VIA MEDICA

ORIGINAL ARTICLE

Folia Morphol.
Vol. 80, No. 2, pp. 331–335
DOI: 10.5603/FM.a2020.0072

ISSN 0015–5659
eISSN 1644–3284
journals.viamedica.pl

Origin and main ramifications of coeliac artery in *Cerdocyon thous*

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[Received: 28 May 2020; Accepted: 3 July 2020]

Background: *Cerdocyon thous is the canid with the greatest geographical coverage in South America. The aim of this study was to describe the origin, skeletopy, length and main branches of the coeliac artery in C. thous.*

Materials and methods: *The dissections were performed on 14 cadavers of adult specimens, 6 males and 8 females, with a rostrosacral length average of 67.00 ± ± 4.7 cm and 62.09 ± 5.7 cm, respectively. The specimens were collected dead on highways on the banks of the Atlantic Forest (Rio de Janeiro) and the Pampa biome (Rio Grande do Sul) in Brazil. The cadavers were fixed and preserved in a formaldehyde solution until dissection. The coeliac artery was dissected, the length was measured "in situ" and its main branches were recorded. The coeliac artery emerged as a single artery in all dissected animals.*

Results: *The average length of the coeliac artery was 1.43 ± 0.17 cm in males and 1.39 mm ± 0.24 cm in females, with no significant difference in this measurement between sexes. The predominant skeletopy was at the level of the second lumbar vertebra (57.1%), positioned on average 1.43 cm cranially to the cranial mesenteric artery. In most individuals (92.9%), the classic trifurcation was formed: the coeliac artery branched into the hepatic, left gastric, and lienal arteries. Only 1 male animal presented a bifurcation formed between the hepatic artery and a gastrolienal trunk.*

Conclusions: *These anatomical characteristics are similar to those of other species of the Canidae family, possibly due to their phylogenetic proximity.* (Folia Morphol 2021; 80, 2: 331–335)

Key words: animal anatomy, cardiovascular system, crab-eating-fox, wild carnivorans

INTRODUCTION

Cerdocyon thous (*C. thous*), known as "crab-eating-fox", is the most widely distributed wild canid on the South American continent, populating Colombia to Uruguay. With great adaptability, it inhabits closed and open vegetation areas [8, 9, 18, 19]. Body mass ranges from 5 to 9 kg and can measure up to 1.2 m from the tip of the snout to the tail [19]. The diet is based on fruits, small vertebrates, eggs, insects, and crustaceans, characterising an opportunistic omnivorous diet [9, 18]. *Cerdocyon thous* is threatened by hunting, hit-and-run, and diseases transmitted by

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Canis familiaris (*C. familiaris*), although its conservation is not a concern [9, 18, 19].

The high occurrence of free-ranging *C. thous* and its high frequency in zoos and private collections makes it frequently subject to veterinary care [8, 32].

The coeliac artery (CA) is one of the most important arteries in the abdominal part of aorta; it is a short vessel that emerges ventrally from the abdominal aorta, at the level of the aortic hiatus of the diaphragm muscle [20]. Close to its origin, this vessel is surrounded by the coeliac plexus and ganglia. On the left, the CA forms a syntopic relationship with the stomach; on the right, with the liver and adrenal gland, and caudally with the left lobe of the pancreas [17, 20]. The CA emits the hepatic, left gastric and lienal arteries [17].

In mixed-breed *C. familiaris*, the CA presents two morphological arrangements distinct from branches: classical trifurcation (formed by the hepatic artery, left gastric, and lineal), and hepatic artery and gastrolienal trunk [1]. Anatomy knowledge and possible variations in branches of the main splanchnic vessels is fundamental for planning surgeries and supports comparative studies on vascular arrangement in different species.

The aim of this study was to describe the origin, skeletopy, and main branches of the CA in *Cerdocyon thous*.

MATERIALS AND METHODS

Adult specimens of *C. thous* were collected dead on highways of the Atlantic Forest biome (State of Rio de Janeiro, Brazil) and in the Pampa biome (Rio Grande do Sul, Brazil) under authorisation of the Ethics Committee on Animal Experimentation (protocol 018/2017) and IBAMA/SISBIO (number 33667). Since most of the cadavers collected on highways had abdominal vessels and viscera ruptured, only specimens in perfect condition were selected for the dissection of the CA and its main branches. Thus, 14 cadavers (6 males and 8 females), 7 from each biome, were dissected.

