THE UNIVERSITY OF MINNESOTA

GRADUATE SCHOOL

Report

of

Committee on Examination

This is to certify that we the undersigned, as a committee of the Graduate School, have given Thaddeus B. Reeves final oral examination for the degree of Master of Science in Surgery. We recommend that the degree of Master of Science in Surgery be conferred upon the candidate.

Minneapolis, Minnesota

May 31 1919

A. C. Strachauer
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REPORT

of

Committee on Thesis

The undersigned, acting as a Committee of the Graduate School, have read the accompanying thesis submitted by Thaddeus Benjamin Reeves for the degree of Master of Science in Surgery. They approve it as a thesis meeting the requirements of the Graduate School of the University of Minnesota, and recommend that it be accepted in partial fulfillment of the requirements for the degree of Master of Science in Surgery.

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THESIS

A STUDY OF THE ARTERIES SUPPLYING THE STOMACH AND DUODENUM AND THEIR RELATION TO ULCER

Thaddeus Benjamin Reeves

Submitted to the Graduate Faculty of the University of Minnesota in partial fulfillment of the requirements for the degree of Master of Science in Surgery.

May 1919.

This work was undertaken to determine if possible, whether there is any difference in the character of the arteries in the stomach and duodenum, the regions in which ulcers are prone to occur. At the operating table practically all ulcers of the stomach are found along the lesser curvature, and 98 per cent of the duodenal ulcers are found within one and a half inches of the pylorus; the greater number on the anterior wall within the first inch. It would seem that there must be a special factor to cause this curiously selective character.

The two portions of the bowel, the stomach and the first one and one-half inches of the duodenum should be considered as modified portions of the same region of the primative alimentary tube. From an embryologic standpoint the beginning of the duodenum resembles the stomach in that it arises from the foregut. The first inch is freely movable; it is covered in front and behind by the same layers of peritoneum that cover the stomach. The mucous surface of the first and one-half inches of the duodenum is devoid of folds(valvulae conniventes) and the villi are short. The distribution of blood vessels supplying the stomach and the first one and one-half inches of the duodenum are not regular as they are in the rest of the bowel.

Technic

Sixty-two human stomachs and duodenums procured at necropsies from one to four hours after death have been investigated. Most of the specimens were injected before being removed from the body. For injecting the arteries, slightly acid gelatin-carmin solution gave the best results. Ten per cent gelatin solution was filtered through several thicknesses of cheese cloth. Sufficient carmin to make 1.5 per cent solution was ground in a mortar and partially dissolved in a small amount of water containing a few drops of acetic acid; this was added to the warm gelatin solution and thoroughly stirred. A few crystals of thymol was added as a preservative. When ready for use the gelatin-carmin was melted over a water bath and injected at a temperature between 45°C and 50°C. To inject the capillaries the carmin should first be dissolved in ammonium hydroxid to get rid of the granules, then neutralized with acetic acid (Bayne-Jones). If the gelatin-carmin solution is alkaline, the dye will diffuse through the tissue and obscure smaller vessels.

All of my injections were made through the celiac axis, the hepatic artery being ligated at the porta hepatis, and the inferior pancreatico duodenal at its origin from the superior mesenteric. In some of the cases the splenic artery was clamped off at the hilus of the spleen.

Several injections were made to include the capillaries but no attempt was made to inject the veins, although they were partially filled in a fe instances. As a rule the best injections were in stomachs that were moderately distended either with air or fluid. Specimens distended with air soon after injections were useful when hardened and dried. Fixation of specimens in 10 per cent formalin solution for twelve to twenty-four hours immediately after injection proved the most instructive method as it was then comparatively easy to make a complete dissection of the vessels of the submucosa by means of a dissecting microscope. For microscopic study blocks of tissue were cut from various parts of the stomach and duodenum and fixed in 10 per cent formalin. Serial frozen sections from 50 to 100 microns were cut, stained with hematoxylin and mounted in balsam.

A few specimens were injected with 10 per cent gelatin to which was added bismuth or barium sulphate. One specimen was injected with 15 per cent thorium and one with 25 per cent sodium bromid. Each of these specimens were distended with air and stereoscopic radiographs taken. The ones containing barium or bismuth made the best radiographs (Fig. 1), but since they showed only the larger vessels in the submucosa, they were of little value in this study.

The Gastric arterial system

It may be well to describe briefly the larger vessels supplying the stomach and the duodenum, although my chief interest in this study was in the smaller vessels of the mucosa and submucosa of those areas of the stomach and duodenum in which ulcer is most often found.

The celiac axis

The celiac axis (a. coeliaca) is given off from the anterior surface of the aorta between the crura of the diaphragm a short distance below the aortic opening. It is a short, thick trunk, extends forward and slightly downward above the upper margin of the pancreas for about one-half inch, and then breaks up simultaneously just behind the posterior layer of the lesser sac of peritoneum into the gastric, hepatic and splenic arteries.

The gastric artery

The gastric artery (a. gastrica sinister) runs upward and to the left, crosses the left crus of the diaphragm behind the peritoneum and gains the lesser curvature of the stomach near the cardiac and by arching forward

