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Original Research Article

Macroanatomic investigations on the course and distribution of the celiac artery in Hooded crow (*Corvus cornix*) with special reference to the arterial supply of the stomach

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ABSTRACT

The aim of this study was to investigate the course and distribution of the celiac artery in Hooded crows and to extend our knowledge on the captured crows. Scarce information in the field of veterinary comparative anatomy and the available literature on the celiac artery and its distribution is provided. So, the present study tried to declare the confusion about the course and distribution of the celiac artery in the Hooded crows. Therefore, 10 apparently healthy Hooded crows of different ages and sexes were captured. The birds were anaesthetized by IM injection of 0.5 cc of 2% xylazine HCL (3 mg/kg). Colored gum milk latex (60%) was then injected through the descending aorta. Then, specimens were subjected to fine dissection to demonstrate the origin, course and distribution of the celiac artery. The celiac artery erupted laterally from the right face of the descending aorta opposite to the distance between the 5th and 6th vertebral rib, on a level with the junction of the esophagus and the proventriculus. It proceeded ventrally and slight caudally, where it gave off the esophageal artery after, 5 cm from its origin, the dorsal proventricular artery, splinc arteries and at the middle of spleen then bifurcated into left and right branches. The left branch of the celiac artery gave rise to right hepatic artery, ventral proventricular artery, pyloric branches, ventral gastric artery and then continued as the A. gastrica sinistra. The right branch of the celiac artery released the caudal group of splenic arteries, A. gastrica dextra, then continued as A. pancreaticoduodenalis.

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1. Introduction

Much interest in avian structures and their functions has increased with the increasing importance of birds as food producers, as models in biological re-search, and as pets (McLelland, 1990).

Hooded crow are black birds known for their intelligence and adaptability and for their loud harsh caw, the genus *Corvus* comprises crows, ravens and rock family Corvidae feeds on a wide range of prey, particularly insects and moths as well as spiders, frogs, earthworms and fishes and is distributed worldwide. The importance of crow to the farmer has initiated an increasing interest to establish more accurate and specific anatomical facts about the arterial blood supply of the gastrointestinal tract of hooded crow.

The present study is, therefore, an attempt to provide some additional information on the celiac artery of captured crows. In addition to little attention in the field of veterinary anatomy, crows facilitate controlling environmental balance which helps in feeding of dead animals.

2. Materials and methods

Ten adult Hooded crows (*Corvus cornix*) (4 males and 6 females) were used in the study. Before exsanguinations, crows were anaesthetized by IM injection of 0.5 cc of 2% xylazine HCL (3 mg/kg), followed by the injection of heparin (Cal Heparin, 5000 I.U.) in the wing vein to prevent blood clotting. Each specimen was then exsanguinated through the common carotid artery and left to bleed for five minute. The breast muscles and sternum were carefully removed to expose the heart. Latex neoprene 60% colored with red Rottring ink (Tompsett and Wakelly, 1965) was injected into the descending aorta using a Nelaton catheter of size 8F to 10F (Ma Medical company). The specimens were then kept at 4°C for 24 h to ensure the freezing of latex and then preserved in 10% formalin, 4% phenol and 1% glycerin three days before dissection. The specimens were photographed using Olympus digital camera SP-600UZ 12 mega pixel. The nomenclature used in this study was that given by the Nomina Anatomica Avium (Baumel et al., 1993).

3. Results

A. celiaca

In all ten of the crow examined The celiac artery is the first visceral branch of the descending aorta (Fig. 1, 2, 3 and 4/2) originated from the right lateral side of the descending aorta (Fig.1, 2/1) on a level between the last 5th to 6th vertebral rib in the proximity of the very beginning of the proventriculus.It was ascertained that the crow had seventh pairs of ribs (costae). It extended caudoventrally between the spleen and proventriculus for about 2 cm and terminated on level middle of the spleen into two main branches left and right. The first branch given off by the celiac artery was the esophageal artery after, 5 cm from its origin and gave off dorsal proventricular artery then continuous along the medial border of spleen where it give off 3-4 branches to cranial pole of spleen then at level of middle of the spleen the celiac artery bifurcated into right and left branch.

A. esophagealis

The esophageal artery (Fig. 1,3/2a) was represented by a slender vessel arising from the celiac artery about .5 cm from its origin from the aorta (7specimens) or from the dorsal proventricular artery(3specimens). It proceeded cranially on the dorsal aspect of the thoracic esophagus giving fine twigs to that portion and, finally anastomosed with the esophageal branch of the esophagotracheobronchial artery.

