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STUDY REGARDING THE DISTRIBUTION OF THE CELIAC ARTERY IN NEWBORN CALVES

Sorina-Andreea MIHAI, Cristian BELU, Iulian DUMITRESCU, Bogdan GEORGESCU, Petronela- Mihaela ROȘU, Anca ȘEICARU, Gabriel PREDOI

University of Agronomic Sciences and Veterinary Medicine of Bucharest,
59 Marasti Blvd, District 1, Bucharest, Romania

Corresponding author email: mihai.sorinaa@yahoo.com

Abstract

Ruminants are characterized by the presence of four separate gastric compartments. The volumetric ratio between the proper stomach and the compartments preceding it is not the same throughout the life of the individual. At the early stage of a calf life, the proventriculus is reduced and is not involved in the digestive process. In the specialized literature, there are insufficient data on the distribution of vascular formations in early life and the following evolution of these structures. Our study aims to identify some characteristics of the branches of the celiac artery at an age when the only functional compartment is the abomasum. Following the dissection of the arteries, the classic distribution of some formations was found, but also specific elements: the poorly development of the reticular artery, the presence of a collateral from the left ruminal artery destined for the cardia and the presence of three hepatic branches. Surgery in young cattle requires a thorough knowledge of possible individual arterial variations.

Key words*: vascularization, celiac artery, calf, digestive system.*

INTRODUCTION

A well-functioning digestive system in ruminants has a significant impact on growth, but also on future production (i.e. meat and milk). In the first days of life, calves undergo major changes, both in terms of environment and nutrition (Diao et al., 2019). These stressors can lead to pathologies of the digestive tract, the treatment of which can often include surgery (Davis & Drackley, 1998).

Researches on the vascularization of gastric compartments in ruminants began as early as the 20th century, with authors such as Montané and Bourdelle (1917) and Martin and Schauder (1938) addressing this subject. To understand variations regarding the courses of certain arteries and their origin, is important for any surgery concerning the viscera from the abdominal cavity (Alsafy, 2009; Mohamed, 2020). If these surgeries regard the compartments of the stomach or the intestine (displacement of the abomasum, enterotomy and rumenotomy), a good knowledge of the vascularization of the organs prevents the occurrence of hemorrhages, helps to identify the sources when they occur especially following accidental trauma (loss of integrity of the abdominal cavity associated with external aggressions) and to perform timely suturing of the blood-vessel or blood-vessels involved (Mohamed, 2017).

MATERIALS AND METHODS

The study material consisted of 5 bovine carcasses, aged between 2 and 6 days. The animals used for the study came from breeding farms and were destined for dissection and research in the Comparative Anatomy Laboratory of the Faculty of Veterinary Medicine, Bucharest.

Immediately after slaughtering/exitus of the animals, a longitudinal incision in the linea alba was made between the xiphoid appendix and the pubis, followed by injection of a low-viscosity epoxy resin into the aortic artery. The injection was performed anterior to the celiomesenteric common trunk in a centrifugal direction (Figure 1). In this way, the contrast substance reached through the celiomesenteric trunk and into the branches of the celiac and cranial mesenteric arteries. Hardening of the bicomponent epoxy resin was achieved within 24 hours, during which time the gastrointestinal tract was refrigerated, the substance used solidified, in the arteries and in this way the blood-vessels became easy to trace and highlight. The arteries were then carefully dissected in order, before or after the conservation in formalin of the visceral tract thus prepared.

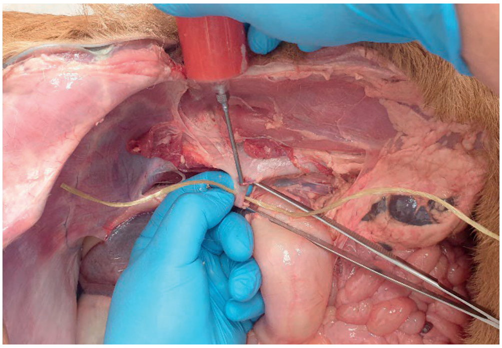

Figure 1. Injection of contrast substance immediately anterior to the celiacomesenteric trunk (original)

To study the morphology of the viscera in two specimens, they were carefully removed from the cavity and emptied of their contents. A moderate amount of polyurethane foam was introduced into each compartment so that the viscera would regain their approximate shape and volume, while avoiding excessive wall tension.

The description, identification and homologation of the formations presented was carried out according to the Veterinary Anatomical Nomination - 2017.

