

A MORPHOLOGICAL STUDY REGARDING THE DISTRIBUTION OF CELIAC AND MESENTERIC CRANIAL ARTERIES IN PIG

UN STUDIU MORFOLOGIC PRIVIND DISTRIBUȚIA ARTEREI CELIACE ȘI MEZENTERICE CRANIALE LA PORC

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ABSTRACT | REZUMAT

The study of arterial formations in animals is part of the sphere of interest of biologists, doctors and veterinarians, especially when the results of these studies are helpful in solving some of the most severe health problems in humans, namely the pathologies of the cardiovascular system. This paper aims to describe two significant collaterals of the abdominal aorta in the pig (*Sus scrofa domesticus*), the celiac artery and the cranial mesenteric artery, a species whose anatomy and physiology are the closest to the human body. Although at first sight, it would seem that the macroscopic anatomy could not offer new things, the investigations carried out on several ten corpses from the youth age category (1 month) demonstrated some individual variants not yet described and detailed in the paper but some aspects that do not seem to overlap completely with those in the literature.

Keywords: cardiovascular, celiac artery, mesenteric artery, abdominal aorta, splenic artery

Studiul formațiunilor arteriale la animale fac parte din sfera de interes atât a biologilor cât și a medicilor umani și veterinari, mai ales când rezultatele acestor cercetări sunt utile în rezolvarea unora dintre cele mai grave probleme de sănătate la om, și anume patologia sistemului cardio-vascular. Scopul acestei lucrări constă în descrierea a două mari colaterale ale aortei abdominale la porc (*Sus scrofa domesticus*), artera celiacă, respectiv artera mezenterică cranială, specie a cărei anatomie și fiziologie este ce-a mai apropiată organismului uman. Cu toate că la prima vedere s-ar părea că anatomia macroscopică nu ar mai putea oferi lucruri inedite, investigațiile efectuate pe un număr de 10 cadavre din categoria de vârstă tineret (1 lună) au demonstrat unele variante individuale, nedescrise încă și detaliate în lucrare, dar și unele aspecte ce par a nu se suprapune în totalitate cu cele din literatură.

Cuvinte cheie: cardio-vascular, artera celiacă, artera mezenterică, aorta abdominală, artera splenică

In every specialized work, it is pointed out that pigs represent a species that is perfect to be used as an experimental model. From a structural and functional point of view, this animal's body presents a lot of similarities with the human one (2, 4, 6, 7). In the medicine's areas, cardio-vascular surgery has paid great attention to using this species for experimental purposes after analysing the advantages of its use compared with small laboratory animals (rats, lab rats) or non-human primates (e.g., baboons). In order to implement new procedures and surgical techniques, the researchers have tried first to learn very well the morphological substrate on which they take action, in the area mentioned above, the vascular anatomy (4, 8). There were different procedures, such as injecting the vessels with contrast substance, followed by stereomicroscope dissections, or observing them through para-

clinical methods such as x-rays, computerized CT scans, or MRIs. Starting in 1930, when the research on the circulatory system anatomy of pigs appeared in a classical reference paper (9), and until present time, when morphological paper based on more modern investigation procedures have appeared, it has been constantly pursued to create of a data base necessary to experimental medicine and veterinary practice (1, 3, 5, 8, 9). With all this, biodiversity offers new elements permanently, which motivates the investigations in this morphological area.

MATERIALS AND METHODS

The study was conducted on ten swine corpses of both genders, and they were approximately one month old. The costal wall was removed to expose the aorta, and the contrast agent was introduced into the arterial structures. First, physiological serum was used to clean the lumen of the arterial vessels. Then, a substance based on natural latex with added red pigment was in-

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jected. The area of interest was isolated by ligating the aorta, posterior to the cranial mesenteric artery before the contrast material injection. The corpses were kept at a temperature of -14°C for 24-48 hours, allowing the latex to solidify. After this time, the left lateral abdominal wall was removed, and the arterial structures were traced and described, using *Nomina Anatomica Veterinaria*.

