

A COMPOSITE STUDY OF THE COELIAC AXIS ARTERY

BY BENJAMIN LIPSHUTZ, M.D.

OF PHILADELPHIA

(From the Daniel Baugh Institute of Anatomy of the Jefferson Medical College, Philadelphia)

THE many vascular variations which are constantly observed in the dissection of adult cadavers show a distinct tendency to group themselves into definite anatomic types. The epoch-making work of Ruge in 1883 contributed greatly to our knowledge of arterial variations. It was his conclusion that these variations tend to fall naturally into distinct groups. Hitzrot's study of the axillary artery, Bean's of the subclavian, and that of the writer on the femoral support Ruge's conclusions.

The first paper on the study of the blood vascular tree presents a consideration of the femoral artery. In this the second paper of the series, a study of the coeliac axis artery is presented. The records which underlie this study were made from student and personal dissections at the Daniel Baugh Institute of Anatomy of the Jefferson Medical College. The dissections of 83 cadavers were recorded; 67 male white, 8 female white, 6 male negro, and 2 female negro.

In the study of the femoral artery, mention is made of the occurrence of numerous minor arterial variations not entirely in accord with the described anatomic types; yet the cases studied show a clear tendency to group themselves into distinct anatomic types. Analogous results are now found in the study of the coeliac axis artery. The classification of the coeliac axis artery is based on the origin and distribution of the gastric, splenic and hepatic arteries. Section A of this paper contains a description of the various types. Section B embraces a description of the gastric, splenic and hepatic arteries and their respective branches. Section C summarizes and discusses the results of the present study.

SECTION A—DESCRIPTION OF TYPES

TYPE I.—This type (Fig. 1) is found in 75 per cent. of the cases classified. It embraces those subjects in which the coeliac axis is the common trunk of origin for the gastric, splenic and hepatic arteries.

BENJAMIN LIPSHUTZ

In 24 of the cases studied the gastric artery is the first branch of the celiac axis and it arises eleven times from the cœliac axis close to the aorta. The gastric artery takes origin six times from the summit of the cœliac axis. The splenic artery in two of the cases observed is the first branch of the cœliac axis. In 21 of the subjects classified, the gastric, splenic and hepatic arteries arise from the cœliac axis at the same level.

The cœliac axis varies in length from 1 to 3 cm. and is not infre-

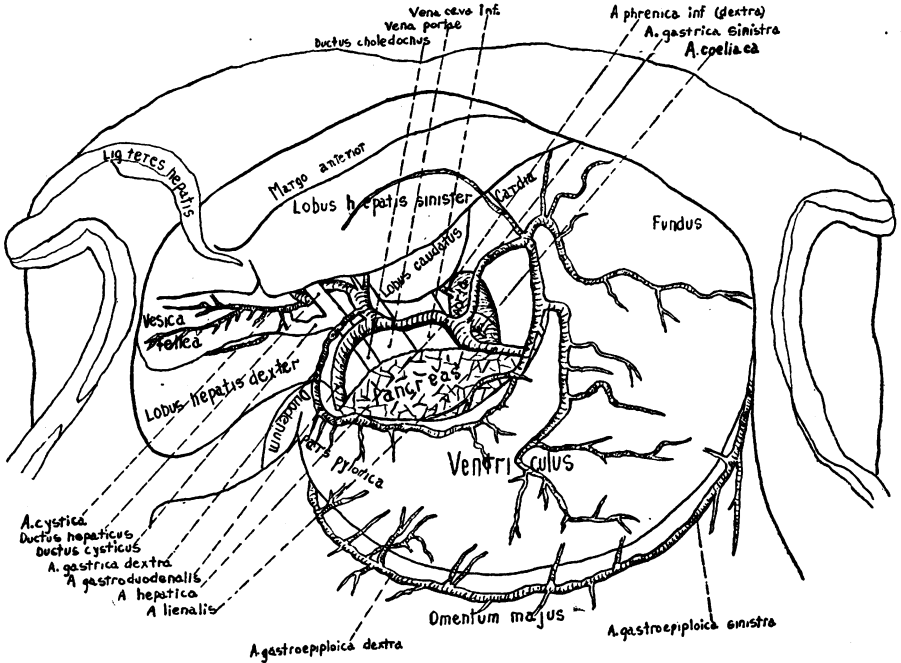


Fig 1.

