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VARIATIONS IN THE BRANCHES OF THE CŒLIAC ARTERY IN THE RABBIT

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It has been noted in some mammals, and no doubt this is true for most species, that there is considerable variation from what is ordinarily understood as the normal condition in the origin and arrangement of certain arteries and veins. Such variations have been reported concerning the origin of groups of vessels, such as the arteries which arise from the systemic aorta and supply the head, neck and fore limbs. Similar conditions have been observed in the post cava and the venous system in general in some mammals. Even the blood vessels in man, both arteries and veins, are subject to a great many variations, or, what are sometimes called, abnormalities.

Students in their work in physiology in this department use approximately one hundred and twenty-five rabbits each year and it has been a matter of very general occurrence to find rabbits in which the arrangement of the arteries did not conform to that which is considered the normal condition. (See Baldwin, this volume, as to carotid variation.)

The origin and arrangement of the branches of the cœliac artery presented a most interesting state of affairs and it was therefore attempted to make a careful record of such variations and note the frequency with which they occurred.

The supply of rabbits consisted of the types which are ordinarily obtained from the average breeder. Many of the animals, however, which were used for our purpose, were secured from the Animal Husbandry Department of Iowa State College and came from their stock supply. Five specially injected rabbits for these observations were about three-quarters Belgian. Both male and female individuals were used.

The arterial system of the rabbits was injected with a red injection mass through the femoral artery, while in a few cases the cœliac artery or one of its branches was injected separately. The blood vessels of rabbits which had just been killed also were studied, in which case the contained blood within the vessels made a careful study comparatively easy.

*Deceased, Feb. 14, 1920.

In selecting rabbits for this investigation the matter of any variation did not mark them as especially desirable, but of the one hundred or more rabbits used in the laboratory, twenty were selected because of their superior injection and these were used for comparison in addition to the five especially prepared specimens.

THE PREDOMINANT ARRANGEMENT OF THE COELIAC BRANCHES

While the relative number of variations are tabulated later in this paper, I shall consider first that condition which is predominant and may therefore be called the normal arrangement of the cœliac branches. (Figure 7:1 and 2; Figure 8:3.)

Where the abdominal aorta (AA) emerges through the diaphragm it gives off the cœliac artery which extends toward the right to the lesser curvature of the stomach. Figure 7:1 and 2, C.) The following branches are given off from the cœliac artery. Between 7 and 9 mm. from the origin of the cœliac there arises the *splenic* artery (S). About half way between the abdominal aorta and the origin of the splenic artery there is given off, on the anterior border of the cœliac, a small branch, the *inferior phrenic* artery (P), which supplies the diaphragm. Bensley in his Practical Anatomy of the Rabbit claims there are several inferior phrenic branches, but in no case have I been able to locate more than one vessel, which is very small. Quite frequently no vessel corresponding to the inferior phrenic was found arising from the cœliac. It is quite possible that where the inferior phrenic artery was not found this may have been the result of imperfect injection, or, what is more probable, it may have arisen from the abdominal aorta directly. While the latter is a very frequent variation in the inferior phrenic in some animals, I was unable to identify it as coming off the aorta in the rabbit. The small size of the vessel, however, may have precluded a proper injection. While the inferior phrenic artery is shown in figure 7:2 and 8:3 and 6, in which cases it was seen, it will not enter further into the discussion in this paper. Between 7 and 9 mm. from the origin of the splenic artery the *left gastric* artery (LG) arises, figure 7:2. The cœliac from this point continues as the *hepatic* artery (H) and gives off, at the junction of the duodenum and the pylorus, the *gastroduodenal* artery (GD). The hepatic artery continues through the lesser omentum to the liver where it divides and supplies the various lobes.