A. proventricularis dorsalis

The dorsal proventricular artery (Fig. 1, 3, and 4/3) was given off from the left lateral wall of the celiac artery, just after origin of esophageal artery It extended caudally along the dorsal aspect of the proventriculus and terminated at the isthmus of the stomach. The first branch given off by the dorsal proventricular artery, that extended cranially, was the *ramus oesophagealis* (Fig. 3, 4/3a) This branch, which followed an anterior path, was distributed to the esophagus, while it was coursing on the proventriculus, it released 5– 10 collateral branches (Fig 1,3 and 4/3b) to the dorsal wall of the proventriculus, and to the isthmus gastric.

Aa. Lienales (Aa. splenicae)

The splenic arteries were represented by 6-8 vessels entering the splenic hilus. The cranial 3-4

branches (Fig. 1, 3, /4) were larger and arose from the celiac artery after the origin of dorsal proventrical; the four caudal branches are much smaller and originated about the caudal pole of the spleen from the right branch of celiac artery.

***Ramus sinister* arteriae celiacae**

The left branch of celiac artery (Fig. 1, 2, 3 and 4/5) is one of the two divergences of the celiac artery just after the detachment of the 3-4 cranial branches of splenic arteries.

Following its origin, this blood vessel extended cranioventrally, at the level of the junction of the proventriculus with the gaster. Along its course, the left branch of celiac artery was ascertained to send a right hepatic artery to the right lobe of the liver, and subsequently to pass to the left side of the median plane after running a transversal course behind the liver. This branch was demonstrated to send a left hepatic artery to the left lobe of the liver. Following the ramification of these branches, ventral proventricular artery, pyloric artery to third compartment of the stomach and the ventral gastric artery and finally left gastric artery were determined to spring from the left branch of the celiac artery.

Arteria hepatica dextra (right hepatic artery)

The right hepatic artery (Fig. 2 /10) was ascertained to emanate from the left branch of the celiac artery just its origin and to terminate in the right lobe of liver (lobus hepaticus dexter), it supplied the right lobe of the liver and gall bladder (*a. vesicae biliaris*). It also supplied the duodenojejunal flexure. In two of the crow examined, this blood vessel originated at the bifurcation of celiac artery into two terminal branches and in one case arose from the right branch of celiac artery.

Left hepatic artery (arteria hepatica sinistra)

This artery was determined to arise from the *ramus sinister* at the ventrolateral region of the gaster distal to the origin of the ventral proventricular artery, and to terminate in the left lobe of the liver (Fig. 2/14). In all the hooded crows examined, the left hepatic artery was observed to be smaller than the right hepatic artery.

R. pyloricus

The pyloric branch (Figs. 2 /11) arose from the left branch of the celiac artery opposite to the origin of ventral proventricular artery. In three specimens it was given from the left hepatic vessels before entering the left hepatic lobe. It rewinded to left surface of the ventriculus.

Proventricularis ventralis

The ventral proventricular artery (Fig. 2/12) detached from the left branch of the celiac artery at the distal third of the proventriculus. It took a short dorsal course to supply the wall of the proventriculus with 1-2 branches and then terminated into2-3 fine twigs, Rr. esophageales (Fig .2/12a) that supplied the terminal part of the ventral aspect of the thoracic esophagus.

Gastrica ventralis

The ventral gastric artery (Fig 2/13) originated from the ventral aspect of the left branch of the celiac artery, about 1 cm below the origin of the ventral proventricular artery. It gave off 1-2 branches to the cranioventral Crassus muscle. It then extended caudally along the ventral margin of the ventriculus giving collateral rami to that portion and anastomosed with those branches of right gastric arteries in the vicinity of the caudal sulcus of the ventriculus.

Rr. succi

The branches of the saccus cranialis (Fig. 3 /23) were represented by 1-2 branches that arose from the left branch of the celiac artery just below the left aspect of the isthmus gastris. It proceeded caudally for a short distance and ramified in the craniodorsal tenuis muscle as well as the Bulbus pyloricus, anastomosing with the right gastric artery.

A. gastrica sinistra

The left gastric artery (Fig 2/15) was the direct continuation of the left branch of the celiac artery beyond the detachment of the left hepatic artery. It passed in the groove between the Pars pylorica (third stomach) and ventriculus. The left gastric artery had a fan-like distribution as it terminated into 4-6 rami in the left ventral aspect of the Ventriculus to supply the gizzard. Along its course it gave of 2-3 collateral branches (to supply the ismuth &distal part of proventriculus.