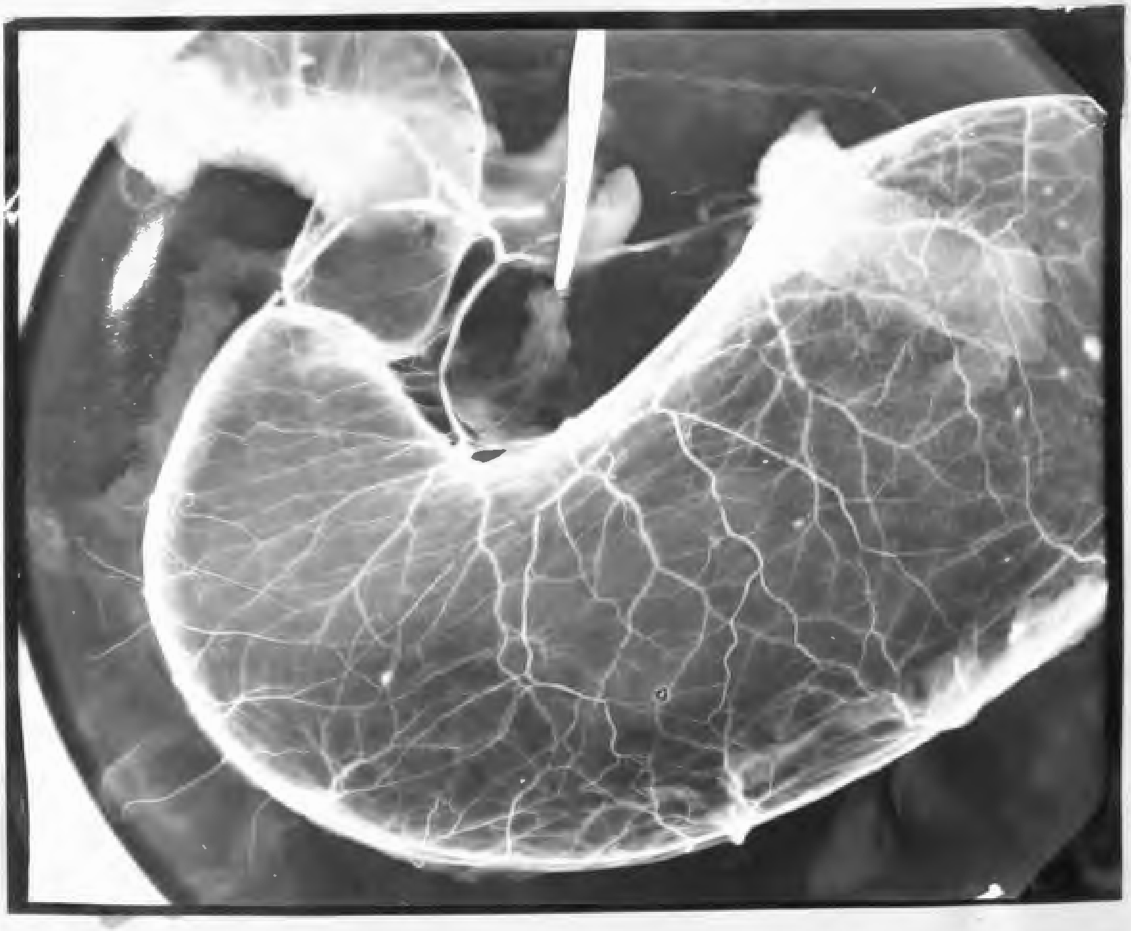

Fig. 1. Stereoscopic radiograph. Vessels injected with gelatin bismuth solution.

between the two layers of peritoneum which are reflected from the stomach and esophagus on to the diaphragm. On reaching the stomach the artery gives off an esophageal branch which soon divides into several smaller ones to supply the terminal esophagus and a limited area of the stomach around the cardia. Just after giving off the esophageal branches the artery curves downward and to the right along the lesser curvature between the two layers of the gastrohepatic omentum. It soon divides into two branches, both having their path along the lesser curvature, one anterior and one posterior. In their course, these branches give off from three to five branches to the surface of the stomach next to which they travel as well as some very small branches to the lesser curvature and to the gastrohepatic omentum. The two main branches may terminate in several different ways. Both may anastomose with the two terminal branches of the pyloric artery (artery gastrica dextra) which in such a case is bifurcated, or only one, more frequently the posterior branch, will anastomose with the non-bifurcated pyloric artery (Figs. 2 and 3). In other cases there is no end to end anastomosis with the pyloric on the surface of the stomach; each branch is lost by the perforation of its secondary divisions into the muscular coats of the stomach; the anastomosis then takes place in the submucosa. Because of the absence of the pyloric artery in a very few instances no sort of anastomosis can be found. Leriche and Villemin found no anastomosis in six of fifty-five cases. In a single case of my series of 62 cases no anastomosis could be found; this was due to the absence of the pyloric artery. From the arcade along the lesser curvature there are from 3 to 5 branches which run downward on both the anterior and posterior wall for a variable distance to penetrate the muscular coats. A second group of very small arteries enter directly through the muscular coats on the lesser curvature.

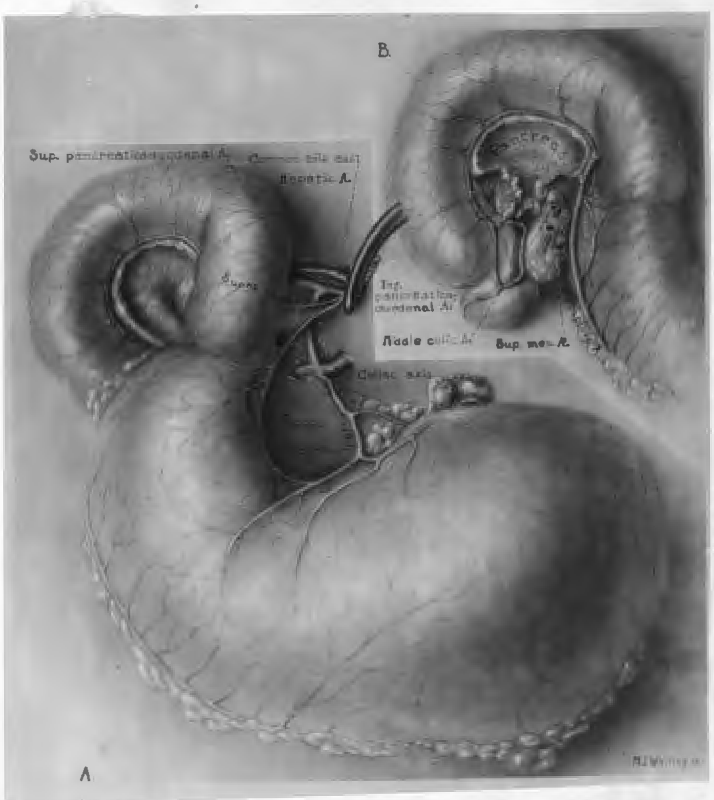

Fig. 2. Dissection: Drawing illustrates the blood supply of the stomach and duodenum. Note the number of vessels along the greater curvature in comparison with the lesser.