Initially, the cadavers were thawed under running water, sexed, and identified by placing a plastic tag attached to the common calcaneal tendon using a string. The rostrum-sacral length of each animal was measured using a precision metal measuring tape. The tip of the snout was used as a reference for the proximal insertion of the tail. The cadavers were placed in right lateral decubitus position to access the thoracic aorta through an incision made between the 6th and 10th left intercostal spaces. The artery was cannulated with a number 8 or 10 urethral probe, depending on the diameter of the vessel, and was attached with a string to prevent leakage and maintain intravascular pressure. Fixation was performed by injecting a 10% formaldehyde solution through the probe in a caudal direction.

Immediately following the fixation of the cadavers, petrolatex S65 (Petrobrás Duque de Caxias Refinery [RE-DUC], Duque de Caxias/RJ) solution was injected and stained with Suvinil pigment for repletion of the arterial system. Then, the cadavers were immersed in polyethylene boxes containing 10% formaldehyde solution for to complete the latex fixation and polymerisation process.

Seven days after the latex injection, the cadavers were dissected in order to determine the origin, skeletopy, and main branches of the CA. After skin removal, two incisions were made in the abdominal wall: the first in the linea alba, starting from the xiphoid cartilage to the pubic region; the second transversely at the level of the last rib in both antimers, starting from the transverse process of the first lumbar vertebra to the linea alba. The cranial coeliac and mesenteric arteries were dissected after locating the abdominal aorta.

A digital calliper (ZAAS Precision, Amatools®) was used to measure the distance between the centres of the origins of the coeliac and cranial mesenteric arteries and the CA length until it originated its first branch.

The mean and standard deviation of the animals' rostrosacral length, CA length, and the distance between CA and cranial mesenteric artery were calculated. These values were compared for both sexes and considered significant when $p < 0.05$ using the unpaired "t" test. The data were analysed using the Graphapad Prism 5® Software.

RESULTS

The rostrum-sacral and CA lenght averages were higher in males (Table 1), while the distance between the coeliac and cranial mesenteric arteries was higher in females, although there was no significant difference in any comparison between sexes ($p > 0.05$).

In all dissected specimens, the CA originated ventrally from the abdominal aorta. The predominant skeletopy of the CA in *C. thous* occurred at the level of the second lumbar vertebra (Table 2).

Table 1. Mean and standard deviation (cm) of the rostrum-sacral length, length of the coeliac artery (CA) and the distance between the coeliac and cranial mesenteric arteries in *Cerdocyon thous*. The p value corresponds to that obtained in the unpaired t-test of comparison of means between sexes

	***Cerdocyon thous* (n = 14)**		
	Males (n = 6)	**Females (n = 8)**	**P**
Rostrum-sacral length	67.0 ± 4.79	62.09 ± 5.78	0.11
CA length	1.43 ± 0.17	1.39 ± 0.24	0.78
Distance between CA and cranial mesenteric artery	1.48 ± 0.20	1.60 ± 0.26	0.36

Table 2. Absolute and percentage frequencies of the skeletopy of the coeliac artery in *Cerdocyon thous*

Skeletopy	Males (n = 06)	Females (n = 08)	Total (n = 14)
L1	2 (33.3%)	–	2 (14.3%)
L1–L2	1 (16.7%)	3 (37.5%)	4 (28.6%)
L2	3 (50.0%)	5 (62.5%)	8 (57.1%)

Although the CA in *C. thous* presented a variable skeletopy between the individuals, there was no statistical difference between sexes (p = 0.05).

In 13 specimens, the classic trifurcation was formed: the CA originated the hepatic, left gastric and lienal arteries (Fig. 1). Only 1 male animal presented a bifurcation formed between the hepatic artery and a gastrolienal trunk (Fig. 2).