RESULTS AND DISCUSSIONS

In the first week of life, the digestive system of ruminants is not fully developed. The abomasum in the newborn calf is the only one of the four chambers actively involved in digestion, with nutrients coming from the milk. As the calf gets older, it begins to diversify its diet, consuming solid feed, and consequently the gastric compartments increase in volume, with the rumen becoming the most developed of them (Sisson & Grossman, 1969).

The figures below clearly demonstrate the abovementioned elements, showing the relationship between the forestomach and the proper stomach, the abomasum being the only functional compartment (Figures 2 and 3).

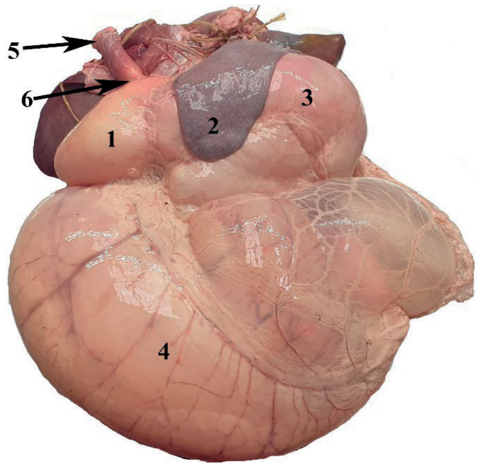

Figure 2. Gastric compartments in the ruminant - left side (original):
1 - reticulum; 2 - spleen; 3 - rumen; 4 - abomasum; 5 - oesophagus; 6 - cardiac orifice

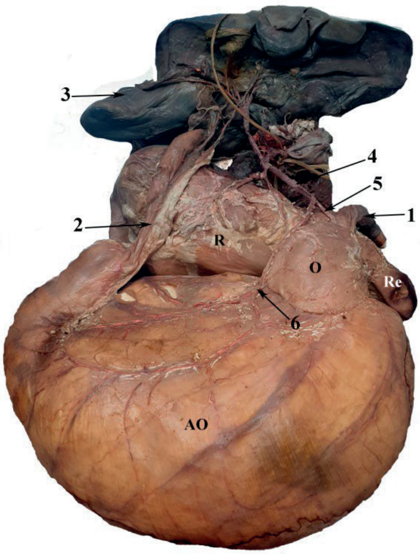

Figure 3. Gastric compartments in the ruminant - right side (original):
R - rumen; Re - network; O - omasum; AO - abomasum
1 - oesophagus; 2 - duodenum; 3 - liver; 4 - left gastric artery; 5 - left gastroepiploic artery; 6 - the place where left gastric artery divides into two branches

Following the measurement of the gastric compartments at moderate fullness, relative values were obtained and used to determine the proportion of each compartment. The values obtained are represented in the chart below (Figure 4).

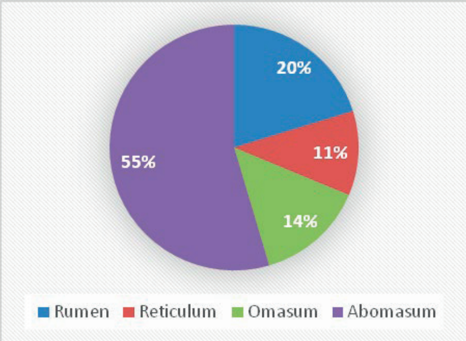

Figure 4. Ratio of gastric compartment proportions in the newborn calf

Other studies have shown similar values, Davis et al, 1998: rumen and reticulum - 38%, omasum - 13%, abomasum - 49%, and in the research by Heinrichs and Jones, 2003: rumen - 25%, reticulum - 5%, omasum - 10% and abomasum - 60%.

In the following are presented the results on the origin and distribution of the arteries of these compartments in the specimens analyzed. In all dissected cases the celiac artery split in common with the cranial mesenteric artery, thus forming celiacomesenteric trunk (Figure 5).

The splenic artery (*A. lienalis*) runs caudo-ventrally and to the left, with no notable characteristics, except that in all cases the left ruminal artery forms a common trunk with the lienal artery (Figure 5).

