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ANATOMICAL STUDIES OF THE VAGUS NERVE AND ITS BRANCHES TO THE STOMACH.

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In the course of some work on the influence of the vagi nerves on the functions of the stomach, it was fou nd necessary to obtain an accurate knowledge of their anatomical distribution in the abdomen, and this paper is the outcome of the investigation.

The course and distribution of the vagi nerves to the oesophagus and to the intra-abdominal organs are given in very general terms and brief space in the present textbook of anatomy. The literature reveals many varying statements as to the arrangement, whilst the structure of the oesophageal plexus as shown by earlier observers has been neglected. In any account of the sub-diaphragmatic distribution of the vagi,it is necessary to consider the influence of the structure of the oesophageal plexus on this distribution.

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Mitchell, G.A.G. (1939)(8) summarizes the differences found by various workers, the principle being:

1. The number of nerve stems passing through the oesphageal opening of the diaphragm.
2. The presence or absence of an anterior and posterior gastric plexus.
3. The presence or absence of a sub-serous ganglifform plexus.

Method

Specimens for dissection were prepared as follows:

1. The tissue are immersed in acetic acid(1%)for 24 hours.
2. They are washed and placed in carbolic acid (6%) for 20 to 40 minutes.
3. They are again washed and then preserved in saturated watery solution of picric acid, after 24 hours in this they are ready for dissection.

Prepared in this manner, the specimens are soft and pliable and the nerves are easily recognized as white glistening strands. Specimens keep indefinitely in the picric acid solution, but it must be borne in mind that the penetrative action is not great and that the larger organs, such as the liver, may undergo central autolysis.

Dissections were made of six adult male cadavers.

The following account is compiled from these; minor individual variations occur and are referred to in the descriptions of the individual specimens.

DISSECTION OF THE VAGUS

Both vagi, having passed posterior to the lung roots, incline anteriorly and medially and proceed to divide, the right usually into three branches, sometimes four; the left almost invariably into three. These branches are then arranged about the lower third of the oesophagus in the following manner: two branches of the left nerve pass to the anterior aspect of the oesphagus and there unite with one branch of the right which has also reached this aspect; the latter branch is small as compared with the remaining divisions of the right nerve. Together these nerves form a very simple plexus on the anterior surface of the oesophagus, and from this one or two stems pass through the oesophageal opening of the diaphragm, forming the anterior vagal trunk.

The remaining divisions of the right and left nerves, in number usually two or three of the right and one of the left, have by now passed to the posterior aspect of the oesophagus and there form a plexus, again simple, from which there usually arises a single trunk, the posterior vagal trunk, passing through the oesopha-

geal opening of the diaphragm.

The oesophagus is supplied by numerous fine twigs which arise from these various stems as they lie closely applied to its wall. Intercommunications between the main stems of the anterior group are found and between the stems of the posterior group, varying in number,and with their number the plexus varies in complexity. The oesophageal plexus is, therefore, seen to be composed of an anterior and a posterior group of nerves.

The anterior vagal trunk (Figure 1) having passed through the oesophageal opening as one or two stems,supplies several fine twigs to the lower end of the oesophagus and to the cardia. It then breaks up into its main branches, in most cases from three to six in number. These may be divided into two groups; a group lying to the right and on an anterior plane usually consisting of two stems, and a group to the left and on a deeper plane of three to four stems.

The left group may or may not show interconnections, few or many in number, in the latter case an anterior gastric plexus is formed. Its main branches of distribution associate themselves with the anterior branches of the left gastric artery, and supply the region of the anterior surface of the cardia, fundus and proximal por-