RESULTS AND DISCUSSION

The celiac artery (*A. celiaca*) takes birth behind the aortic aperture of the diaphragm, in the area of the last thoracic vertebra or the first lumbar vertebra. At its origins, it presents a medium calibre of 3 mm and a 1.5 cm length. At approximately 3 mm of its origin, it emits a powerful caudal phrenic artery (*A. phrenica caudalis*) in the cranio-ventral sense, which follows the side face of the left middle pillar of the diaphragm. The celiac artery ends bifurcated through the splenic artery and the hepatic artery. The left gastric artery comes from the splenic artery, with about 40% of the cases being double (Fig. 1).

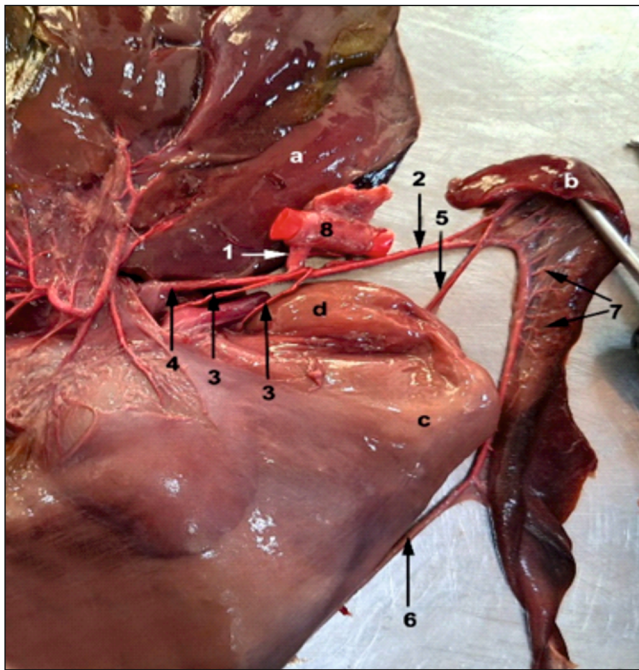


Fig. 1. Terminal branches of the celiac artery in pigs. 1- the celiac artery; 2- the splenic artery; 3- the left gastric artery; 4- the hepatic artery; 5- the artery of the diverticula; 6- the left gastro-epiploic artery; 7 - splenic branches; 8 - aorta; a - liver, visceral side; b - spleen; c - the fundic extremity of the stomach; d - gastric diverticulum

The splenic artery (*A. lienalis*) accompanies the cranial border of the left lobe of the pancreas and then passes into the gastro-splenic ligament between the spleen and the gastric diverticulum. It's directed to the

spleen's hilum. Shortly before entering it, it emits a branch for the gastric diverticulum, the artery of diverticula (*A. diverticuli*), which runs to the posterior face of this structure. It is detached from the common trunk with the first splenic branches, which penetrate into the upper extremity of the spleen. About 2 cm from this diverticulum, a fine branch breaks off, which irrigates the left upper third of the great curvature of the stomach - the fundic branch. Subsequently, the splenic artery comes in relation to the spleen hilum in the middle third of it, which it follows up to the lower third limit, where the splenic artery bifurcates. A branch intimately follows the visceral face of the spleen to its distal extremity, and the other branch is the **left gastro-epiploic artery** (*A. gastroepiploică sinistra*), which follows the greater curvature of the stomach in the thickness of the greater epiploon (Fig. 1, arrow 6). In the initial trajectory, it is distant from the great curvature, but at its half, it joins the stomach wall to anastomose with the right gastro-epiploic artery. Near the origin (2 mm), the splenic artery emits the **left gastric artery** (*A. gastrica sinistra*), which joins the bottom of the stomach, caudally crosses the cardiac orifice, and descends at a certain distance from the small curvature under the peritoneum of the visceral face of the stomach, which is distributed mainly. This artery emits only inconstant oesophageal branches that most often come from the right gastric artery. On the other hand, quite frequently (40% of cases) is double (Fig. 1, arrow 3), even triple (10% of cases), and one of these branches can come from the hepatic artery. The main branches of the splenic artery intended for the left lobe of the pancreas emerge from a relatively strong trunk, the pancreatic branch, which arises after the origins of the preceding collaterals.