The *splenic* artery arises from the ventral border of the cœliac, curves to the right then to the left and then to the right again,

very much like a letter S, on the dorsal surface of the fundus of the stomach. It gives off one (figure 7:2, and 8:3, 5, 6, 7) or often two or more (figure 8:4, 8) large vessels, the *short gastric* arteries (SG), to the left portion of the greater curvature of the stomach. The splenic artery after a short distance then gives rise to one or more very small vessels which supply a portion of the pancreas (figure 8:3). One or more of these vessels are often given off before the short gastric. The splenic now passes to the hilus of the spleen where it gives off to the spleen, one or more branches which in turn break up into a great many smaller branches. The splenic continues into the greater omentum and then toward the right to the greater curvature of the stomach as the *left gastræpiploic* artery (LGE) where it supplies the walls of the stomach and finally anastomoses with the *right gastræpiploic* artery (RGE) from the other side.

The *left gastric* artery (LG) arises from the cœliac, dorsal to the cardia of the stomach, between 5 and 7 mm. from the origin of the splenic, divides immediately into three branches all of which divide in a radiating fashion on the surface of the stomach. Two of these branches supply the ventral surface of the stomach and are separated by the œsophagus. The one to the left sends small branches to the œsophagus while the most extreme right branch of the right vessel anastomoses across the lesser curvature of the stomach with the *right gastric* artery. The third branch supplies the dorsal stomach wall.

The *hepatic* artery (H) is a continuation of the cœliac. It continues to the right and cephalad and after giving off several small branches to the pancreas it gives rise to a vessel which extends to the posterior; the *gastroduodenal* artery (a. gastroduodenalis). This vessel, which is dorsal to the pyloric stomach, divides into two branches, the larger one of which supplies the duodenum and pancreas, being known as the *superior pancreatico-duodenal* artery (a. pancreaticoduodenalis superior), while a recurrent branch, the *right gastræpiploic* artery (a. gastrœpiploica dextra), passes through the greater omentum toward the left to the greater curvature of the stomach and anastomoses with the left gastrœpiploic artery. The hepatic artery now enters the lesser omentum on its way to the liver but gives off a small branch, the *right gastric* artery (RG), which passes to the pylorus and anastomoses with the right branch of the left gastric artery across the lesser curvature of the stomach (figure 7:1 and 2).

VARIATIONS FROM THE NORMAL BRANCHING

In discussing the variations from the normal, one branch will be considered at a time and in the same order as presented above.

The *splenic* artery presents peculiarities in the number and arrangement of its branches mainly concerning the short gastric arteries. There may be one, two or more of these branches coming off at the same place or at intervals from the splenic. By far the most common arrangement is where but one or two branches come off together as shown in all the figures. While there are variations in the number and arrangement of the splenic branches they need no further discussion. I would mention a possible variation, however, which I was unable to note in the rabbits studied, that is, the possibility of the splenic artery arising directly from the abdominal aorta. In one case, the splenic, while originating on the cœliac, came off at the base. Cases where the origin of the splenic was on the aorta have been noted in this laboratory while Piersol mentions the same condition as a possible variation in man.

The *left gastric* artery and its branches present by far the most interesting variations. From a condition which has been designated as the normal (figures 7:1, 2; 8:3), in which case the vessel immediately divides into three main branches, the following variations have been noted and figured. In figure 8:4 the dorsal branch, which is always shown in the figures as a short unbranched vessel, comes off the right branch instead of having its origin in common with the right and left branches. This condition is shown in figure 8:6 also. In figure 8:5 and 7 its origin is on the left branch. In figure 8:8 two vessels are shown, one from the right branch and the other from the left. It is interesting to note how far removed these origins may be from the normal as shown in figure 8:5 and 8. The right and left branches show considerable variation in their origin. In figure 8:5 and 6 the origins on the cœliac are quite far apart. The origin of the branch which anastomoses with the right gastric artery also varies considerably as shown in figure 8:5, 6, 7 and 8.

The *hepatic* artery, which in the normal condition is a continuation of the cœliac, after giving off the left gastric artery, is shown in figure 8:6 and 8, in what appears to be a continuation of the right branch of the right gastric artery. The facts are, however, that the hepatic artery, in this case, does not give off the gastroduodenal artery after the left gastric, but the hepatic and the gastroduodenal arteries are given off before a part or all of the left gastric, while in

figure 8:6 and 8 the three or more origins of the left gastric are scattered over a comparatively long area. Probably the most interesting hepatic arterial variation is that shown in figure 8:7 where a second hepatic artery (HE) comes off the right branch of the left gastric artery.