FIG. 1.—This arrangement of the branches occurs in seventy-five per cent. of the cases classified.

quently partly covered at its origin by the diaphragm. It is worthy of note that in eight subjects of this group both the cœliac axis and its branches are poorly developed; these subjects present no additional vessels from the adjacent arteries to compensate for this apparent deficiency in blood supply. There are in this type (Fig. 1) 53 male white, 4 female white, 3 male negro, and 1 female negro subjects. This is the type which is described in the German, English and French anatomical text-books most universally used.

STUDY OF CŒLIAC AXIS ARTERY

TYPE 2.—This type (Fig. 2) is present in 15 per cent. of the cases classified. In this group the hepatic and splenic arteries both arise from the cœliac axis artery. The gastric artery occurs as a separate branch directly from the abdominal aorta, and in every case observed it is cephalic to the origin of the cœliac axis. The cœliac axis artery divides at its summit into the splenic and hepatic arteries. There are in this group 11 subjects in all—9 male white, 1 female white, and 1 male colored.

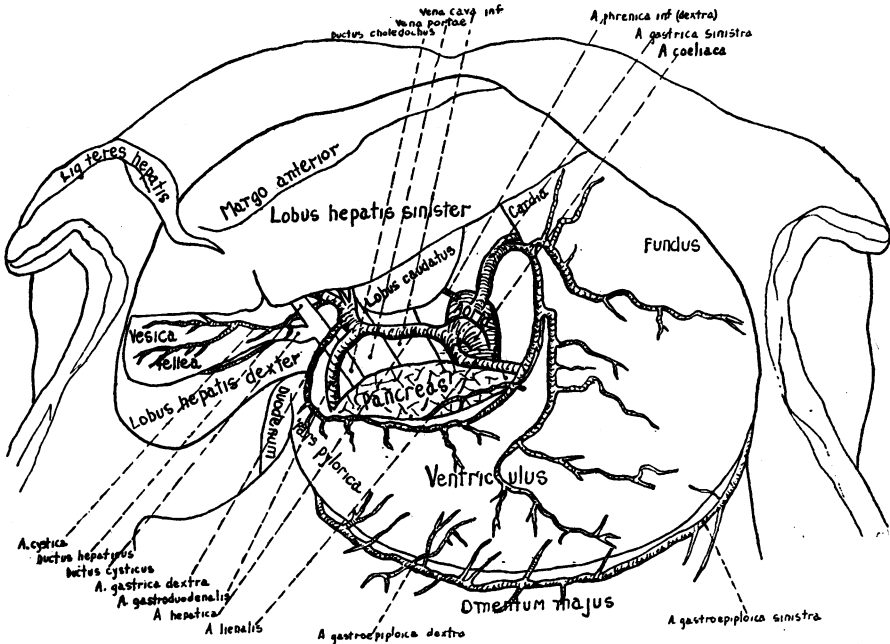


Fig 2

FIG. 2.—This type occurs in fifteen per cent. of the cases classified.

TYPE 3.—This type (Fig. 3) is present with slight variations in 6 per cent. of the subjects studied. In this type the gastric and hepatic arteries take origin from the cœliac axis artery. The splenic artery arises as a separate branch from the abdominal aorta. The hepatic artery in 3 subjects of this group is represented by two vessels each of which has a separate origin from the cœliac axis artery. There are of this type 5 subjects; 3 male white, 2 female white, and 1 male negro.

BENJAMIN LIPSHUTZ

TYPE 4.—This type (Fig. 4) occurs in 4 per cent. of the cases classified. The cœliac axis in this group is the trunk of origin for the gastric and splenic arteries. The hepatic artery occurs as a separate branch directly from the abdominal aorta.