The hepatic artery (*A. hepatica*) at its origin has a calibre similar to that of the splenic artery, with which it detaches at an acute angle. After a trajectory of about 2 cm, it emits the common trunk of the right lateral branch and the right medial branch. After 1-2 mm of it, the hepatic artery emits a fine branch for the caudate lobe. This sometimes has (20% of cases) its origin in the right lateral branch. The common trunk of the right lateral and medial branches, after a trajectory of about 1 cm, ends through the two branches at a sharp angle.

The right lateral branch (*R. dexter lateralis*) descends on the caudal face of the liver towards the upper extremity of the right hepatic notch (between the right lobe and the right intermediate lobe), the level where it ends at a sharp angle, through a branch that penetrates the right lateral lobe and a thinner branch that approaches the right lateral caudo-lateral face of the right intermediate lobe (Fig. 2, arrow 2).

The right medial branch (*R. dexter medialis*) descends to the right of the hepatic hilum, to the left of

the right lateral branch, and to the upper extremity of the right intermediate lobe. It is longer and slightly more voluminous than the right lateral branch. Before entering the parenchyma of the right intermediate lobe, on the right side of the cystic duct, this branch emits a cystic artery (*A. cystica*), which runs to the origin of this duct (Fig. 2, arrow 3).

The gastro-duodenal artery (*A. gastroduodenalis*) originates at the same level as the common trunk of the lateral and medial hepatic branches. It is directed towards the right end of the stomach and terminates through the right gastroepiploic artery and the cranial pancreatic-duodenal artery (as seen in Fig. 2, arrow 4). Just before its terminal bifurcation, a small branch measuring about 2 cm in length emerges, which reaches the lesser curvature of the pyloric antrum near the pylorus opening.

The right gastroepiploic artery (*A. gastroepiploica dextra*) emits 3-4 fine, slightly flexuous branches, which irrigate the right extremity of the greater curvature of the stomach, after which it engages in the thickness of the greater omentum, which is in intimate contact with the great curvature of the stomach.

The cranial pancreatic-duodenal artery (*A. pancreaticoduodenalis cranialis*) engages with the small curvature of the duodenum and anastomoses with the caudal pancreatic-duodenal artery, the indirect branch of the first jejunal artery. The hepatic artery gives rise to the **artery of the quadrate lobe**, located about 0.5 cm left of the gastroduodenal artery. Near its origin, a small gastric branch, approximately 3 cm in length, approaches the dorsal edge of the pyloric antrum (Fig. 2, arrow 15). The artery of the quadrate lobe descends behind the hepatic hilum. It enters the quadrate lobe through two main branches issued successively at a distance of about 0.5 cm. A cystic branch is also detached, which approaches the cystic canal from the left side (Fig. 2, arrow 11). About 1 cm to the left of the artery of the quadrate lobe, the hepatic artery emits a relatively fine branch, which distributes the parenchyma, ventral by the hepatic hilum. Approximately at the same level, but in the opposite direction, from the hepatic artery, a branch is detached that is oriented towards the lesser curvature of the stomach, which it approaches at the origin of the pyloric antrum (Fig. 2, arrow 15'). After emitting this fine