The variations in the *gastroduodenal* artery have already been mentioned. It may come off the cœliac in common with the hepatic (figure 8:8) and a part or all of the left gastric, or it may branch off the hepatic some distance beyond the left gastric, which is the normal condition. The range of variations here is quite considerable.

The *right gastric* artery may have its origin on the hepatic, the latter being normal or abnormal, or it may, as is shown in figure 8:4, 5, 7 and 8, come off the gastroduodenal.

FREQUENCY OF VARIATIONS

If the branches of the cœliac artery and their ramifications in different rabbits were compared with any considerable degree of detail, each particular case, no doubt, would stand by itself. But with the details as shown in figures 3 to 8 as the criterion for the degree of minutia, it will be interesting to compare the branches as a whole and note the frequency of such variations.

The following table of twenty-five rabbits will show that the total number of variations is greater (68 per cent) than the normal condition, which is only 32 per cent. The frequency of the next most numerous is 24 per cent. If we consider that the modifications listed under 2 and 3 in the table, especially 2, in which case the right gastric artery comes off the hepatic and which is the normal condition, we find that the total frequency of case 1 in the table and the modifications of 2 and 3 (2, a and 3, a) is 68 per cent of the total.

TABLE SHOWING THE FREQUENCY OF VARIATIONS

	Number	Percentage Normal	Percentage Abnormal
1. Rabbits showing (normal) condition, as Fig. 3	8	32	
2. Rabbits showing condition, as Fig. 4	1		4
(a) As Fig. 4 except right gastric comes off the hepatic	3		12
3. Rabbits showing condition, as Fig. 5	1		4
(a) As Fig. 5 except right gastric comes off the hepatic	6		24
4. Rabbits showing condition, as Fig. 6	4		16
5. Rabbits showing condition, as Fig. 7	1		4
6. Rabbits showing condition, as Fig. 8	1		4
Total	25	32	68

It appears from the facts at hand that it is perfectly logical to accept the condition as shown in figures 7:1, 2; 8:3 as the normal, both on account of its more frequent occurrence and again because it seems to be the condition around which abnormalities vary.

As to the causes for these variations, it is beyond the realm of this paper to determine. It is, however, of considerable anatomical and developmental importance to throw some light upon the subject on account of its frequency in mammalian animals. McClure ('00) has discussed in detail abnormalities in the post cava of the cat, as well as variations in the venous system of Didelphys. Hunt ('18) shows some interesting variations in the carotid of the cat. Piersol in his Human Anatomy points out similar conditions in the cœliac as well as in many other vessels in man. Besides these, there are hosts of cases where other variations have been noted in other mammals.

McClure ('00) has suggested the possible causes for these abnormalities in the post cava of the cat as domestication, inbreeding, disease, drugs and shocks. Concerning some of these there seems to be some disagreement. Slomaker ('00) finds abnormalities in the circulatory system of the common gray rabbit where domestication as a cause is eliminated. McClure, later ('06), working with Didelphys, disproves at least one of his earlier conclusions as to the cause. He says, "It is generally conceded that variations in the venous system occur with greater frequency among domesticated animals than among those living in the wild state; an idea, however, which is most certainly erroneous, as shown by the conditions met with in Didelphys." It is my opinion that none of these five causes suggested by McClure have any influence, or if so, they can hardly be accepted as a determining element.

The most general explanation, in many cases, as to the causes of such variations is reversion. But Pearl ('08) has shown that if we accept this explanation as to the cause we are simply begging the question, while it raises a very important question concerning natural selection. He says, "They all (abnormalities*) point to the same conclusion; namely, that onotogeny may take an entirely new course, which in all probability has never appeared in the racial history before, and yet immediately reach an adaptive end result." "Natural selection by individual elimination clearly fails to explain such adaptive morphogenesis." He states further, "It is suggested that some form of internal selection offers a possible explanation for such causes."

*Writer's word in parenthesis.

