recognize this branch to avoid an inadequate vagotomy.

Minor contradictions can be found amongst the foremost authors regarding the total number of gastric branches. Hovelaque [12] describes 4 to 6 branches. Jackson [13] describes 1 to 9 branches with an average of 4. Gorostarzu [2], Rouviere [3] and Testut [4] describe 5 to 7 branches. In our dissections we confirmed the amount of 5 to 7 branches. The most common finding was 5 branches (60%). Even though this may be of anatomical interest, Johnson [15] states that it lacks practical importance.

We observed that the hepatic branch originates from the terminal plexus in 60% of cases. Although there isn't much detail in the literature with regards to the descriptions of this nerve branch, Jackson [13] provides an in depth description. We feel that this structure is relevant for two main reasons. First, it is a useful guide to finding the terminal plexus. Second, it's important to identify this structure so as to avoid unnecessary lesion. Gorostarzu [2] and Harkins [16] described a method to facilitate the visualization of this nerve. By pulling gently on the greater curvature inferiorly, anteriorly and to the left, the lesser omentum is tensed, revealing the hepatic and principal nerves. Also, laying the lesser omentum over the dark colored caudate lobe creates a contrasting visual effect which helps identify the hepatic nerve. Both of these techniques were of great utility during our dissections and we recommend its use during surgery.

The distance between the first and last gastric branch was a measurement that was not described in the literature. However, the relationship between the pylorus and the distal gastric branches has been investigated. Hovelaque [12] and Johnson [15] suggest that the principal gastric nerve does not reach the pylorus. Conversely, Harkins [16] and Griffith [8], describe a pyloric branch that should be conserved during surgery. We believe that the distance between the first and last gastric branch can be useful when trying to locate the pyloric branch, which should be spared when performing a highly selective vagotomy. Our measurements were widespread which is likely explained by anthropometric differences between the cadavers.

Gorostarzu [2] makes reference to an important relationship between the hepatic nerve and the replaced left hepatic artery (when its origin can be found from the celiac trunk or the left gastric artery). This is significant in that a lesion to the left hepatic nerve could also entail damage to the left hepatic artery, a potentially serious complication. In our dissections we could not find this relationship, due to the fact that in all our dissections the left hepatic artery maintained its traditional origin from the proper hepatic artery.

In 1943 Lars Dragsted [17] described a surgical technique in which the anterior vagus nerve was sectioned, which he named *truncal vagotomy*. Given that the nerve was severed proximal to the terminal plexus, the hepatic, pyloric, gastric and duodenal branches lost their parasympathetic effects. In consequence, patients who underwent this procedure suffered from numerous complications. Basing himself on Dragsted's studies, Griffith [18] published a modified technique called *proximal anterior vagotomy* (PAV). PAV consisted in a selective sectioning of gastric branches, avoiding lesion to non-gastric branches.

This technique which later became known as *selective vagotomy* was shown to have less adverse effects than *truncal vagotomy*, nonetheless, many surgeons were reluctant to using this method since the nerves theoretically conserved were later damaged during the accompanying pyloroplasty. Holle [19] concluded that an even more selective sectioning of the proximal gastric nerves which reach the fundus (cardiac branch) would cause diminished acid secretion since this is the area of highest concentration of parietal cells. Finally, it was Johnston in England and Amdrup in Denmark who described the *parietal cell vagotomy*. This consists in a severing of the gastric branches more than 6 cm from the pylorus which produces, in theory, a denervation of practically all parietal cells according to Johnson [15].

Conclusions

Knowing the anatomy of the anterior vagus nerve in the esophageal hiatus is important when practicing surgical maneuvers in the area so as to minimize unnecessary lesions. Familiarity of its anatomy is therefore an indispensable tool when planning surgical approaches in this region.

In the esophageal hiatus, the most frequently found structure was the terminal plexus of the anterior vagus nerve. The hepatic nerve most commonly originates from this plexus, however it may originate either proximal or distal to the plexus in a considerable number of cases. This variability is essential to recognize given that an accidental lesion to any of these structures may result in hepatic or cholecystic denervation. Naturally, surgeons wishing to perform any type of vagotomy should be thoroughly familiar with these variants so as to obtain better results and less unnecessary adverse outcomes.

There was little variance in the number of gastric branches. Conversely, the length of the principal nerve was extremely variable. We think that these finding is of minimal importance in surgical practice.

Although medical management has been quite successful in the management of gastroduodenal ulcers and gastro-esophageal reflux disease, surgeons must still be wary that many patients will require surgical procedures to cure their illness. Precise anatomical knowledge of this area is consequently of fundamental value to avoid both recurrence and complications.

Our study has several limitations. The sample size is small, which may leave uncommon anatomical variants unaddressed. We have seen this when attempting to describe variants of the left hepatic artery. Although readily described, we did not encounter any replaced left gastric arteries in our dissections. Moreover, this is an observational study which aims to provide descriptions, and thus a thorough statistical analysis cannot be performed. Finally, we only studied cadaveric specimens, which have been maintained in formaldehyde for varying amounts of time. A study of live patients may offer better insight into the subject matter.

We have found through our study that many of the previous descriptions are, in fact, rather accurate and closely resemble our own results. However, we have found several discrepancies between previous authors and our own findings, and believe it's important to pay attention to *these* variants in particular. There is not a unified consensus in the literature and in several cases we have produced new descriptions. For the reasons aforementioned we place emphasis in identifying the precise anatomy of this region and its multiple variants, so as to lessen unnecessary mistakes during surgical practice.

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