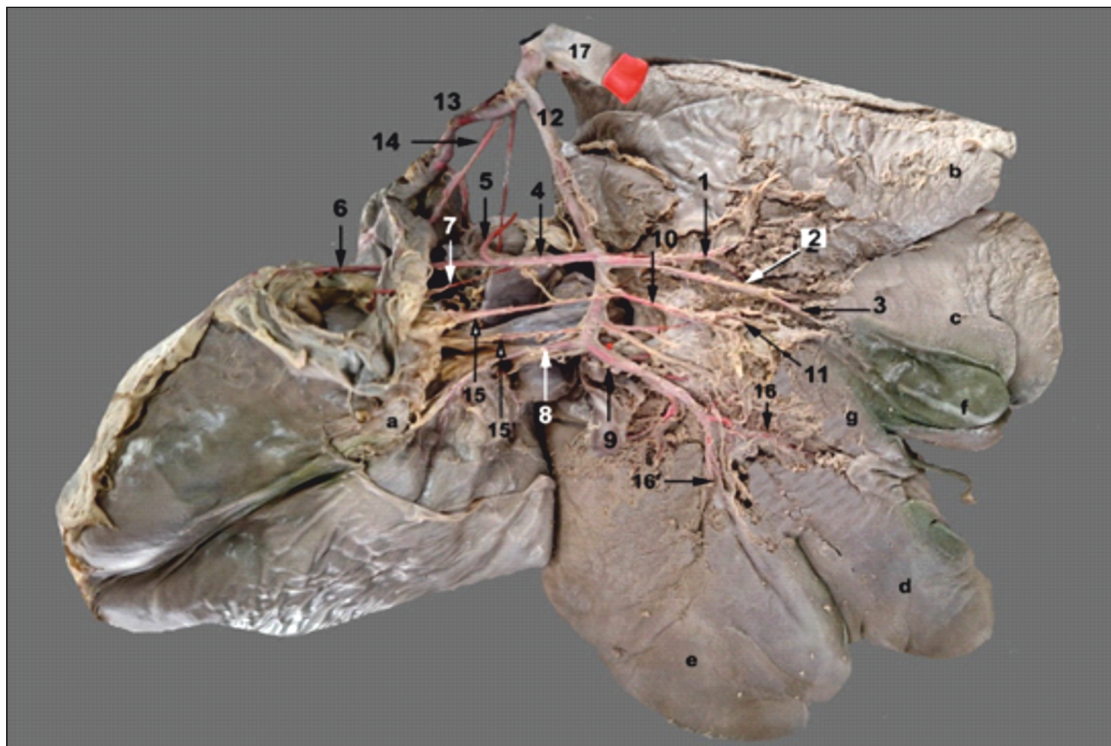


Fig. 2. Distribution of the hepatic artery in swine. 1-the right side branch; 2- the middle right branch; 3-the cystic artery; 4-the gastro-duodenal artery; 5-the cranial pancreatic-duodenal artery; 6-the right gastro-epiploic artery; 7-the gastric branch destined for the pyloric antrum; 8-the right gastric artery; 9-the left branch of the hepatic artery; 10-the quadrate lobe artery; 11-the cystic branch from 10; 12-the hepatic artery; 13-the splenic artery; 14- the left gastric arteries; 15, 15'- branches detached from the collateral of the hepatic artery intended for the pyloric antrum; 16, 16'-terminal branches, lateral left and intermediate left, of the hepatic artery; 17-segment of the aorta; a-small curvature of the stomach; b-the right hepatic lobe; c-the intermediate right lobe; d-the intermediate left lobe; e-the left side lobe; f-the gallbladder; g-the quadrate lobe.

branch, the hepatic artery emits a strong right gastric artery and ends up through the left branch, its true continuation (Fig. 3, arrow 9).

The right gastric artery (*A. gastric dextra*) is located within the lesser omentum and is directed towards the lesser curvature of the stomach. It originates about 1 cm from the stomach and gives off a retrograde oesophageal branch that travels to the gastro-oesophageal junction. From there, it accompanies the oesophagus in a retrograde direction to join the oesophageal branch of the bronchial-oesophageal artery. Upon reaching the level of the lesser curvature of the stomach, the right gastric artery branches out into a fan shape, ending in 5-6 branches, which are mainly distributed to the parietal face of the stomach near the lesser curvature. One of these branches is better represented and penetrates halfway through the stomach wall at its lesser curvature.