The whole question as to the cause or causes seems at present to be without a solution. It seems, therefore, that the entire problem of abnormalities or variations waits upon the further knowledge of embryology and a solution of the factors which govern and regulate embryonic development.

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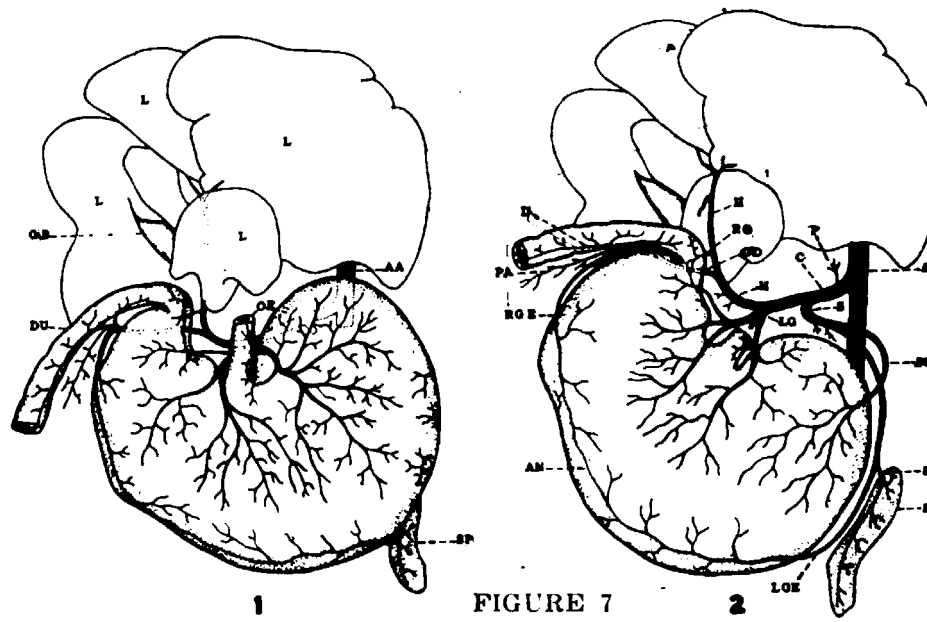
EXPLANATION OF SYMBOLS USED IN ALL FIGURES

AA	abdominal aorta (aorta abdominalis)
AN	anastomoses
C	cœliac artery (a. cœliaca)
D	duodenal artery (a. duodenalis)
DU	duodenum
GB	gall bladder
GD	gastroduodenal artery (a. gastroduodenalis)
H	hepatic artery (a. hepatica)
L	liver
LG	left gastric artery (a. gastrica sinistra)
LGE	left gastrœpiploic artery (a. gastrœpiploica sinistra)
OE	œsophagus
P	inferior phrenic artery (a. phrenica inferior)
PA	superior pancreaticoduodenal artery (a. pancreaticoduodenalis superior)
RG	right gastric artery (a. gastrica dextra)
RGE	right gastrœpiploic artery (a. gastrœpiploica dextra)
S	splenic artery (a. lienalis)
SB	splenic branch (r. lienalis)
SG	short gastric artery (a. gastrica brevis)
SP	spleen



1 FIGURE 7 2

Fig. 1. Cœliac artery in the rabbit showing stomach in natural position, the liver turned up and the duodenum and œsophagus cut.

Fig. 2. Same as Fig. 1 with the stomach turned to the right and the spleen somewhat displaced posteriorly showing the branches of the cœliac artery and their distribution.

FIGURE 8

Fig. 3 Cœliac artery showing normal branching. Similar to Figs. 1 and 2.

Fig. 4 Right gastric artery arising from the gastroduodenal, while the dorsal branch of the left gastric comes off the left branch.

Fig. 5 Left gastric showing two origins with a dorsal branch coming off each one. Right gastric arising from the gastroduodenal artery.

Fig. 6 Left gastric artery showing four separate origins with the gastroduodenal coming off the cœliac and hepatic arteries.

Fig. 7 A second hepatic artery (HE) coming off the right branch of the left gastric and the right gastric coming off the gastroduodenal.