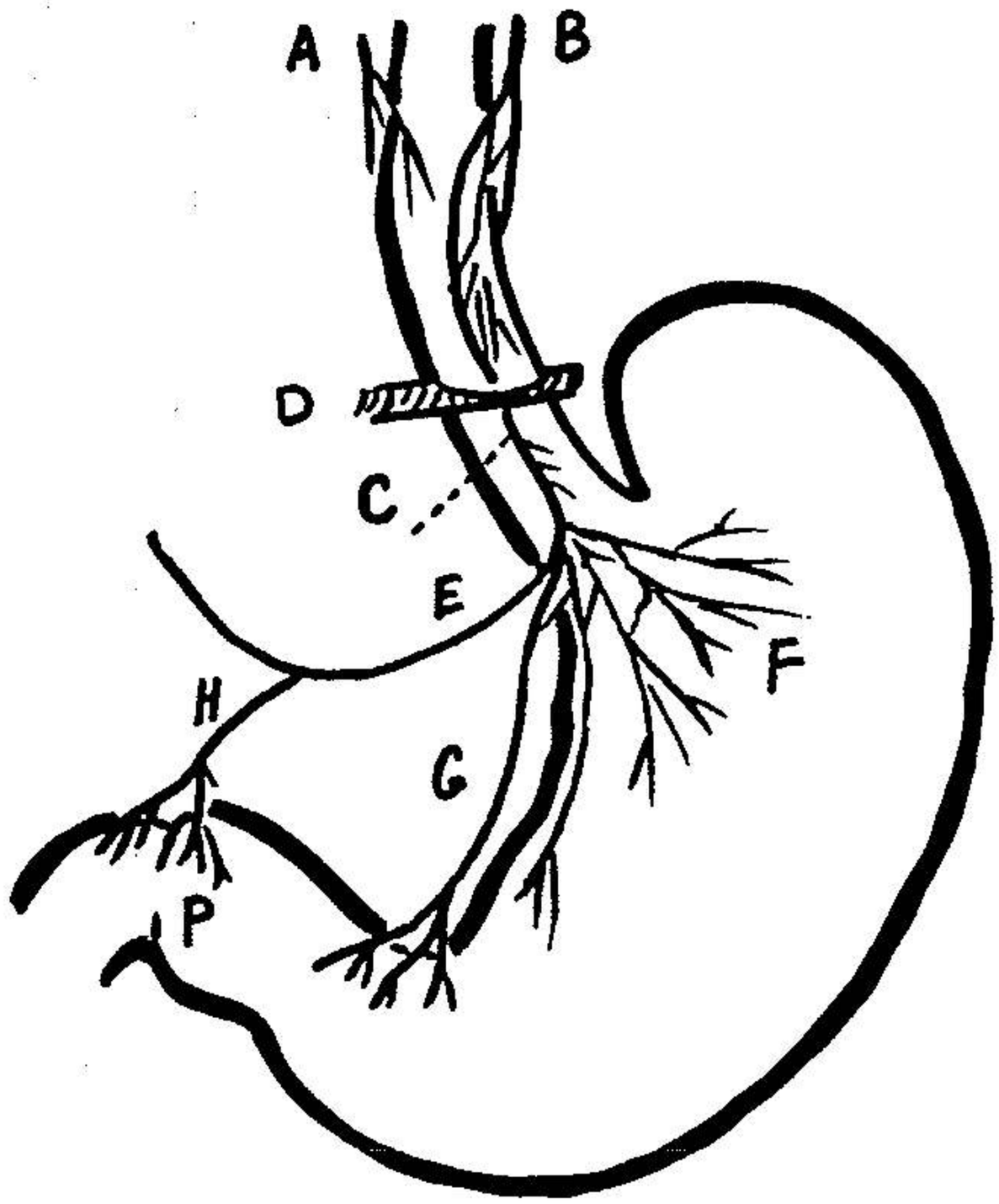

Fig.1. Drawing made from a dissection showing the normal formation and distribution of the anterior vagal trunk. A, right vagus. B, left vagus. C, anterior vagal trunk. E, hepatic branch. F, gastric branches. G, principal anterior nerve of the lesser curvature. H, branches to pylorus and first stage of the duodenum. P indicates the position of the pylorus; I, that of the incisura angularis, and D the diaphragm.

tion of the body of the stomach. Some communications are also always present with the right group of branches.The right group gives origin to three main branches of distribution; the first passes out into the lesser omentum and proceeds toward the porta hepatis, its manner of termination being described below. The second, a large nerve, passes down between the layers of the lesser omentum a short distance from and parallel to the lesser curvature of the stomach and is distributed to the anterior surface of the pyloric antrum and body of the stomach in the neighborhood of the incisura angularis, but does not reach the pyloric canal. The third branch lies on and follows the lesser curvature along the line of attachment of the lesser omentum; it is to be traced in most cases to the incisura angularis. These last two are, in most instances, reinforced by fibers from the left group of branches. Communications to the coeliac plexus from the branches of the anterior vagal trunk are present, passing proximally with the left gastric artery. One or two communications are received from branches of the posterior trunk on the lesser curvature in the region of the cardia. That branch of the right group proceeding toward the porta hepatis is frequently duplicated. Its terminal twigs are divided into two series;

a proximal which can be traced into the porta hepatis, and a distal turning downwards from which twigs pass(A) to the pylorus and the first stage of the duodenum,(B) to run with the right gastric artery and thus to the region of the pyloric canal,(C)to run deep to the pylorus and first stage of the duodenum with the gastro-duodenal artery and so towards the head of the pancreas and second stage of the duodenum, (D) to run proximally on the wall of the hepatic artery, and (E) to communicate with sympathetic twigs passing to the gallbladder.Those fibers running on the walls of the right gastric,gastroduodenal and hepatic arteries soon become lost amongst sympathetic twigs, and in many cases, they may be observed to communicate with these.