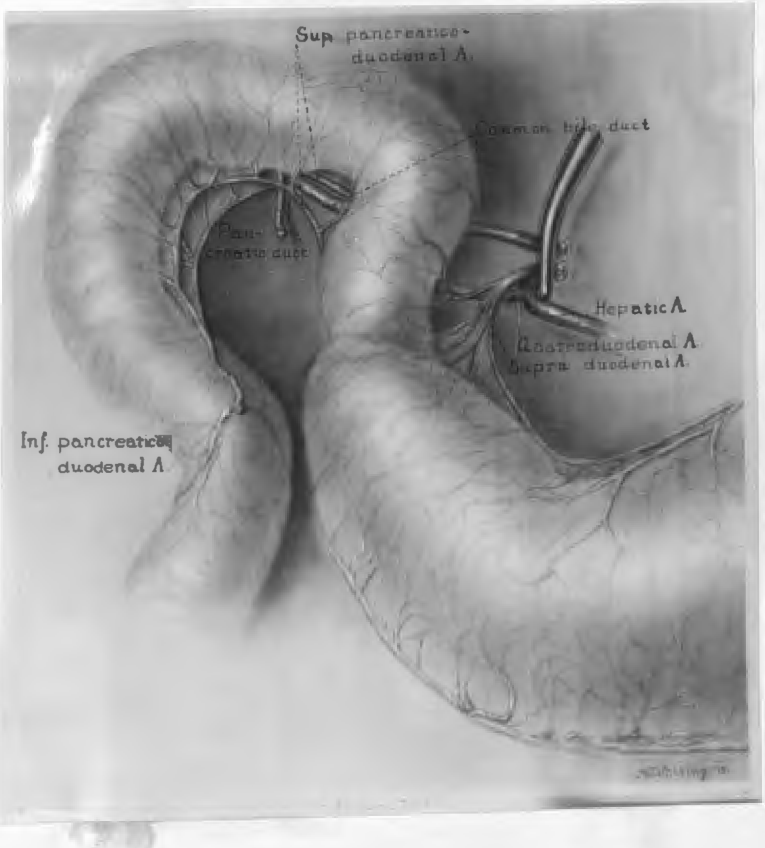

Fig. 3. Dissection: Drawing illustrates the blood vessels and their relations to the pyloric end of stomach and duodenum. Anterior view. Pancreas dissected away.

The hepatic artery

The hepatic artery runs slightly forward and to the right over the right crus of the diaphragm and along the upper border of the head of the pancreas behind the posterior layer of the lesser sac of peritoneum. It bends forward, crosses the left surface of the portal vein, and enters between the two layers of the gastrohepatic omentum at the upper margin of the duodenum. It then courses upward and to the right to the porta hepatis of the liver lying in the free margin of the gastrohepatic omentum in front of the portal vein and to the left side of the common bile duct. On entering between the two layers of the gastrohepatic omentum the hepatic artery gives off the pyloric artery (artery gastrica dextra). This vessel descends between the two layers of peritoneum to the pylorus giving off branches, both to the anterior and posterior surfaces, which usually anastomose with the duodenal vessels in the submucosa. The artery terminates on the lesser curvature of the stomach as described. The gastroduodenal artery is given off from the hepatic soon after the pyloric. It varies from one-half to one inch in length and descends behind the first part of the duodenum about three-fourths of an inch to the right of the pylorus, where it terminates by dividing into the superior pancreatico duodenal and the right gastro-epiploic. The right gastro-epiploic usually gives off one or two very small branches to the lower margins of the first part of the duodenum, then enters between the two layers of the gastrocolic omentum to run along the greater curvature of the stomach and anastomoses with the left gastro-epiploic from the splenic. From this arch branches are given off at much more frequent intervals than on the lesser curvature. Although arteries from the lesser curvature are fewer in number they run a longer course (Figs. 2 and 3). The branches from both arches run in the serous coat for a short distance, then perforate the muscular layers to form a very extensive series of anastomoses in the submucosa.

The splenic artery (artery lienalis)runs a rather tortuous course more or less horizontally to the left over the left crus of the diaphragm , left suprarenal and upper pole of the left kidney, and just above the upper margin of the pancreas behind the posterior wall of the lesser sac of peritoneum. On leaving the region of the kidney it enters between the two layers of the lienorenal ligament and breaks up into several branches which enter the hilus of the spleen and at the same time give off the right gastro-epiploic and several short gastric branches. These vessels enter between the two layers of the gastrolienal ligament and pass onto the greater curvature of the stomach. The left gastro-epiploic runs to the right by anastomosing with the right gastro-epiploic it forms the arcade of the greater curvature. The short gastric branches are distributed to the left end of the greater curvature where they help to supply the fundus and they pass to both anterior and posterior surface and anastomose in the submucosa with the cardiac branches of the left gastric and left gastro-epiploic arteries.

Arteries of the gastric submucosa and mucosa.

On examining the plexus or series of anastomoses made by the arteries in the submucosa it is found that there is quite a marked difference between those of the lesser curvature and those of the rest of the stomach. Compare Figs. 5 and 6.