Fig. 8 Various origins of the left gastric arising over an area of one and a half inches on the hepatic artery, with the right gastric coming off the gastroduodenal artery, while the latter arises from the cœliac.

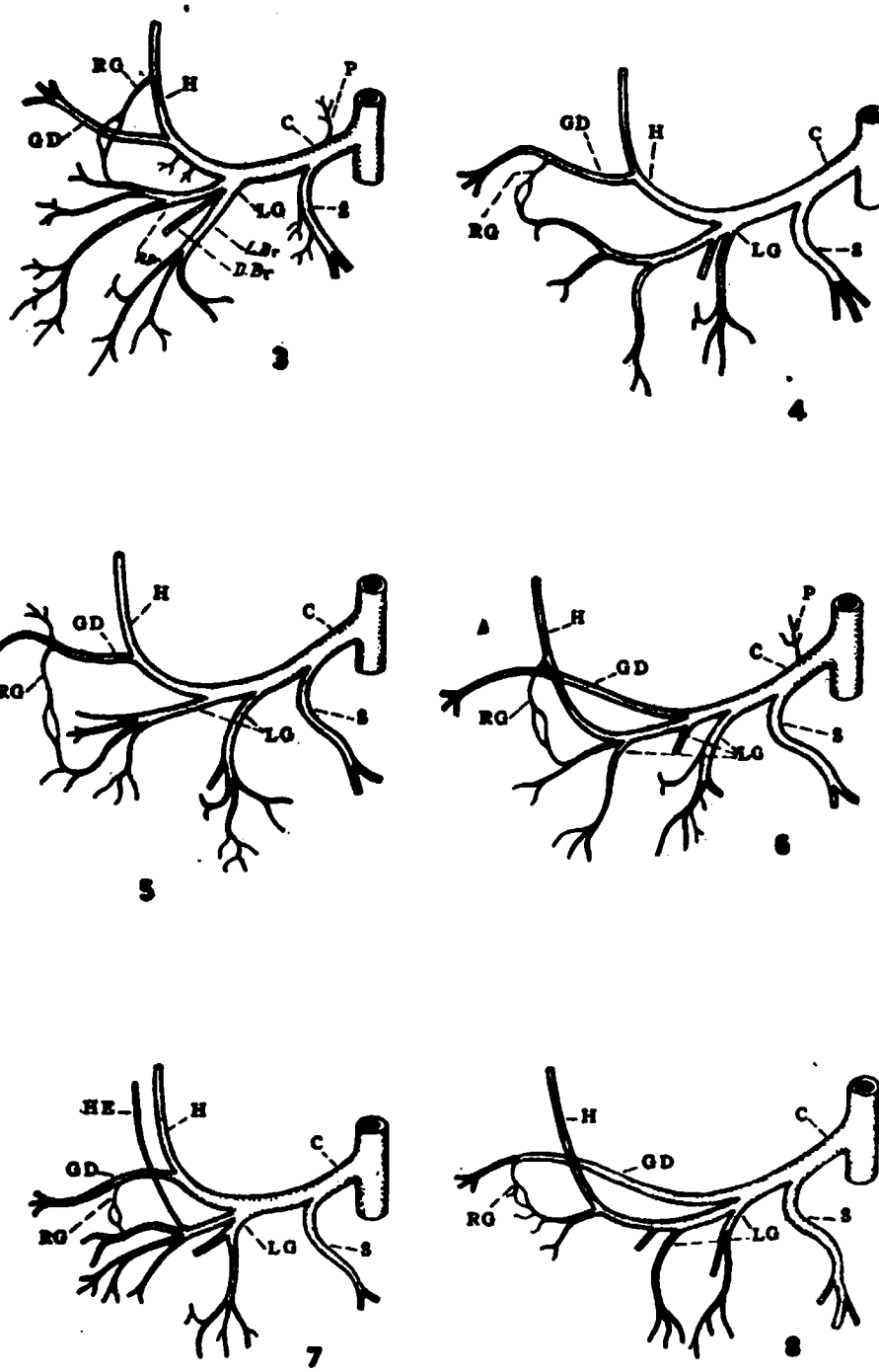

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FIGURE 8