SECTION B—DESCRIPTION OF BRANCHES

A. Gastrica Sinistra.—This vessel is the smallest of the three branches of the cœliac axis. It, however, is considerably larger than the right gastric (pyloric) artery. It arises in 15 per cent. of the cases observed as a separate branch of the

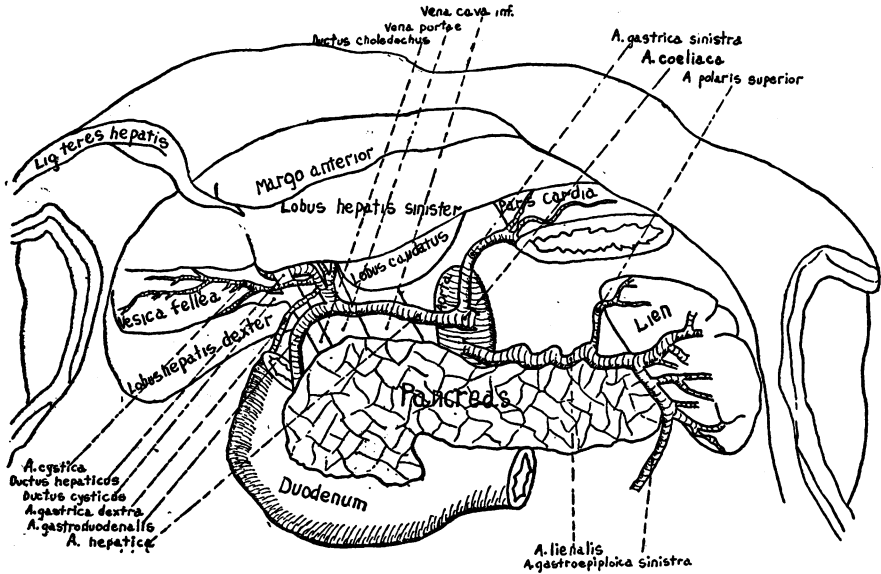


Fig. 3.

FIG. 3.—This arrangement of the branches occurs in six per cent. of the subjects studied.

abdominal aorta, and its point of origin is always cephalic to the origin of the cœliac axis artery. As it courses between the two layers of the lesser omentum, along the lesser curvature of the stomach, it is found in 35 per cent. of the subjects studied as two parallel stems. The site of division of the left gastric artery into a double vessel varies from one and a half to three cm. from its origin. In no case observed is the left gastric artery present as a double vessel at its origin. It occurs as a single vessel along the lesser curvature of the stomach which gives origin to the branches passing downward over both surfaces of the stomach in 65 per cent. of the cases classified. The left gastric artery occurs six times in a trunk common with the hepatic. In two of the subjects observed, it is present in a trunk common with the splenic artery. In one subject it takes origin from the abdominal aorta in a trunk common with the hepatic and superior mesenteric arteries; the splenic artery arising as a separate branch directly from

STUDY OF CELIAC AXIS ARTERY

the aorta and taking a circuitous route looping around the left gastric artery to gain its usual site and distribution.

The oesophageal rami are unusually large and well marked in 30 per cent. of the subjects studied. In three bodies observed, they are found as branches of the right inferior phrenic, and four times as branches of the hepatic branch of the left gastric. The cardiac rami vary in number and size and are usually not as well marked as the oesophageal rami. In 8 of the cases classified they are present as branches of the hepatic branch of the left gastric.