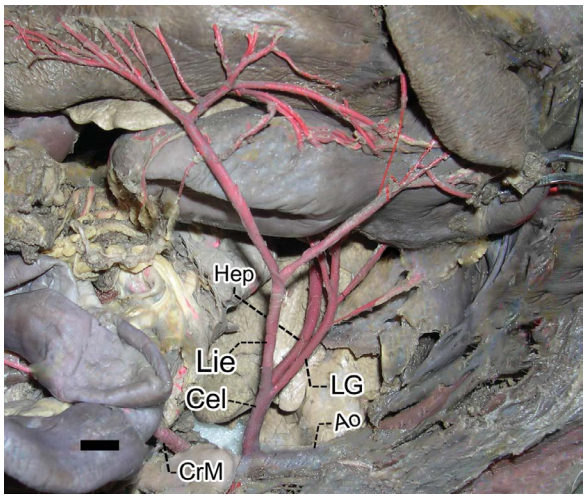

Figure 1. The aorta (Ao), cranial mesenteric (CrM) artery and coeliac artery (Cel) and its main branches (classic trifurcation): hepatic (Hep), left gastric (LG) and lienal (Lie) arteries in a female, adult, specimen of *Cerdocyon thous*. Scale bar: 10 mm.

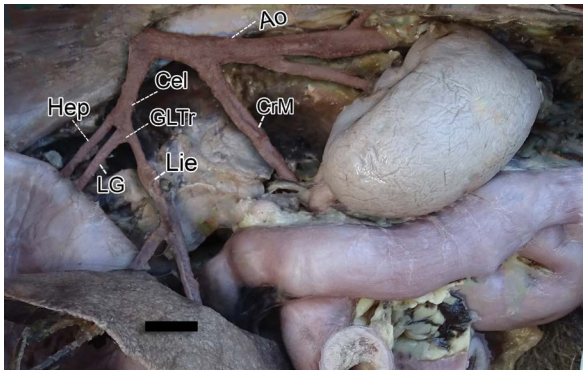

Figure 2. The aorta (Ao), cranial mesenteric (CrM) artery and coeliac artery (Cel) and its main branches. In this specimen, an adult male *Cerdocyon thous*, coeliac artery originated a gastrolienal trunk (GLTr) and a hepatic artery (Hep); the gastrolienal trunk bifurcated into lienal (Lie) and left gastric (LG) arteries. Scale bar: 10 mm.

DISCUSSION

Origin

The CA emerged ventrally from the abdominal aorta, close to the aortic hiatus of the diaphragm, similar to what is described in different mammals [1–3, 10, 22, 23, 27, 33]. However, in *Bubalus bubalis* foetuses [24] and in 33% of *Lycalopex gymnocercus* specimens [22], the origin of the CA occurred in the thoracic aorta. Despite phylogenetic proximity to *Lycalopex gymnocercus*, no coeliac arteries originating in the thoracic aorta were found in the sampling of *C. thous* from the present study.

Some studies have noted variations in the emergence of the CA in some species of mammals and mention the presence of a common trunk formed by the coeliac and cranial mesenteric arteries called the coeliac-mesenteric trunk. It was reported with *Ovis aries* [21], *Bubalus bubalis* [24], *Capra aegagrus hircus* [13], *Myocastor coypus* [23], *C. familiaris* [30], *Felis catus* [29], *Didelphis albiventris* [11], and humans [15]. In humans, another arrangement has been described: the formation of the coeliac-bimesenteric trunk, formed by the coeliac, superior mesenteric, and inferior mesenteric arteries [7, 26].

Regarding the incidence in mammals, the coeliac--mesenteric trunk was divided into three groups: a group with a regular or preponderant incidence, observed in *Cavia porcellus*; a group with frequent incidence, observed in *Ovis aries*; and a group with a low or zero incidence observed in *Castor fibre*, *Erinaceus europaeus*, *Mesocricetus auratus*, and *Mus musculus* [31]. In canids, the occurrence of coeliac-mesenteric trunk is described only in *C. familiaris* [30], not being found in *L. gymnocercus* [22] or *C. thous*.