The posterior vagal trunk (Figure 2),in most cases a single stem, supplies fine twigs to the lower oesophagus and cardia, the lowest of which is of some size and constancy. It then divides shortly after passing through the oesophageal opening into two main divisions. Of these, the smaller is destined for the stomach, the larger for the coeliac and other abdominal sympathetic plexuses.

That portion for the stomach gives off first fine twigs to the lower oesophagus and cardia, one of which,

distributed to the posterior aspect of the cardia,is of some size and constancy. A branch then passes for a short and variable distance along the lesser curvature and se-nds twigs, in most cases two, to communicate with bran-ches of the anterior vagal trunk. A common method of ter-mination of the gastric stem is that in which a branch is given off to the posterior aspect of the proximal

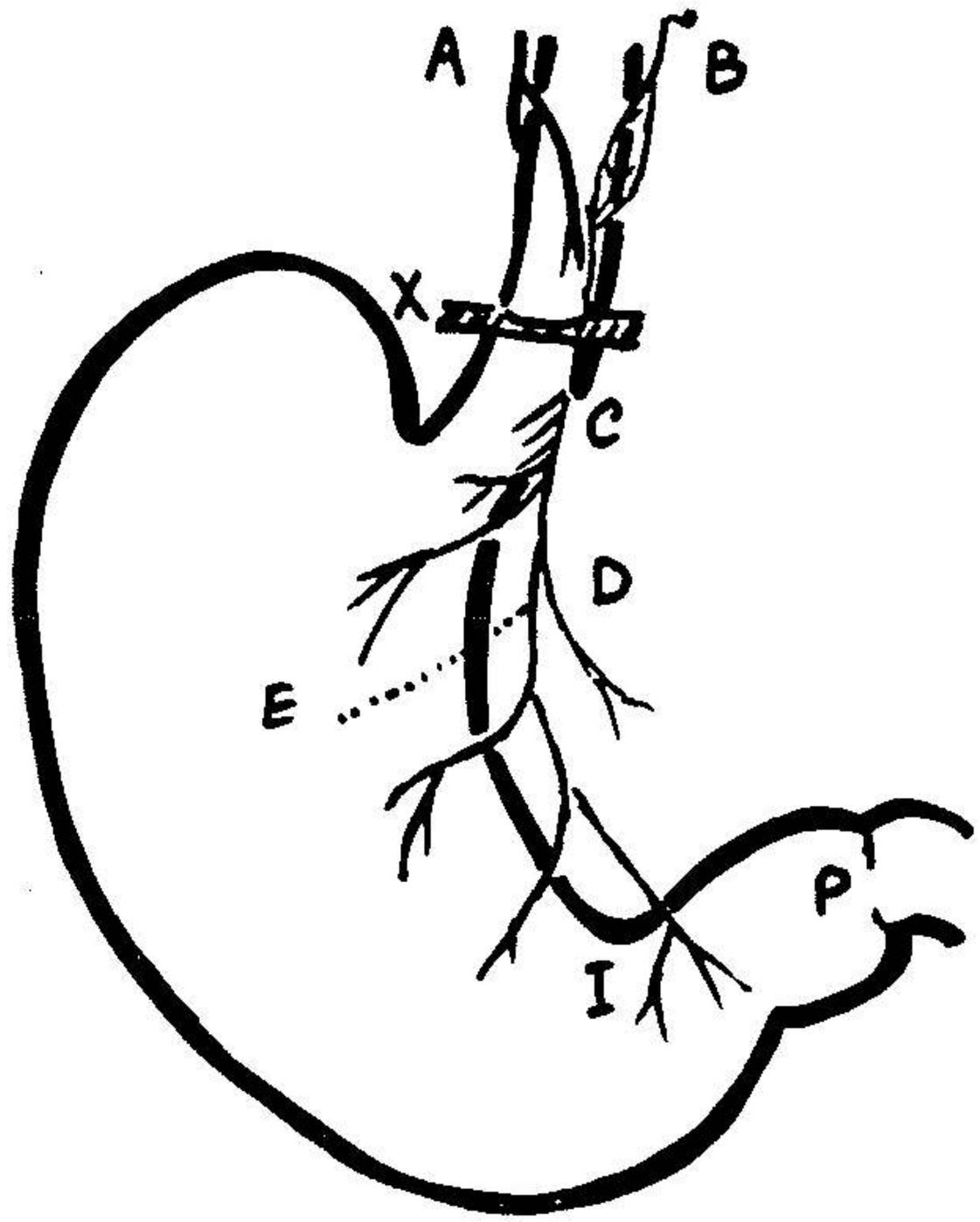

Figure 2 Drawing made from a dissection illustrating the normal formation and distribution of the poster-ior vagal trunk. The stomach has been turned to the right exposing the posterior surface.A,left vagus. B,right vagus. C,posterior vagal trunk, D,coeliac division. E,gastric division, P,indi-cates the position of the pylorus. I,that of the incisura angularis,and X diaphragm.

portion of the body. The stem then continues in the falciform ligament and gives off three branches for the supply of the posterior surface of the body and pyloric antrum, these at their terminations associating themselves with the branches of the left gastric artery. The most distal of them is distributed in the neighborhood of the incisura angularis, but does not reach the pyloric canal.

As with the anterior vagal trunk a plexus, the posterior gastric plexus, may or may not be formed. When present it is confined to the gastric divisions of the trunk. The major portion of the posterior vagal trunk associates itself with the stem of the left gastric artery and passes proximally. It supplies fibers to both right and left coeliac ganglia. Other fibers may be traced directly on to the splenic artery and to the pancreas and some, anastomosed with sympathetic fibers, run with the superior mesenteric artery and to the renal and suprarenal plexuses.

It is a matter of considerable difficult to determine whether these last fibers are vagal or sympathetic or both, on account of their intricacy and of the manner in which the nerves are matted together.

DISSECTION I