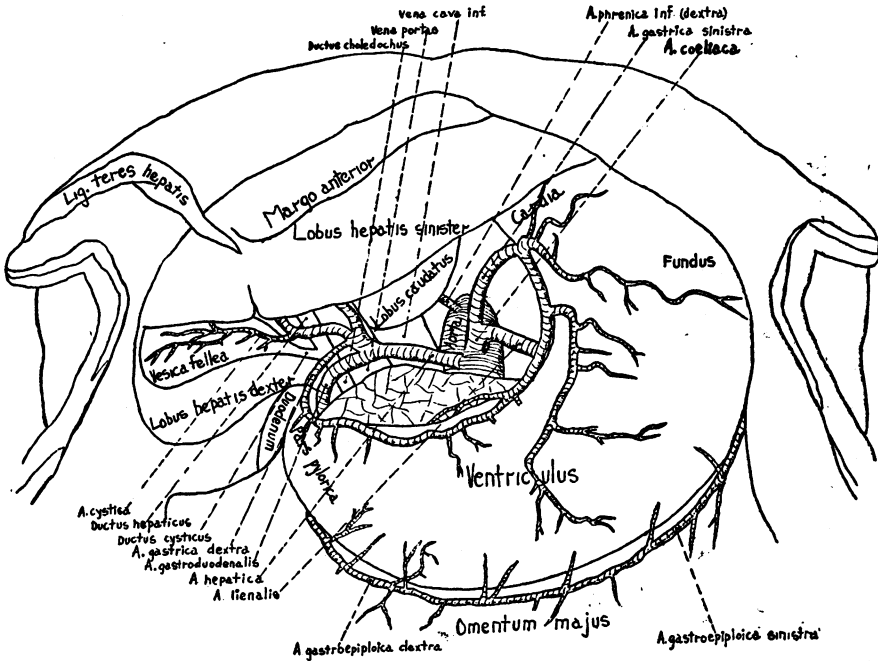


Fig. 4

FIG. 4.—This type is present in four per cent. of the cases classified.

A hepatic branch of the left gastric artery is found present in 35 per cent. of the subjects studied. This vessel varies both in size and in its anatomic distribution. It passes upward between the two layers of the lesser omentum to the inferior (visceral) surface of the left lobe of the liver in 16 of the cases observed. It is distributed as a branch to the transverse (portal) fissure 11 times and 3 times to the posterior surface of the liver and the oesophagus. It not infrequently gives origin to a number of twigs to the cardiac end of the stomach. This vessel in those cases in which it gains the portal fissure of the liver and in its distribution constitutes a left hepatic artery does not, however, replace the left hepatic which is present and well developed.

A. Lienalis (Splanic).—This vessel is the largest of the three branches of

BENJAMIN LIPSHUTZ

the cœliac axis. The splenic artery arises from the cœliac axis in 92 per cent. of the subjects studied. It occurs 6 times as a separate branch directly from the aorta. In 15 per cent. of the cases classified, it takes origin from the abdominal aorta in a common trunk with the hepatic. In two bodies observed it is present in a common trunk with the left gastric.

In 67 per cent. of the cases classified this vessel is large and presents numerous tortuosities as it pursues its more or less transverse course from right to left along the upper border of the pancreas accompanied by the underlying splenic vein to gain the spleen. In 33 per cent. of the cases classified, this vessel is straight or only slightly tortuous. The splenic artery at its termination divides into two or three large terminal trunks, which break up into 6 to 10 branches before they enter the spleen. There are three terminal branches in 72 per cent. of the subjects classified; A. polaris superior, A. terminalis superior, and A. terminalis inferior; the two latter vessels enter the hilum of the spleen. In 28 per cent. of the subjects there are two terminal branches; A. terminalis superior and A. terminalis inferior, the A. polaris superior arising from the trunk of the splenic or as a branch of the A. terminalis superior. The termination of the splenic artery usually occurs at the border of the middle and lower thirds of the spleen. The splenic artery breaks up into its terminal branches at a distance varying from one to seven cm. from the spleen. In 10 per cent. of the cases studied, the division of the splenic artery into its terminal branches is from 6 to 7 cm. from the spleen.

In 4 of the cases studied, the splenic artery in addition to its numerous pancreatic rami gives off at its origin an unusually large branch which is distributed to the head of the pancreas.