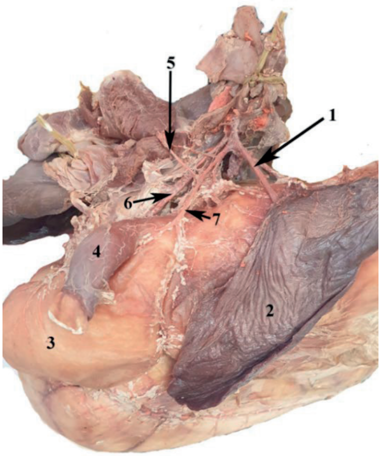

Figure 5. The origin of the main branches of the celiac artery - dorsal view (original):
1 - the splenic artery; 2 - the spleen; 3 - the reticulum; 4 - the abdominal part of the oesophagus; 5 - phrenic branches; 6 - the left gastric artery; 7 - the reticular artery

The left ruminal artery (*A. ruminalis sinistra*) emits at 0.5 cm from the origin a phrenic branch that approaches the diaphragm near the dorsal border of the liver. Immediately after this, the left ruminal artery emits the reticular artery. After the arising of the reticular artery, the left ruminal artery passes to the right of the ruminal atrium behind the cardiac orifice, with a ventro-cranial oblique course towards the cranial ruminal groove. At about 1 cm from the origin, it emits a relatively thin branch about 5 cm long and with a flexuous course that branches off to the right side at the cardia. After crossing the cranial ruminal groove from right to left, it will engage the left ruminal groove, level where it emits collaterals both to the upper margin and ventral branches for to the ventral sac of the rumen. The left ruminal artery is smaller than the right homologous artery and is distributed mainly to the first two thirds of the parietal surface of the rumen. In the left caudal third, the rumen is irrigated by terminal branches of the right ruminal artery, which cross the caudal groove of the rumen and follow the dorsal and ventral coronary grooves on the left side of this compartment.

The right ruminal artery (*A. ruminalis dextra*) didn't present any particular features compared to those found in the literature, being the main source of rumen irrigation.

The reticular artery (*A. reticularis*) intersects the medial surface of the right gastric artery and sends at 1 cm from its origin a phrenic branch which is distributed to the diaphragmatic pillars. Subsequently, the artery passes superior to the ruminal atrium, to the right of the cardiac orifice then continues to the superior margin of the reticulum, below the reticulo-omasic junction. Along its course it gives off a variable number of branches (8-10) of varying caliber, collaterals that are mostly directed towards the visceral side of the reticulum**.**

The left gastric artery arises in all cases at the the same level as the hepatic artery. This artery is the most developed branch of the celiac artery, distributing to the abomasum, which is the only functional gastric compartment in newborn ruminants. It passes to the right face of the omasum and continues its course towards the abomasum, specifically at the level of the lesser curvature. Being included in the structure of the lesser omentum after a trajectory of about 2 cm along the above-mentioned curvature, it doubles over a portion of the course of about 12-13 cm, before it anastomoses with the right homologous artery in the vicinity of the angular notch. The distance between the two collaterals of the left gastric artery is about 4 cm near the middle of the lesser curvature. No accessory reticular artery was present in any of the specimens in the study.

On the course, the left gastric artery gives off the left gastroepiploic artery (*A. gastroepiploica sinistra*), forming an acute angle between them.

After a 4 cm path**, the left gastroepiploic artery** emits 1-2 thin branches to the ruminal atrium. The next two collaterals distribute to the right side of the omasum. To the left are emitted the reticular branches which correspond to the accessory reticular artery that is present in small ruminants (Figure 6).

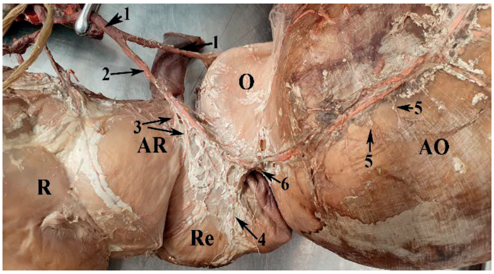

Figure 6. The distribution of the left gastroepiploic artery (original):
R - rumen; RA - ruminal atrium; Re - reticulum; O - omasum; AO - abomasum;
1 - left gastric artery; 2 - left gastroepiploic artery; 3 - branches for the ruminal atrium; 4- reticular branches; 5 - abomasal and epiploic branches; 6 - first branch destined for the *fundus* of the abomasum.

The hepatic artery (*Artera hepatica*) runs ventro-laterally and to the right. The hepatic artery has two terminals: the right branch and the left branch, in one specimen a middle branch is present.

The left branch (*Ramus sinister*) extends approximately horizontally to the deep surface of the left portion of the caudate lobe, where it emits two thin dorsally oriented branches that enter the parenchyma at the base of this lobe. When it emerges from under the caudate lobe, it is visible for about 1 cm, after which it enters deep into the left lobe. This branch usually gives off the right gastric artery.