The oesophageal plexus: the left vagus divides intc three main branches, the right into four. Two of those from the left nerve unite together with the smallest of the right to form the anterior vagal trunk,which passes through the oesophageal opening as a single trunk. The remaining branch of the left joins together with three of the right to form the posterior vagal trunk,passing through the oesophageal opening as a single stem. All these branches supply fine twigs to the oesophagus.

The anterior vagal trunk, having passed through the diaphragm, supplies numerous fine twigs to the lower oesophagus and cardia. It then divides into (1) a single hepatic ramus, passing out between the layers of the lesser omentum to the porta hepatis, and (2) four larger branches which pass to supply the stomach, no anterior gastric plexus being formed. The largest of the gastric branches lies in the lesser omentum and follows the lesser curvature as far as the region of the pyloric antrum. It is reinforced in the neighborhood of the cardia by a small branch from the posterior vagal trunk.

The posterior vagal trunk divides into two portions, the larger passing towards the coeliac plexus along the trunk of the left gastric artery, the smaller to the

stomach.

The latter branch supplies fine twigs to the lower oesophagus and cardia and also two small twigs which wind about the cardia to join branches of the anterior vagal trunk. Two main branches of the gastric division are then found passing along the lesser curvature; the proximal supplies the posterior surface of the body of the stomach, whilst the more distal supplies the pyloric antrum.

DISSECTION II

Oesophageal plexus: the left vagus divides into three branches, the right into four. These are arranged in the usual manner; two from the left nerve and one from the right form the anterior vagal trunk; three of the right and one of the left the posterior vagal trunk. The anterior trunk passes through the oesophageal opening of the diaphragm as a single stem, the posterior trunk in the form of two stems.

The anterior vagal trunk supplies fine twigs to the oesophagus and cardia and three branches to the fundus and proximal part of the body of the stomach; one branch follows the lesser curvature living in the lesser omentum, supplies twigs to the body and terminates in the region of the incisura angularis, its terminal twigs

reaching the pyloric antrum. An hepatic ramus is given off in the usual manner; this breaks up as it lies between the layers of the lesser omentum and becomes intermingled with sympathetic fibers. It gives off twigs to the porta hepatis and otherswhich descend to the pyelorus and first stage of the duodenum. No anterior gastric plexus is present.