A. Gastro-epiploica Sinistra.—Its point of origin from the splenic artery is variable. The most frequent origin of this vessel is as a branch of the cephalic terminal trunk of the splenic artery. It occurs 12 times as a branch of the caudal terminal trunk. In 14 of the cases classified, this vessel arises from the trunk of the splenic artery before it breaks up into its terminal branches. In 6 of the subjects studied, it arises from the middle of the trunk, and in one instance within two cm. of the cœliac axis artery. In 5 of the subjects observed, the splenic artery gives origin to a large branch which courses cephalically and is distributed to the left lobe of the liver. The middle cœlic artery in two of the cases studied occurs as a branch of the splenic.

A. Hepatica.—This vessel is the most variable of three branches of the cœliac axis, and in the adult is intermediate in size between the splenic and gastric. It occurs as a branch of the cœliac axis artery in all but three of the subjects studied. In the latter it arises as a separate branch directly from the abdominal aorta. In 15 per cent. of the cases classified, it takes origin in a common trunk with the splenic artery. It arises 6 times in a trunk common with the gastric artery. In one case observed, it is found present in a common trunk with the gastric and the superior mesenteric arteries.

The hepatic artery is represented as a double vessel in 11 per cent. of the cases studied, *i.e.*, its two terminal rami—*ramus dexter* and *ramus sinister*—arise as separate branches directly from the cœliac axis artery. The hepatic artery arises as a single vessel in 89 per cent. of the cases observed and it presents great variation at the point of division into its two terminal branches. This division occurs six times within one and a half cm. from its origin and the branches pass from left to right along the free border of the lesser

STUDY OF CÆLIAC AXIS ARTERY

omentum as two parallel stems. In 22 per cent. of the cases studied, this division occurs at the site of origin of the gastroduodenal artery. The most frequent point of division is within two to three cm. of the portal (transverse) fissure of the liver. In 9 of the cases classified, both of the terminal branches again divide into two or more stems at or close to their origin as they ascend to gain the liver. The right hepatic artery usually passes dorsad of the hepatic duct. In a small number of subjects, it is found ventral to the hepatic duct.

A. Gastrica Dextra (Pyloric).—This vessel in every case observed is smaller than the left gastric artery. The most frequent origin of the pyloric artery is as a branch of the hepatic lateral to the origin of the gastroduodenal artery. In 22 per cent. of the cases studied, it occurs as a branch of the gastroduodenal artery. It is found four times as a branch of the right hepatic artery and three times as a branch of the left hepatic. The pyloric artery arises in two of the cases classified, as a separate branch directly from the cœliac axis artery. In one case observed, it is present as a branch of the superior mesenteric artery. In 21 per cent. of the subjects classified, this artery is represented as two parallel vessels which arise from the trunk of the hepatic and continue between the two layers of the lesser omentum along the lesser curvature of the stomach as two vascular arches.

A. Gastroduodenalis.—This artery presents few variations in its origin. Its most frequent origin is as a branch of the hepatic artery, before the latter divides into its terminal branches. In every case observed its origin is medial to the origin of the pyloric artery. In three of the cases classified, it occurs as a branch directly from the cœliac axis.

In almost every subject observed, the right gastro-epiploic artery is of greater length and calibre than the superior pancreaticoduodenal artery. The superior pancreaticoduodenal artery occurs in all but three of the subjects studied as a branch of the gastroduodenal. In the latter three subjects it is present as a branch of the hepatic artery. The right gastro-epiploic artery is found in all but four of the cases classified as a branch of the gastroduodenal, where it occurs as a branch of the hepatic artery.