All the arterial branches destined to supply the stomach penetrate the muscle coats and enter the submucosa where they form a very extensive plexus, or net-work of comparatively large vessels. Those from both curvatures anastomose freely with each other and reach across to anastomose with those of the opposite curvature (Fig. 5). The plexus is remarkable in that all the vessels

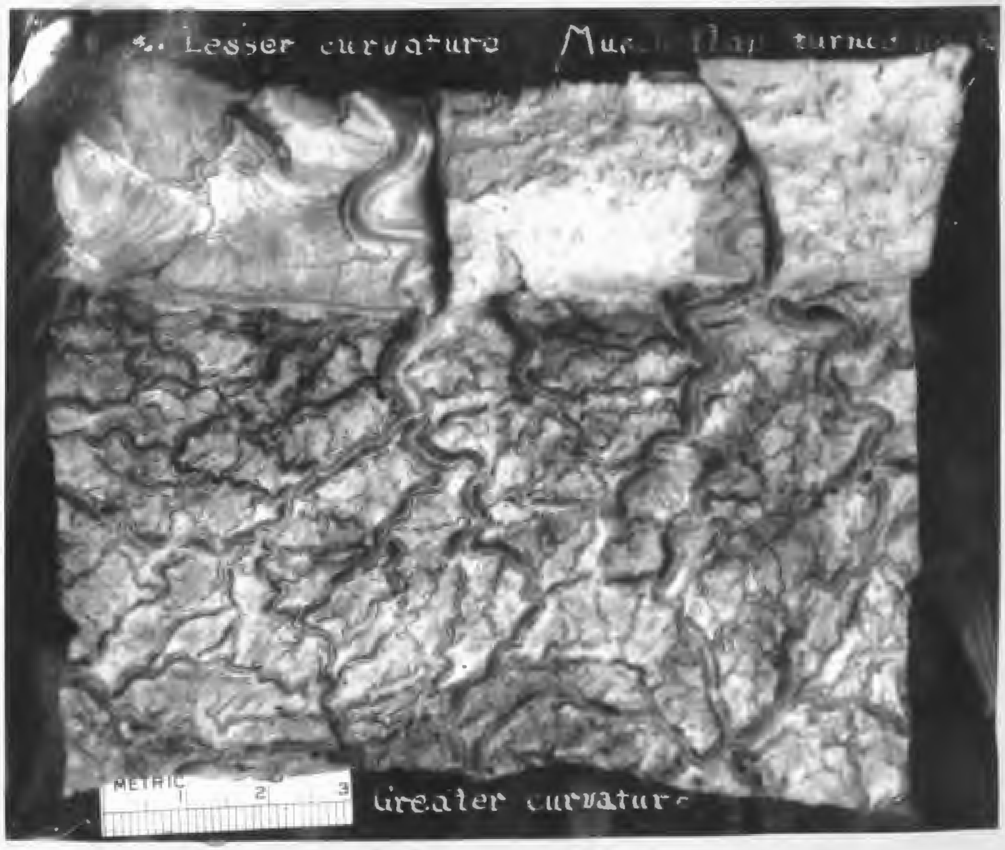

Fig. 5. Arteries of the submucosa of the posterior wall of the stomach. Note the winding tortuous course of the smallest branches. Dissection with photograph.

Fig. 6. Dissection: Drawing illustrates the submucous plexus of arteries on lesser curvature of stomach. Note their length, size and general direction.

run a very tortuous wavy course and give off branches which are to a great extent of equal size throughout the entire stomach except along the lesser curvature. Since the submucous plexus on the lesser curvature is different from that in other parts of the stomach, I shall describe it separately; it is made up by small perforating branches from the main trunks along the lesser curvature. On entering the submucosa these vessels bifurcate and run more or less parallel to each other between the esophageal opening and the pylorus. They are much smaller, make fewer anastomoses and run more than twice the distance of the same sized vessel in any other part of the stomach (Fig. 6). By means of rather small branches this plexus anastomoses with those on the anterior and posterior walls. The two plexuses have the same relative position in the wall of the stomach; that is, midway between the inner muscle coat and the muscularis mucosa. In an injected specimen it is quite easy to dissect away either or both the mucous and muscular coats.

From the plexus of arteries in the submucosa two systems of branches are given off; one passes to the muscular coats and the other to the mucous coat. I shall not describe the former. In many respects my findings agree with the investigations of Disse published in 1904. The system of vessels going to the mucosa is somewhat complicated. The vessels run in a slanting direction towards the muscularis mucosa and at the same time take a very tortuous, winding, course. They usually divide twice before reaching the muscularis, the branches having the same spiral-like course, often twisting about each other and in this manner passing through the muscularis mucosa. As they enter into the mucosa they suddenly become smaller by giving off branches that are terminal arteries, connected only by means of a capillary network (Figs. 7 and 8). These vessels continue to run a rather winding course and it seems that the transition from arterioles into capillaries may take place anywhere in the mucosa, but for

Fig. 7. Arteries of the stomach mucosa with a few capillaries injected. Photomicrograph x50.

Fig. 8.. Vessels entering the gastric mucosa. Note the sudden diminution in size of the vessels. Many terminal branches are not injected because of plugging with carmin granules. Photomicrograph x50.

the most part the change is in the deepest half (Fig. 9). According to Disse[3] each end artery supplies an area of mucosa about 2.5 mm. in diameter. From the character and arrangement of the arteries in the submucosa, it would seem that they are markedly well adapted for the regulation of the blood supply to the mucosa.

Arteries of the duodenum

The duodenum, except for its first one and one-half inches, receives its blood supply entirely from the superior and inferior pancreatico-duodenal arteries. The superior is one of the terminal branches of the gastro-duodenal, and arises behind the duodenum about three-fourths of an inch to the right of the pylorus. It inclines to the right and soon divides into an anterior and posterior branch. These, however, may come off separately from the gastro-duodenal (Fig. 4). The two branches run downward between the duodenum and the head of the pancreas; they are both overlapped by the thin margin of the pancreas projecting in front of and behind the margin of the duodenum. The posterior of these branches runs in intimate relation with the lower portion of the common bile duct (Figs. 3 and 4). The inferior pancreaticoduodenal is given off from the superior mesenteric just before the latter passes in front of the third part of the duodenum. It runs to the right behind the superior mesenteric vein and soon divides into the anterior and posterior branches which run along between the duodenum and the pancreas to anastomose with the two branches of the superior pancreaticoduodenal, thus making two arcades in the curvature of the duodenum as shown in Figs. 3 and 4. From these two arcades, branches pass quite regularly to the anterior and posterior walls of the duodenum and tend to encircle the bowel. After reaching the bowel they soon pierce the muscular coats and form a submucous plexus by a series of anastomosing arcades (Fig. 10). This plexus is made up

Fig. 9. Arteries of stomach mucosa. Capillaries and veins injected. Photomicrograph x50.