The posterior vagal trunk supplies the lower oesophagus and cardia as in other specimens and sends, on the cardia, communicating twigs to the branches of the anterior trunk. Its two stems then divide into gastric and coeliac divisions, the two gastric unite and proceed as a single stem in the left gastro-pancreatic fold;this stem supplies three branches to the posterior surface of the stomach and terminates near the incisura angularis: it reaches the pyloric antrum. The coeliac divisions pass separately to become lost in the coeliac plexus. No posterior gastric plexus is present.

DISSECTION III

The oesophageal plexus: the left vagus divides into three branches, two of these unite together with one smaller branch of the right vagus on the anterior aspect of the oesophagus to form the anterior vagal trunk:

this passes through the oesophageal opening of the diaphragm as a single stem. The right divides into three main branches: the smallest (as seen above) unites with the branches of the left vagus to form the anterior trunk, the remaining two together with the third branch of the left vagus, noted above. unite to form the posterior vagal tunk on the posterior surface of the oesophagus; this again passes through the oesophageal opening as a single trunk. All branches supply fine twigs to the oesophagus. Minor divisions of these branches exist accentuating the plexiform arrangement. The anterior vagal trunk, having supplied several small twigs to the oesophagus and cardia, breaks up on the anterior aspect of the cardia into at first three and later five main branches.

The two lying to the left and on a deeper plane form the anterior gastric plexus lying on the cardia and supplying branches to the cardia, fundus and body of the stomach; a branch passes in the lesser omentum along the lesser curvature of the stomach to the region of the incisura angularis. The two lying to the right and on a more superficial plane are distributed as follows: one follows the lesser curvature to the pyloric antrum;the other passes out between the layers of the lesser omentum to the liver, this branch communicates with the

sympathetic fibers from the coeliac plexus which run with the right inferior phrenic and left gastric arteries. A branch from the deep division of the anterior vagal trunk also passes in the lesser omentum to the liver and is reingorced by a twig from the posterior vagal trunk. A third hepatic twig crossing in the lesser omentum is derived from the sympathetic plexus about the left gastric artery. From these branches which pass between the layers of the lesser omentum towards the liver, twigs may be traced into the porta hepatis, to the pylorus, and to unite with sympathetic fibers passing to the gall bladder; others run downwards posterior to the pylorus to pass with the gastroduodenal artery towards the head of the pancreas and second stage of the duodenum, while yet others accompany the hepatic artery, passing proximally towards the coeliac plexus.

The posterior vagal trunk divides into two groups of branches the smaller for the stomach, the larger for the coeliac and other sympathetic plexuses.

The branches for the stomach consist of several small oesophageal and cardiac branches, one of which is of some size. The remaining stem runs in the left gastro-pancreatic fold and gives off three branches for the supply of the posterior surface of the stomach and py-

loric atrum; the most distal of these is distributed in the neighborhood of the incisura angularis, but does not reach the pyloric canal.

The larger division of the posterior vagal trunk associates itself with the stem of the left gastric artery; two chief branches were identified entering the coeliac ganglia to the right and left of the aorta. Twigs continued directly on to the splenic artery and into the substance of the pancreas, those on the splenic artery being finally lost amongst sympathetic fibers.

DISSECTION IV

The oesophageal plexus possesses the customary basic structure; two branches of the left vagus together with one of the right form the anterior vagal trunk: two branches of the left nerve and two of the right form the posterior vagal trunk. Both vagal trunks pass as single nervès through the oesophageal opening of the diaphragm. The anterior vagal trunk breaks up on the anterior aspect of the cardia into four branches, three lying to the left supply the anterior aspect of the cardia, fundus and body, that on the right gives origin to firstly,a large branch which lies in the lesser omentum and follows the lesser curvature, to be distributed in the

neighborheed of the incisura angularis; and secondly, branches to the liver which form a plexiform arrangement in the lesser omentum. Pyloric twigs are derived from the lowest of these branches to the liver. The posterior vagal trunk supplies twigs in the normal manner to the lower oesophagus and to the cardia, the main trunk then divides into gastric and coeliac divisions. The gastric division gives off two branches for the supply of the posterior surface of the body of the stomach and termina-tes in the region of the incisura angularis, some twigs reaching the pyloric antrum. The coeliac division passes mainly to the coeliac plexus; some twigs however pass onward together with sympathetic fibers.

No anterior or posterior gastric plexus was present.

The remaining dissections differed in no essential detail from those described above.