A. Cystica.—The cystic artery shows considerable variation in size, origin and relation. Its size is usually proportionate to the size of the gall-bladder. This vessel occurs most frequently as a branch of the right hepatic artery. In those cases observed in which the right hepatic artery breaks up into two or more stems in its course to the portal fissure, the most lateral twig gains the gall-bladder and becomes the cystic artery. The right hepatic artery in 40 per cent. of the cases studied closely adheres to the dorsal surface of the cystic and hepatic ducts near their point of union, at which site the cystic artery frequently arises. In 8 per cent. of the subjects this vessel occurs as a branch of the hepatic artery before it breaks up into its two terminal branches, and as it ascends laterally towards the gall-bladder, it passes ventrad of the hepatic duct and ventrocephalad of the cystic duct to gain its usual site and distribution. In one subject the right hepatic artery is distributed entirely as the cystic. In 11 per cent. of the cases classified, the cystic artery occurs as a branch of the left hepatic. The cystic artery is usually cephalad and ventrad of the cystic duct. In 3 of the cases observed, this vessel is caudal to the cystic duct; and in 2 of the subjects it has a position lateral to the cystic duct. The cystic artery in 3 of the cases studied is present as a separate branch directly from the superior mesenteric (Fig. 5D). It is found three

times as a branch of the gastroduodenal artery. In 8 per cent. of the cases classified, the cystic artery is represented by two parallel vessels which arise separately from the right hepatic, except in 2 of these subjects in which they arise from a hepatic branch of the superior mesenteric (Fig. 5 C) and pass ventrad and cephalad to the cystic duct in their course to the gall-bladder. This additional cystic artery arises in two subjects observed, directly from the aorta

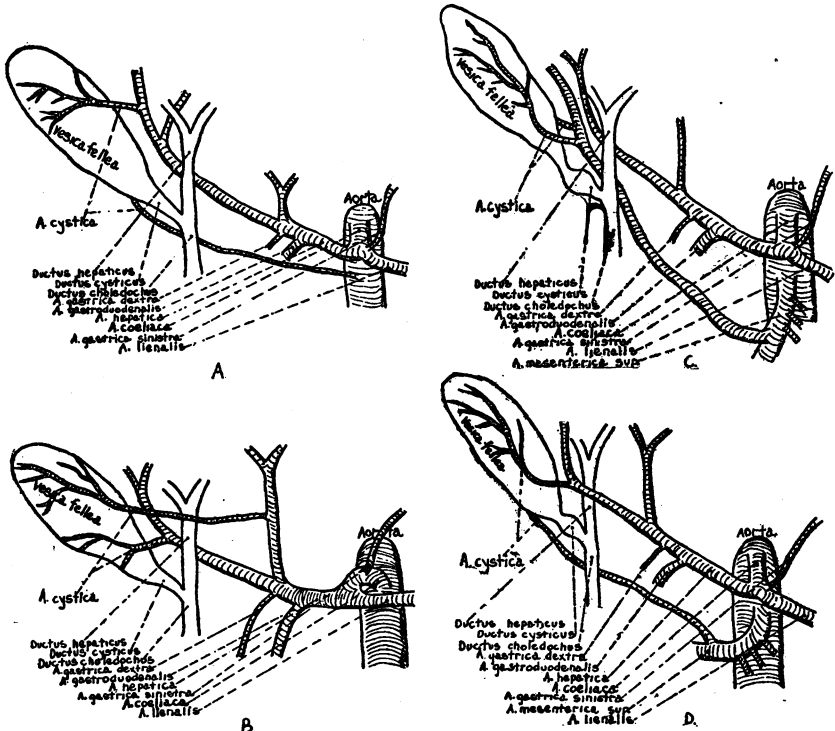


FIG. 5.—These drawings illustrate unusual variations in the occurrence of the cystic artery as a twin vessel. *A*, the additional cystic artery arises directly from the abdominal aorta and is found in three of the eighty-three subjects studied. *B*, the additional cystic artery occurs as a branch of the left hepatic and courses ventrad of the hepatic duct and right hepatic artery. This occurs in only one subject. *C*, both cystic arteries arise as branches of a hepatic branch of the superior mesenteric artery. This is found in two of the subjects studied. *D*, the additional cystic artery is present as a branch directly from the superior mesenteric artery. This variation occurs in three of the subjects studied.

(Fig. 5 A) and courses dorsad to the common bile-duct and is caudal to the cystic duct as it reaches the gall-bladder.