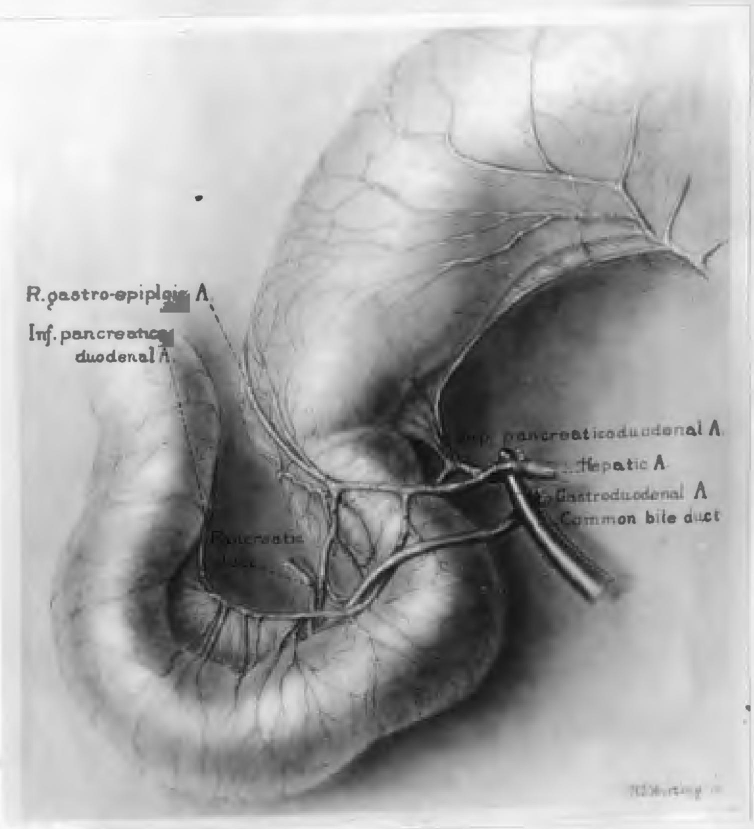

Fig. 4. Dissection: Drawing illustrates the blood vessels and their relations to the pyloric end of stomach and duodenum. Posterior view. Pancreas dissected away.

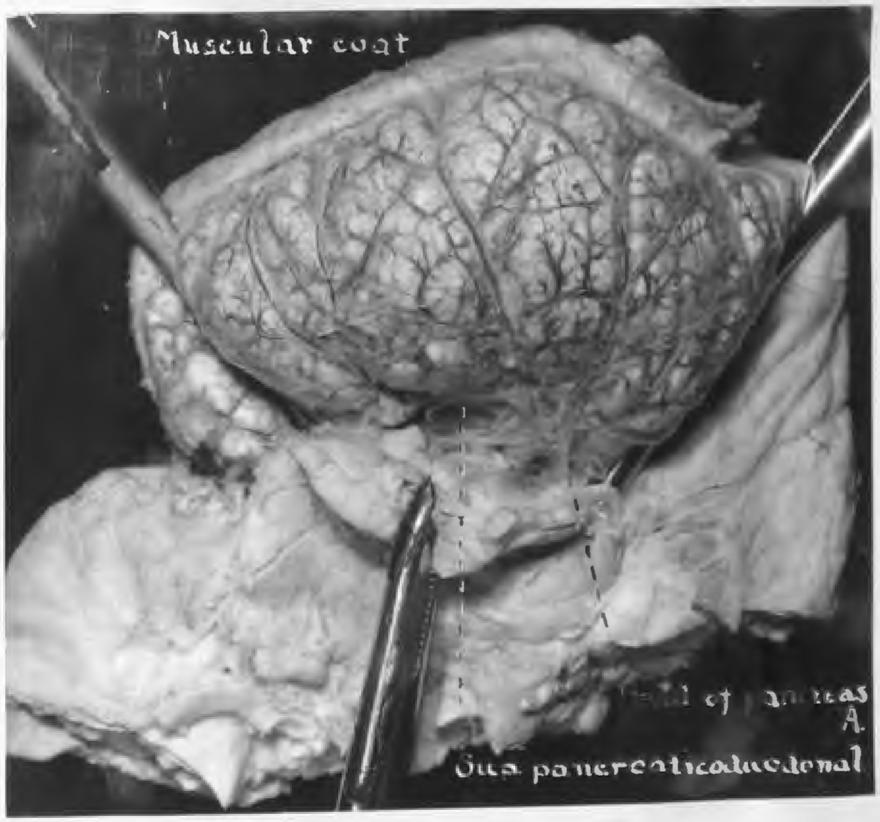

Fig. 10. Anterior wall of the second part of the duodenum; muscular flap dissected away. Photograph of specimen.

by a series of branches being given off from the larger arteries encircling the bowel. These branches anastomose with each other; they are short and relatively of the same length and caliber. The encircling vessels become gradually smaller until finally they are the same size as the anastomising branches. Under these conditions it seems that the blood pressure must be the same in all branches entering the mucosa, thus insuring a constant blood supply to all parts of the mucosa. From the submucous plexus vessles are given off to supply the muscular coats; these vessels will not be described here. The greater part of the blood stream is carried to the mucosa through two sets of arteries, one to the villi, and one to the lower ends of the crypts. On piercing the muscularis the arteries give off a variable number of branches to the villi; there being usually one to each villus. This artery passes almost through the center and terminates in capillaries near the summit (Fig. 11) The crypt type of artery, on entering the mucosa, divides into several branches which radiate in all directions and run along the bases of the glands (Mall)[4]. These in turn give off branches which pass upward around the glands and soon terminate in capillaries which supply the glands and stroma (Figs. 11 and 12).