Table 3. Summarisation of common skeletopy, average length and primary branches of coeliac artery in species of the order Carnivora

Species	Family	N	Common skeletopy	Length	Branches
C. thous	Canidae	14	L2	1.41 cm	Hepatic, left gastric and lienal arteries
L. gymnocercus [22]	Canidae	15	L2	–	Hepatic, left gastric and lienal arteries
V. vulpes [12]	Canidae	06	L1	–	Gastrolienal trunk and hepatic artery
C. familiaris [1]	Canidae	30	L1	0.98 cm	Gastrolienal trunk and hepatic artery or hepatic, left gastric and lienal arteries
M. martes [34]	Mustelidae	01	-	–	Gastrolienal trunk and hepatic artery
M. p. furo [13]	Mustelidae	–	–	–	Hepatic, left gastric and lienal arteries
N. nasua [5]	Procyonidae	04	L1	–	Hepatic, left gastric and lienal arteries
F. catus [33]	Felidae	30	L1	1.30 cm	Gastrolienal trunk and hepatic artery or hepatic, left gastric and lienal arteries
L. pardalis [28]	Felidae	02	–	–	Hepatic, left gastric and lienal arteries

Skeletopy

In domestic carnivores, the coeliac artery has a predominant origin at the level of the first lumbar vertebra (Table 3) [1, 29, 33], although origin points as cranial as the 13th thoracic vertebra or as caudal as the 2nd lumbar vertebra are often described [1, 25, 33]. In the wild canid *L. gymnocercus,* the predominant skeletopy of the CA was at the level of the 2nd lumbar vertebra, varying cranially to the 1st lumbar [22], similar to the results obtained in the sampling of *C. thous* in this research. In other carnivores, including *C. familiaris* and *Felis catus* as well as wild canids *Vulpes vulpes* and procyonid *Nasua nasua*, the skeletopy was at the level of the first lumbar [1, 5, 12, 33].

Getty et al. [17] reported that the CA appears at the level of the 17th and 18th thoracic vertebra in *Equus ferus caballus*, at the level of the 1st lumbar vertebra in *Bos taurus* and *Ovis aries*, between the 1st and 2nd lumbar vertebra in goat [16], and between the last thoracic vertebra and the 1st lumbar vertebra in *Sus domesticus*. In *Oryctolagus cuniculus*, the coeliac artery's level predominates between the 13th thoracic vertebra and the 1st lumbar [2], ventrally to the 1st lumbar vertebra in *Cavia porcellus* [17], and the coeliac trunk appears at the level of the 12th thoracic vertebra in humans [26].

Reports of CA length measurements are still scarce. In the *C. familiaris* it measures around 2 cm [14], 1.3 cm in *Felis catus* [33], and about 1.4 cm in *C. thous*. Regarding the distance between the origins of the coeliac and cranial mesenteric arteries, it was described as 3 mm in *Bubalus bubalis* foetuses, ranging from 1.8 to 5 mm [24]. In humans, it was 12 mm, ranging from 3 to 23 mm [4]. The mean value found in *Lycalopex gymnocercus* was 6.66 mm, had a moderate correlation with the animal's length [22], and was smaller than in the *C. thous* specimens analysed.

Main branches

The classic trifurcation of the CA into hepatic, left gastric and lienal arteries was the most prevalent arrangement in *C. thous*, similar to that registered in *C. familiaris*, *Oryctolagus cuniculus*, *Myocastor coypus*, and *Galea spixii* [1, 2, 10, 27]. The bifurcation in a hepatic artery and gastrolienal trunk found in a single specimen of *C. thous* of this sampling was also reported as sporadic in *C. familiaris* [1, 14]. However, this bifurcation was found in almost half of *Felis catus* [33]. In *Oryctolagus cuniculus*, unlike in other species, the CA emitted only one arrangement: the lienal artery and then the left gastric artery, which continued to be hepatic [2]. In *Hystrix cristata* and *Dildelphis albiventris*, the CA was divided into only two branches: the lienal artery and the hepatic artery in all animals studied [6, 11].

CONCLUSIONS

It can be concluded that the CA in *C. thous* originates as a single artery in the ventral face of the abdominal aorta, predominantly at the level of the second lumbar vertebra, about 1.5 cm from the cranial mesenteric artery, cranially. The artery measures about 1.4 cm until the predominant classic trifurcation occurs, although a bifurcation variant can be verified. These anatomical characteristics are similar to those described in other canids, possibly as an expression of the evolutionary proximity of these species.

Funding

Research Support Foundation of Rio Grande do Sul (FAPERGS), National Council of Technological and Scientific Development (CNPq), Rio de Janeiro State Research Foundation (FAPERJ) and Coordination of Superior Level Staff Improvement (CAPES) Finance Code 001.

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