Rossi e Cavi in a study of 96 subjects found the cystic artery present as a twin vessel in 11.5 per cent. of the subjects; Belou in a study of 150 subjects in 19 per cent., and Branco in a study of 50 subjects, in 12 per cent.

A. Accessoria Hepatica.—Mention is made in the description of the gastric and splenic arteries of the occurrence of the accessory hepatic artery. In 35 per cent. of the cases classified, it occurs as a branch of the left gastric artery and in 5 subjects as a branch of the splenic artery.

STUDY OF CŒLIAC AXIS ARTERY

This vessel occurs in 15 per cent. of the cases as a branch of the superior mesenteric artery. It arises in a trunk common with the superior mesenteric or as a branch of the superior mesenteric from 1 to 3 cm. of its origin. The usual distribution of this vessel is as the right hepatic artery; in only two of the subjects is the anatomic distribution of this vessel as a left hepatic. The accessory hepatic artery ascends in its course to gain the liver, passes behind the stomach and pancreas, dorsal and medial to the common bile-duct, directly dorsal to the site of the union of the cystic and hepatic ducts, and at the portal fissure it is lateral to the hepatic duct and portal vein. In 4 of these subjects the gastroduodenal artery occurs as a branch of this vessel and in 3 of the subjects it gives origin to the pyloric and gastroduodenal arteries. This accessory hepatic vessel breaks up into two or more stems, one of which becomes the cystic artery or gives origin to the latter. In 3 of these cases the hepatic artery arises in its entirety from the superior mesenteric and pursues a course as outlined above.

A. Phrenica Inferior.—Both phrenic arteries arise 5 times as separate branches from the cœliac axis artery. In 2 of the cases studied, they arise from the cœliac axis artery in a common stem. The left inferior phrenic artery occurs 6 times as a branch directly from the cœliac axis, in 2 of which subjects this vessel gives off a number of small pancreatic rami. The right inferior phrenic artery is present in three of the cases classified as a branch of the cœliac axis.

SECTION C—SUMMARY AND DISCUSSION

(1) A comparison of the types of the arteria cœliaca demonstrates the unusual predominance of Type I. This arrangement is present in seventy-five per cent. of the subjects and is the type described in all standard anatomical text-books. Type II occurs in fifteen per cent. of the cases and Types III and IV in ten per cent. The occurrence of Type I in so large a number of the cases classified stands out as one of the most interesting results of this study.

(2) This study embraces the dissection of eighty-three cadavers, sixty-seven male white, eight female white, six male negro, and two female negro. No relation of the branches to age could be drawn as there were only adults in this series. In the study of the femoral artery the negro subjects presented a greater proportionate number of variations and anomalies than the whites. The number of negro subjects in this series is, however, too small to present an analogous study.

(3) The left gastric artery occurs more frequently as a branch of the abdominal aorta than the splenic or hepatic arteries. The left gastric artery in thirty-five per cent. of the subjects studied is represented along the lesser curvature of the stomach as two parallel vessels. The right gastric artery (pyloric) appears as two parallel vessels in 21 per cent. of the cases studied.

The splenic artery frequently presents numerous tortuosities and is of unusually large calibre. In 30 per cent. of the cases classified, this vessel pursues a straight or only slightly tortuous course. The hepatic artery occurs as a double vessel in 11 per cent. of the cases studied. Each branch has a separate origin from the coeliac axis. The cystic artery usually arises from the right hepatic and in 8 per cent. of the subjects it appears as a twin vessel. It is usually ventrocephalad of the cystic duct.

(4) An accessory hepatic artery occurs in 35 per cent. of the cases classified as a branch of the left gastric; in 15 per cent. of the subjects as a branch of the superior mesenteric, and 5 times as a branch of the splenic. In one subject the hepatic, superior mesenteric and left gastric artery arise from the abdominal aorta in a common trunk. The hepatic artery arises three times in its entirety from the superior mesenteric. In 25 per cent. of the cases studied, the coeliac axis gives off only two branches—in 15 per cent. it is the hepatic and splenic arteries, in 6 per cent. the hepatic and the gastric, and in 4 per cent. the splenic and the gastric. Rossi e Cavi in a study of 102 subjects found the coeliac axis artery absent in 2 of the subjects; its branches, the gastric, splenic and hepatic arteries arising independently from the abdominal aorta.