The first one and one-half inches of the duodenum receives its blood supply chiefly from an artery which is usually given off from the gastroduodenal or hepatic. This vessel has been described at length by Wilkie under the name of "supraduodenal artery". From its origin, as shown in Figs. 2, 3, and 13, it runs downward between the two layers of the lesser omentum to the upper margin of the duodenum. Here it gives off a small branch to the posterior surface of the duodenum while the main vessel comes on the anterior surface to anastomose rather sparingly with a small branch of the pyloric, a small branch of

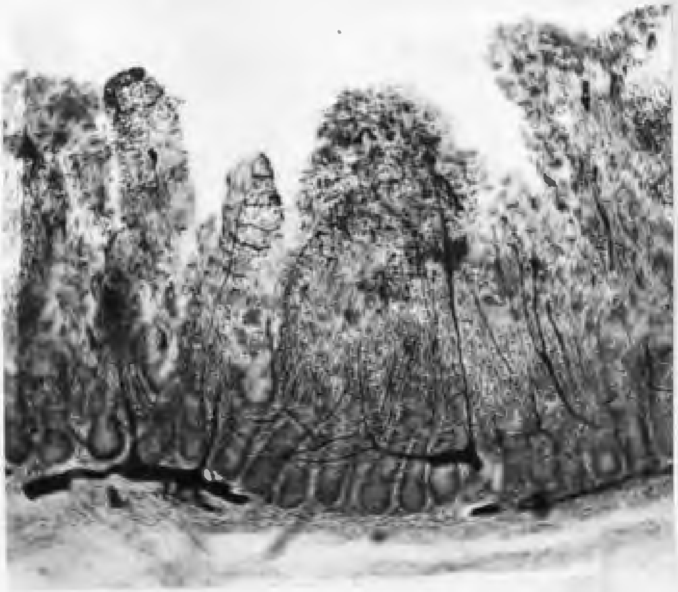

Fig. 11. Villus and crypt type of arteries in duodenum. Capillaries injected. Photomicrograph x50.

Fig. 12. Villus and crypt type of arteries in duodenum. Most of the crypt vessels plugged with carmin granules. Photomicrograph x50.

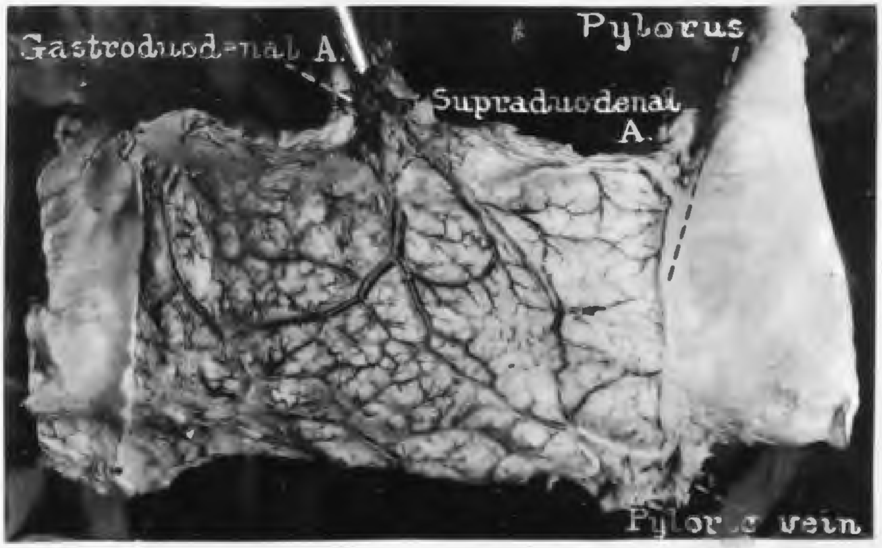

Fig. 13, Dissection: Photograph shows submucous plexus of arteries. First part of duodenum. Note how few vessels are in the first inch.

the right gastro-epiploic, and with branches of the superior pancreaticoduodenal (Fig 13). The posterior wall of the first one and one-half inches of the duodenum is supplied chiefly by small branches from the gastroduodenal artery, given off as that vessel passes behind the bowel. It also receives some small twigs from the supraduodenal, pyloric and right gastro-epiploic arteries. These arteries, soon after reaching the wall of the duodenum, penetrate the muscular coat and form a submucous plexus which is strikingly different from that lower down in the bowel. Compare the first and second halves of Figure 13. The first inch certainly has very few arteries in the submucosa in comparison with other parts of the duodenum. It would seem that this explains the observation of W.J. Mayo regarding the "anemic spot" usually seen on the surface of the bowel in this region. From the submucous plexus of vessels branches are given off to the mucosa which simulate to a marked degree the vessels of the stomach. They are not quite so large nor do they run so consistently tortuous a course. Yet many are definitely of the spiral gastric type; this is particularly noticeable just as they enter the muscularis mucosa (Figs. 14 and 15). Besides the gastric type of crypt vessels in the first inch of the duodenum are the villus type; and since the villi are not so numerous nor so high as they are farther down in the bowel, these arteries are correspondingly modified (Fig. 16). There are possibly a few more arteries in the submucous plexus on the posterior than are on the anterior wall of this portion of the duodenum, otherwise the blood vessels are similar.

The transition from stomach to duodenum is not sharply marked either in the mucosa or in the submucosa. Brunner's glands are often found in the pylorus and the pyloric glands frequently extend over into the duodenum (Bailey). In fact, Brunner's glands are believed by Oppel and others to be a continuation of the pyloric glands. Certainly the gastric type of artery is carried over into the duodenum, the change being gradual. According to Mall the crypt vessels

Fig. 14. Gastric type of spiral artery in the duodenum. Branches plugged with carmin granules, hence no other vessels in the field. This in itself is suggestive of a terminal artery. Photomicrograph x100.

Fig. 15. Gastric type of spiral artery entering mucosa of duodenum. Branches plugged with carmin gelatin. Photomicrograph x100.