The left branch (*Ramus sinister*) is longer and more voluminous than the right branch. It goes behind the liver and reaches the area on the right side of the oesophageal notch. At a distance of 0.5 cm from its origin, it sends out two branches that go into the liver tissue on the ventral side of the hilum area. Then, it

sends out another branch that goes towards the dorsal lateral direction and is distributed in the upper third of the left lobe. Around 1 cm away from the incision between the left lobes and the left middle, the hepatic artery divides into two branches of approximately equal size and ends at a sharp angle (Fig. 3, arrow 16, 16').

The medial branch of the bifurcation mentioned appears as a true **medial left branch** (*Ramus sinister mediales*) and enters the parenchyma of the left intermediate lobe from its visceral face. The left branch of the bifurcation is actually the **left lateral branch** (*Ramus sinister laterales*), which is the true continuation of the hepatic artery in the left lobe of the liver. It has a trajectory from the thickness of the left lobe of the liver near its medial edge to the near ventral edge of the organ. In its downward trajectory, this branch emits a variable number of collaterals (2, arrow 4), which have a lateral-ventral oblique trajectory in the thickness of the left lobe of the liver.

The cranial mesenteric artery (*A. mesenterica cranialis*) detaches from the abdominal aorta caudal to the celiac trunk. It has a calibre of about 3 mm at its origin, and after a trajectory of about 1 cm, it emits frequently [70% of a **caudal pancreatic-duodenal**



Fig. 3. The branches of cranial mesenteric artery in pigs. 1 - the cranial mesenteric artery; 2 - the jejunal arteries; 3 - the ileocolic artery; 4 - the cecal artery; 5 - the colic branch; 6 - the right colic artery; a - the terminal portion of the jejunum; b - jejunum; c - cecum; d - eccentric shifts of the ascending colon; e - descending colon; f - the tip of the helicoidal anse

artery (*A. pancreaticoduodenalis caudalis*)], which runs to the lesser curvature of the duodenum. At this level, it bifurcates into a cranial, indirect branch, which follows the lesser curvature of the duodenum, in a retrograde sense, to anastomose with the cranial pancreaticoduodenal artery (the direct branch of the gastroduodenal artery), and a direct branch that anastomoses with the indirect branch of the first jejunal artery (this represents the proper caudal pancreaticoduodenal artery). Although well represented, in 30% of cases, this first collateral of the cranial mesenteric artery may be missing, and an indirect branch of the jejunal artery realizes the anastomosis with the cranial pancreaticoduodenal artery.

At about 2 cm from the origin, the cranial mesenteric artery emits the first of the **jejunal arteries** (*A. jejunales*). It descends into the thickness of the greater mesentery on a caudo-ventral trajectory at a distance of the lesser curvature of the jejunum and anastomoses with the indirect branch of the second jejunal artery. After the first jejunal artery is 1 cm from it, the cranial mesenteric artery will give the second jejunal artery, the third jejunal artery, and the common trunk of the third jejunal artery and ileocolic artery. The second jejunal artery is much more voluminous than the first one (it has an almost double diameter). It descends into the thickness of the large mesentery to the jejunum and emits the indirect branch at about 2 cm of origin. This is directed in reverse to the intestinal transit and anastomoses terminal with the first jejunal artery. This results in a primary jejunal arch, located about 2 cm from the lesser curvature of the jejunum, from which a variable number of branches (16-18) are detached, with different calibres and lengths. These branches, after a very short trajectory (3-4 mm), anastomose each other, forming a secondary jejunal arch. From this arch, there are many fine collaterals (40-50 branches), which descend through the greater mesentery to the lesser curvature of the jejunum.

After the indirect branch is issued, the second jejunal artery is directed as the intestinal transit in the thickness of the great mesentery and anastomoses with the indirect branch of the third jejunal artery, resulting in a second primary jejunal arch, which is wider and more voluminous than the first jejunal arch. From the greater curvature of this arcade are detached multiple jejunal branches (40-45), which, after a short but variable path (1-4 mm), will anastomose again through finer direct and indirect divisions, resulting in a secondary jejunal arch. This has a similar configuration to the one described above.