(5) An unusually interesting anomaly occurs in two of the cases observed, the so-called "truncus coeliaco-mesenterica" (Ratke and Meckel). The coeliac axis and the superior mesenteric arteries take origin in a common trunk. This is an entirely normal condition in the anuria, some of the chelonia, and some of the mammalia (Keibel and Mall). Tandler interprets this as a result of the persistence of the large primitive ventral anastomosis between the early segmental coeliac axis and superior mesenteric groups. This longitudinal anastomosis is the trunk of origin for the gastric, splenic and hepatic arteries. The main part of the trunk is the superior mesenteric and as this is the stronger vessel it in this way takes over the branches which usually arise from the coeliac axis. The presence of a partial persistence of this longitudinal anastomosis explains the occurrence of the origin of the hepatic artery or an accessory hepatic artery from the superior mesenteric.

(6) The contention of Ruge in 1883 that arterial variations group themselves into distinct anatomic types is supported by the studies of Hitzrot, Bean and those of the writer. The descriptions of the arterial trunks as contained in standard anatomical text-books conform usually to but one type. Composite studies of the individual arterial trunks,

STUDY OF COELIAC AXIS ARTERY

each study embracing the investigation of a large number of cadavers, disclose that the variations found allow of a natural grouping into distinct anatomic types.

The usual and accepted conventional opinion, that whenever a vessel occurs which is at variance with the classic text-book description it is an anomaly, needs to be revised. In studying a large number of arteries of one of the large arterial trunks of the body, certain variations are found to occur with sufficient frequency to justify the establishment of distinct groups. At times variations occur which differ so widely from the normal types of the vessel that they cannot be classified; these alone should be termed anomalous.

This interesting phase of anatomical study—the establishment of anatomic types, simplifies and makes more easy of comprehension all the variations of the large arterial trunks of the body. A knowledge of the types of the larger arterial trunks will aid the surgeon in avoiding troublesome and dangerous hemorrhage that otherwise could not be averted, and it is incumbent that he move slowly in operative procedures until he has determined the exact anatomy of the part. The constant variations in size, calibre and number of the branches may be an etiological factor in the production of certain pathologic conditions.

Professor J. Parsons Schaeffer, head of the Department of Anatomy of the Jefferson Medical College, at whose suggestion these studies were begun, kindly permitted me to make full use of all the material in his department and I take this opportunity of expressing my thanks for his interest, attention and criticism in this work.

LITERATURE

- Bean, R. B.: A Composite Study of the Subclavian Artery in Man. *American Journal of Anatomy*, vol. iv, 1904.
- Belou, Pedro: *Anatomia de los conductus biliares, de la arteria cistica*. Buenos Aires, Imp. Oceana, 302, p. Roy 8°, 1915.
- Do Rio, Branco: *Anatomie du tronc cœlique*, Paris, 1912.
- Hitzrot, J. M.: A Composite Study of the Axillary Artery in Man. *Johns Hopkins Hospital Bulletin*, 1901.
- Keibel and Mall: *Manual of Embryology*, Philadelphia, Pa., 1910.
- Lipshutz, Benjamin: A Composite Study of the Femoral Artery. *Anatomical Record*, vol. x, No. 5, 1916.
- Rossi e Cavi: Studio morfologico delle arterie delle stomaco. *Archives italiano di anat e embriol.* Florence T III fasciculæ, 2 pp., 485-526.
- Ruge, G.: *Beitrag zur gefasslehre des Menschen*. *Morph. Jahrb.*, B. 9, 1883.
- Sousloff: *Archives russes de chirurgie*, T. v, 1907.
- Tandler, Julius: *Zu entwickelungsgeschichte der Menschlichen Darmarterien*, Anatomische Hefte. Band xiii, Wiesbaden, 1904.