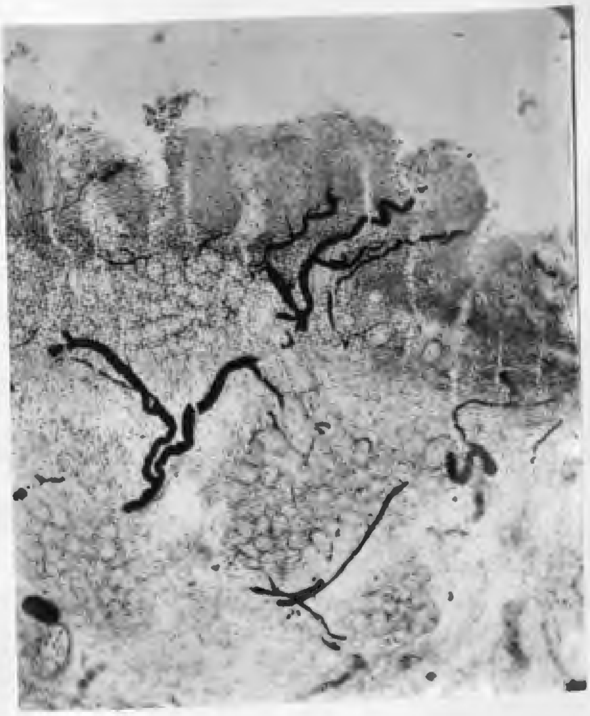

Fig. 16. Gastric type of artery giving off villus branches. The smaller cryptic branches are plugged with injecting material. Photomicrograph x50.

of the small intestine become submucous vessels in the stomach and the arteries to the villi become smaller and are the stellate vessels of the mucosa in the stomach.

The significance of gastric and duodenal arteries in relation to ulcer.

The character of the arteries of the submucosa and of the mucosa of the stomach from a normal as well as from a pathologic standpoint have a physiologic significance. The glands secrete chiefly during digestion when the walls of the stomach are expanded, during this period they need a rich blood supply. From a physiologic standpoint it is of advantage to the organism if the flow of blood to the capillaries of the mucosa is made less difficult when the stomach is filled, and that the blood supply is limited when the stomach is empty. With a full stomach, when the walls are expanded, all of the rugae or folds of the mucosa disappear except two along the lesser curvature; all the winding spiral curves and marked tortuosities of the arteries are straightened out, except those along the lesser curvature; thus the resistance offered the blood stream by the very tortuous arteries decreases and the flow of blood to the mucosa is made less difficult (Waldeyer). Of course, there is undoubtedly a nervous influence at work at the same time causing a dilatation of the vessels. But the latter influence is entirely separate and distinct from the mechanical resistance offered by the vessels. As the stomach empties itself and becomes gradually smaller following digestion, the arteries of the mucosa and submucosa become more tortuous and the blood meets with greater resistance. Thus the blood content of the mucosa is not nearly so great in an empty as in a full stomach.

Among the most generally accepted theories advanced regarding the etiology of gastric and duodenal ulcer is the theory that they are caused by a hematogenous infection. The clinician and the surgeon in their attempts to establish a cure for ulcer are realizing more and more that they are dealing with an infectious process.

Pathologic changes in the vessels result in marked changes in the blood flow, due not only to partial obstruction, but also to a diminished elasticity and contractility of the arterial walls. Virchow was among the first to call attention to the fact that thrombosis or other vascular lesions producing obstruction of the vessels in the gastric mucosa result in hemorrhagic necrosis which, in the presence of the gastric juice, leads to ulcer. A local end arteritis producing practically an obstruction of a vessel, which makes few or no anastomoses and supplies relatively a large area of the mucosa, probably causes a chronic gastric ulcer in rare instances in elderly people, just as superficial ulcers and even gangrene is produced elsewhere by the same cause. This type of ulcer will not heal, probably because of the lack in power of the diseased vessels to regenerate new ones to supply the affected area with arterial blood. Various observers in their attempts to produce gastric and duodenal ulcer by disturbing the circulation have shown that embolism of the vessels entering through the muscularis mucosa gives the most pronounced results. The collateral circulation of the vessels in the submucosa is so great that one of the four large vessels passing on to the wall of the stomach may be ligated without being harmful to the stomach (Baumann). The collateral circulation in the mucosa, however, is limited, for the most part, to capillaries.

Cohnheim, in 1890 produced acute ulcers by the injection of foreign substances into the gastric circulation. In these cases the injecting material seemed to occlude the vessels entering the muscularis mucosa and to cut off the circulation to a limited area of the mucosa. The action of the gastric juice on the dead or devitalized tissue probably contributed to the production of acute ulcers. This type of ulcer heals readily since there is nothing to cause additional destruction of tissue, and since the natural tendency of the body is to repair the damage done.

Rosenow injected streptococci isolated from gastric and duodenal ulcers in man into the venous circulation of experimental animals and produced gastric and duodenal ulcer in 60 per cent, and a total of ulcer and hemorrhage in 83 per cent of the animals injected. To quote from his summary: "The ulcers produced by the injection of streptococci resemble those in man in location, in gross and microscopic appearance, and in that they tend to become chronic, to perforate, and to cause severe or fatal hemorrhage". According to Rosenow's description, "both the circumscribed hemorrhage and the ulcer are cone-shaped with the base of the cone at the surface and the apex at the muscularis". From the anatomic arrangement of the vessels in the mucosa, this circumscribed area of hemorrhage is just what one would expect from thrombosis or distrubance of the circulation of the vessels entering through the muscularis mucosa. Since this type of ulcer is produced by streptococci it tends to become chronic and to have all the characteristics of ulcer in man; the streptococci serve as a constant irritant and prevent healing. The continued action of the localized infection in the deep layers produces local circulatory disturbance, hemorrhage, anemia, etc. Since the gastric juice digests devitalized tissue, and since the vascularization of the underlying tissue may become gradually less, perforation may be the final outcome.