DISCUSSION

The results of this investigation on the distribution of the vagi nerves may be discussed under three headings: (1) the structure of the oesophageal plexus, (2) the branches and distribution of the anterior vagal trunk, and (3) the branches and distributionof the posterior vagal trunk.

(1) The oesophageal plexus

The descriptions of the general formation of the plexus given by Mitchell and Haddad,(2)(7)(8) have been confirmed. It is important to note that the plexus possess a most constant structural basis, which, as Mitchell stated, demonstrates definitely that each vagus supplies fibers to both the anterior and posterior surfaces of the stomach; the anterior and posterior vagal trunks formed from this plexus pass through the oesophageal opening of the diaphragm as single stems in the majority of cases: in none of my specimens was either trunk divided into more than two divisions. The descriptions found in the literature differ considerably as to the number of stems passing through the diaphragm, some even stating that the oesophageal plexus itself is continued through on the the cardia; it is probably rare to find more than two stems replacing either the anterior or posterior vagal trunk.

(2) The anterior vagal trunk

The preceeding findings are in general similar to those of Mitchell, G.A.G., some points, however,require discussion.

The anterior vagal trunk gives off one, sometimes two or three branches to the liver which cross to that

organ in the lesser omentum. and communicate with sympathetic fibers(9) Kurylico(6) states that the pylorus receives its entire nerve supply from above and believes them to be sympathetic, derived from nerves accompanying the hepatic artery (right hepatic plexus), and running a recurrent course in the lesser omentum. In my dissections such pyloric twigs are present and it would appear that certain of these are vagal in origin: in one case a definite branch from the main branch of the anterior vagal trunk passes out into the lesser omentum and supplies the pylorus from above, without having any connection with sympathetic fibers or supplying a branch to the liver.

The main branch of the anterior gaval trunk lies between the two layers of the lesser omentum and follows the lesser curvature of the stomach. It reaches the region of the incisura angularis and its terminal twigs supply the pyloric antrum: in no case does this nerve send fibers as far as the pyloric canal or sphincter. Kurylico supports this view, but Mitchell and Haddad(2). amongst many others, state that all the anterior surface of the pyloric region receives its nerve supply from this branch which runs along the lesser curvature.

(3) THE POSTERIOR VAGAL TRUNK

The descriptions given by Hoffman(4)and Evans,(1) of the gastric divisions are largely substantiated by my investigation. The statement of Evans that a posterior or anterior gastric plexus may or may not be present is confirmed; if present it is confined to the gastric branches. A point to emphasize is that the gastric division reaches the stomach by passing through the left gastro-pancreatic fold and its continuation, the falciform ligament; its branches do not lie in the lesser omentum.

In general it may be stated that this investigation, except on a few points, confirms the work of Mitchell and it is evident that, with the exception of the papers of Mitchell, no observer has attempted to give a full account of the course and manner of distribution of the vagi nerves in their lower thoracic and abdominal course; the result of this has been that the importance of the infulence of the oesophageal plexus on their distribution has been lost sight of.

Finally, it must be noted that the descriptions of the oesophageal plexus as usually given are inaccurate and misleading, that the statement that the left vagus supplies the anterior surface of the stomach and the right the posterior, is incorrect, and that the variety

of findings in regard to the anterior and posterior gastric plexuses depend on (a) their variability, and (b) the opinion of the individual observer as to what constitutes a plexus.

SUMMARY

1. The oesophageal plexus is in the structure and arrangement of its larger branches constant.
2. Two trunks arise from the oesophageal plexus, the anterior vagal trunk and the posterior vagal trunk; each trunk contains fibers of both left and right vagi nerves.
3. These vagal trunks in the majority of instances pass through the oesophageal opening of the diaphragm each in the form of the or two stems.
4. Anterior and posterior gastric plexuses may or may not be present: the one may be present, the other absent. If present. their formation is limited to the branches destined for the supply of the stomach.
5. The manner of distribution of the vagal branches is in the main constant.
6. The main gastric branches lie in the neighborhood of the lesser curature.
7. The anterior vagal trunk supplies the anterior surface of the stomach as far as the pyloric antrum; it does

not supply the pyloric canal and sphincter through those branches which lie along the lesser curvature. This statement holds good for the posterior vagal trunk and the posterior aspect of the stomach.

8. The pyeloric canal, sphincter, and first stage of the duodenum receive their nerve supply from above, receiving twigs from the vagal branches to the liver.
9. Sympathetic fibers derived from the coeliac plexus reach all regions of the stomach. Twigs may be seen to unite with and run with vagal twigs.

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