The right branch (*Ramus dexter*) is poorly developed and has a smaller calibre. It follows a descending course on the surface of the portal vein and enters the hepatic parenchyma at its ventral edge, to the right side of the cystic duct (Figure 7)**.**

Figure 7. The terminals of the hepatic artery (original):
1 - hepatic artery; 2 - middle branch; 3 - left branch; 4 - right branch; 5 - gastro-duodenal artery; 6 - the right gastro-epiploic artery; 7 - the cranial pancreatico-duodenal artery; 8 - the cystic artery; 9 - the right gastric artery

The middle branch was present in 20% of cases studied. When it was present, the right gastric artery was a collateral of the middle branch. The middle branch had approximately the same diameter as the left branch and a descending path in the superficial plane to the portal vein. At the superior margin of the quadrate lobe, it makes a leftward bend after which it enters deep into the hepatic parenchyma. In its path it emits at its inferior margin 7-8 collaterals that progressively decrease in length and diameter and enter the parenchyma at the ventral margin of the portal vein.

The right gastric artery (*A. gastrica dextra*) generally has its origin in the left hepatic branch. A special case was encountered in the specimen presenting the middle branch of the hepatic artery, in this situation the right gastric artery is a first collateral of this branch (Figure 8).

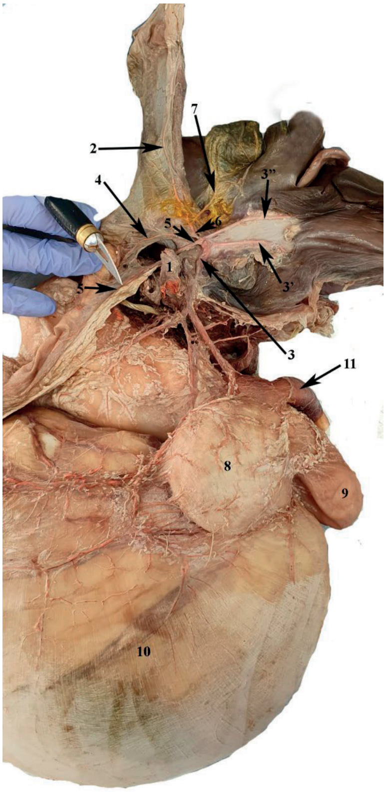

Figure 8. The gastric compartments and the origin of the main branches of the celiac artery - craniodorsal view: 1 - the celiac trunk; 2 - the cranial pancreatico-duodenal artery; 3 - the lienal artery; 3' - the middle branch of hepatic artery; 3" - the left branch of hepatic artery; 4 - the right gastroepiploic artery; 5 - the right gastric artery; 6 - gastro-duodenal artery; 7 - cystic artery; 8 - omasum; 9 - reticulum; 10 - abomasum

The gastroduodenal artery (*A. gastroduodenalis)* has about 1 cm and seems to be an extension of the hepatic artery, dividing at an acute angle into a cranial branch (representing the right gastroepiploic artery) and a caudal branch (representing the cranial pancreatoduodenal artery). **The right gastroepiploic artery** (*A. gastroepiploica dextra*) orients towards liver, level where it also emits pancreatic branches (towards the liver, towards the hilum), after which it crosses the great curvature of the duodenum in intimate relation to it. At about 4-5 cm from the pylorus, it emits a pyloric branch which ends in the area of this orifice, after which the gastro-epiploic artery is engaged in the thickness of the greater omentum at 2- 3 cm distance from the greater curvature of the cecum. The cranial pancreaticoduodenal artery has its course recorded in the literature. In contrast to the data in the literature which mentions the cystic artery as a collateral of the gastro-duodenal artery, we identified in one specimen a particularity, the origin of the artery being in the cranial pancreatico-duodenal artery. The cystic artery follows the cystic duct along the gallbladder wall, giving branches on the anterior side of the gallbladder wall (2 branches) and one on the posterior side.

CONCLUSIONS

Following dissection of the arteries previously injected with a low-viscosity epoxy resin, it was observed that in general the main trunks were distributed according to the common norm, but there were also specific elements, including: a poor development of the reticular artery associated with difficulty in the identification its oesophageal branches, the presence of a collateral branch from the left ruminal artery irrigating the right surface of the cardiac orifice, the presence in one calf of three hepatic branches, an aspect which is not reported in the literature.

A particular case was the origin of the cystic artery, which in 20% of specimens originated from the cranial pancreaticoduodenal artery.

Finally, we can conclude that the research should be extended to a larger number of animals of different ages in order to certify the correlations between the development of the gastric compartments and the morphological particularities of the gastric arteries at different stages.

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