As has been stated, the rugae of the stomach mucosa disappear with expansion of the walls. There are two folds, however, one anterior and one posterior along the lesser curvature extending from the esophageal orifice toward the pylorus which do not disappear (Waldeyer). Lewis has shown these folds on his reconstruction models of the stomach in the human fetus. He has described a canal along the lesser curvature which he named "canalis gastricus". Waldeyer in his review of this subject states that these folds become larger with the filling of the stomach and finally form a canal running lengthwise of the lesser curvature. When a stomach is distended with air or fluid even to the point of rupture the lesser curvature takes comparatively little part in the distention and the break always occurs at the fundus. I have noticed particularly that it is more difficult to get a good injection of the vessels in the mucosa of the lesser curvature than elsewhere, even with distention of the stomach. This is also true of the first inch of the duodenum. Mall in his work on dogs' stomachs, reports similar difficulties in injecting the vessels of the pylorus and of the beginning of the duodenum.

The vessels of the mucosa on the lesser curvature are not essentially different from those in the rest of the gastric mucosa. But the arteries making up the submucous plexus are very much smaller and make longer anastomoses than those in the rest of the submucosa. Due to the permanent folds the vessels along the lesser curvature do not have so great an opportunity to straighten out with moderate distention as those in other parts of the stomach. Thus the resistance offered the blood stream by the much smaller and constantly winding tortuous arteries is never removed. As a result the blood current entering the mucosa is constantly slower and at a lower pressure than in any other region of the stomach. Hence it seems the arteries are more liable to thrombosis.

As I have stated the arteries making up the submucous plexus in the first inch of the duodenum are comparatively few in number. They are rather small and do not anastomose freely. From this plexus we find along with others the gastric type of spiral tortuous artery entering the mucosa. The mucous lining is practically devoid of folds, therefore distention has little effect toward the straightening out of these vessels. The rather limited blood supply in itself to this area of the duodenum probably cause a slower blood current. Further, the gastric type of artery being present offers a remarkable resistance to the blood stream. Due to these conditions it seems that the arteries of the first inch of the duodenum are more liable to thrombosis than those of any other region.

Conclusions

This investigation shows that the anatomic arrangements of the arteries along the lesser curvature of the stomach and throughout the first inch of the duodenum are such that they are predisposed to thrombosis. The plexus of vessels in the submucosa on the lesser curvature is made up of much smaller and longer arteries without as free anastomoses as in other regions of the stomach. The branches from this plexus run a very tortuous course to enter the mucosa. The resistance offered the blood stream is constantly greater and, as a result, the blood current is slower as it enters the small arteries of the mucosa. The submucous plexus of arteries in the first inch of the duodenum is made up of relatively few vessels in comparison to other parts of the duodenum. They are small and do not anastomose freely; they give off branches to the mucosa some of which simulate the gastric type of spiral artery. The rather limited blood supply and the gastric type of artery predispose to thrombosis. Since the vessels are more liable to be occluded by emboli, it is reasonable to suppose that they are an important factor in the production of ulcer by hematogenous infections.

By these observations I wish to call attention to the character and distribution of the smaller arteries in stomachs and duodenums altogether anatomically normal, and to submit the hypothesis that possible slight deviation from the normal may contribute to peptic ulcer. In any consideration of ulcer it must be remembered that this disorder is relatively and actually rare; according to Osler ulcer occurs in 1.32 per cent of all persons in the United States and in Canada. Finally, one must remember the fact that high grade bacteremias do not frequently produce gastric or duodenal ulcer.

REFERENCES

1. Bailey, F.R. Text book of histology. New York, Wood, 5th ed., 1916, 652 pp.

2. Baumann, A.E. Uber den Hamorrhagischen Infarkt des Magens hervorgerufen durch embolischen Verschluss Arterieller Magengefässe. Inaug.-Dissert., München, 1909.

3. Bayne-Jones, S. The blood vessels of the heart valves. Am. Jour. Anat., 1917, xxi, 449-463.

4. Cohnheim, J. Lectures on general pathology. London, New Syndenham Society, 1890, iii, 878

5. Disse, Uber die Blutgefässe der menschlichen Magenschleimhaut, besonders über die Arterien derselben. Arch. f. mikros. Anat., 1904, lxiii, 515-531.

6. Leriche, R and Villemin, F. Recherches anatomiques sur l' artere coronaire stomachique. Bull. Soc. anat. de Paris, 1907, 6.s., ix, 224-229.

7. Lewis, F.T. The form of the stomach in human embryos with notes upon the nomenclature of the stomach. Am. Jour. Anat., 1912, xiii, 477-503.

8. Mall, F.P. Die Blut-und Lymphwege im Dünndarm des Hundes. Abhandl. d. math.-phys. cl. d. k. säch. Gesellsch. d. Wissensch., 1887-8, xiv, 151-200.

9. Mall, F.P. The vessels and walls of the dog's stomach. John Hopkins Hosp. Rep., 1896, i, 1-36.

10. Mayo, W.J. Anemic spot on the duodenum, which may be mistaken for ulcer. Surg., Gynec. and Obst., 1908, vi, 600-601.

11. Oppel, A. Lehrbuch der vergleichenden mikroskopischen Anatomie der Wirbeltiere. Jena, Fischer, 1897, ii, 337-375.

12. Osler, W. The principles and practice of medicine. New York, Appleton, 8th ed., 1916, 491.

13. Rosenow, E.C. The causation of gastric and duodenal ulcer by streptococci. Jour. Inf. Dis., 1916, xix, 333-384.

14. Virchow, R. Historisches, Kritisches und Positives zur Lehre der Unterleibsaffektionen. (Paragraphs on gastric ulcer). Arch. f. path. Anat., 1853, v, 362-364.

15. Waldeyer, Die Magenstrasse. Sitzungsber. d. k. preuss. Akad. der Wissensch., 1908, xxix, 595-606.

16. Wilkie, D.P.D. The blood supply of the duodenum. Surg. Gynec. and Obst. 1911, xiii, 399-405.