The third jejunal artery, after 1-1.5 cm, it ends with two uneven branches, the direct branch being longer and more voluminous. The indirect branch anastomoses terminate with the direct branch from the second jejunal artery, resulting in the primary and secondary

jejunal arches that are configured similarly to those described above. The direct branch emits numerous collaterals, which detach from both the ventral edge and its dorsal edge. Dorsal collaterals are rarer but longer than ventral collaterals. These collaterals will give through the anastomosis of their direct and indirect branches the secondary jejunal arch, from which are detached numerous fine and very frequent jejunal branches, which approach the small curvature of the jejunum. The first dorsal collateral, emitted by the direct branch, is detached approximately at the junction of the jejunum with the ileum. The indirect branch of this collateral is oriented towards the small curvature of the ileum, where it anastomoses with the ileonic branch of the ileocolic artery.

The ileocolic artery (*A. ileocolica*), after separating at an angle with the third jejunal artery, engages in the thickness of the greater mesentery, orienting itself towards the base of the cecum. After a trajectory of about 2 cm, it ends with a mesenteric ileonic branch, a cecal artery, and a colic branch. The most numerous collaterals of the ileo-colic artery approach the intestinal wall in the ileo-ceco-colic junction area.

The colic branch (*Ramus colicus*) of the ileocolic artery appears as a genuine direct branch of it. It descends near the lesser curvature of the helicoidal colon, together and within close distance of the right colic artery, with which it anastomoses at the level of the central curvature of the ascending colon (at the limit of the last concentric coils with the first eccentric shift). Frequently (70% of cases), the colic branch of the ileocolic artery appears double, in the form of two parallel, close, and approximately equally calibrated arteries. Finally, the two branches converge terminally after an independent trajectory of 6-7 cm. By their length, both branches emit collateral, being more numerous those with origin in the branch located closer to the lesser curvature of the colon. Each collateral ends in a direct branch and indirect branch from which anastomosis with neighbouring branches results in an arterial arch from which numerous fine colic branches will be detached, addressing the lesser curvature of the concentric coils of the helicoidal colon.

The right colic artery (*A. colica dextra*) emerges from the cranial mesenteric artery at about 2 cm of its origin, in the opposite direction to the first jejunal artery. Frequently, it breaks off into the common trunk with the **middle colic artery** (*A. colica media*), from which it separates after a short (0.5 cm) trajectory. Subsequently, the right colic artery descends into the thickness of the ascending colon, to its central flexure, where it anastomoses with the colic branch of the ileocolic artery. On its trajectory, it emits numerous colic branches, which approach the lesser curvature of the eccentric coils of the helicoidal colon. It should be noted that these colic branches are much shorter than

the colic branches given by the ileocolic artery for the concentric coils of the ascending colon. The middle colic artery is oriented towards the lesser curvature of the transverse colon, where it bifurcates.

The indirect branch of the bifurcation becomes anatomized with the right colic artery, and the direct branch anastomoses with the left colic artery (an indirect branch of the caudal mesenteric artery). It has a relationship through its cranial face with the transverse colon, and on the right side, with the body of the pancreas. It runs ventro-caudally and slightly to the left, then in the mesentery describes a curve surrounding the colic mass, ending near the ileum.

CONCLUSIONS

As for the celiac artery, it was noted that at this age the splenic and hepatic arteries had a relatively equal calibre, although in some works it is described that in adults the hepatic artery is net more voluminous. In correlation with the literature data, the left gastric artery showed morphological differences that were unique in 50 % of cases, represented by two vessels at 40 % and three at 10 %. The other branches of the splenic artery had intraspecific topographic constancy, complying with the norm „commune”. To the left of the origin of the gastro-duodenal artery, collateral of the hepatic artery, we have identified a branch that distributes to the square lobe, although in literature, including *Nomina Anatomica Veterinaria*, it is not described as a collateral of the hepatic artery. Also, two pyloric branches were identified, detached from the gastro-duodenal artery and the square lobe artery, which were not found in bibliographic sources. In the case of the cranial mesenteric artery, a series of inconsistencies with the data from the literature were identified, in terms of their number, calibre and origin, which is why we believe that additional investigations are necessary.

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