R. dexter arteriae celiacae

The right branch of the celiac artery (Fig 1, 2, 3 and 4/6) was the larger of the two branches into which the celiac artery terminated and from points of size and direction it represented the direct continuation of the stem vessel after releasing the left branch on a level with the middle of the spleen. It proceeded for a mean distance of 2.0 mm along

the medial border of the spleen at right side of the proventriculus in a caudoventral direction to the junction of the gizzard with the duodenum. Prior to reaching the site of the indicated junction, the right branch of the celiac artery gave rise to fourth caudal group of splenic arteries (Fig.1, 3/7) On reaching the indicated junction,; the right branch of celiac artery was determined to split into its terminal branches which extended in different directions namely right gastric artery (Fig 1, 2, 3 and 4 /8) and pancreaticoduodenal artery (Fig. 1, 2, 3 and 4/9).

A. gastric dextra

The right gastric artery (Fig.1, 2, 3 and 4 /8) was represented by a short vessel about 0.5 cm. It was considered as one of the terminal branch of the right branch of the celiac artery at the level of the ascending part of duodenum. It was seen to divide just after its origin into two branches the right dorsal and right ventral gastric arteries.. However, in three of the specimens the short stem representing the right gastric artery was not formed and the latter two arteries were originated directly by the bifurcation of the right branch of the celiac artery.

A. dextra gastric dorsalies

The dorsal right gastric artery (Fig. 3, 4/19) extended caudodorsally, contributed 1-3 branches Rr sccui (Fig.3, 4/19a) to the craniodorsal tenuis muscle as well as 4-6 collateral branches (Fig. 3, 4/19b) to the caudodorsal part of gizzard.

A. dextra gastric ventralies

The ventral right gastric artery (Fig. 3, 4/20) giving off gastro duodenal artery about 5mm from its origin to initial part of descending duodenal, extended along the ventrocaudal surface of the gizzard. Along its course it gave off 3-5 collateral ramis (Fig.3,4/20b) to cranioventral crassus and caudoventral tenis muscles and it anastomosed with the corresponding branch of the left gastric artery.

A. gastroduodenalis

The gastroduodenal artery (Figs. 3, 4/21) was a short vessel, originated from the left wall of the ventral right gastric artery of the A. gastric dextra. It was ramified in the pyloric region and the initial portion of the duodenum descendens, in two examined cases detached from the right branch of the celiac artery left to the origin of the right gastric artery.

A. pancreaticodudenalis

The pancreaticoduodenal artery (Fig. 3, 4/9) was the direct continuation of the right branch of the celiac after the right gastric. It passed along the mesodudenum between the descending and ascending limbs of the duodenum where it supplied a series of branches to the pancreas (Fig.3/17) and duodenal loop. It also gave off A. duodenojejunalis and the jejunal artery.

A. duodenojejunalis

The duodenojejunal artery (Fig4/18) detached from the pancreaticoduodenal artery in eight cases of Hooded crow to supply the duodenojejunal flexure and in two cases arose from the right hepatic artery and gave additional branch to gall bladder.

A. jejunal

The jejunal artery (Fig. 4/16) was detached from of the pancreaticoduodenal artery. It proceeded dorsally for a short distance, and then ended by anastomosis with the similar branch of the cranial mesenteric artery.

Abbreviations in figures

I-V: Costae (numerical), A- Heart, B Proventriculus, C- Gizzard, D- Pars pylorica, E- Descending duodenum, H- Ascending duodenum, I- Pancreas, J- Jejunum, K- Esophagus., G- Gall bladder, N- Spleen, F1- Left Lobe of liver, F2- Right lobe of liver.

1- Aorta descenedens,
2- A.celiaca,
3-A. proventricularis dorsalis, 3a- Rr. esophageales of 3, 3b- Rr. collaterals of 3,
4- Aa. Lienales of 2,
5- Ramus sinster arteriae celicae,
6- Ramus dexter arteriae celicae,
7- Aa. Lienales of 6,
8- A. gastrica dextra,
9- A. pancreaticoduodenalis,
10- A. hepatica dextra,
11- R. pyloricus,
12- A. proventrcularis ventralis, 12a- Rr. esophageales of 12,
13- A. gastrica ventralis,
14- A. hepatica sinster,
15-A. gastrica sinster
16- A .jejunalis of 9,
17- Rr. Pancreatici of 9,
18- A.dunojujnalis of 9,
19- A. gastrica dextra dorsalis, 19a- Rr,Sccui of 19, 19b -Rr. collaterales of 19
20- A. gastrica dextra ventralis, 20a Rr. collaterales of 20
21-A. gastrodudenalis,

1

22 A.mesenterica cranialis, 23- Rr.Sccui of 5

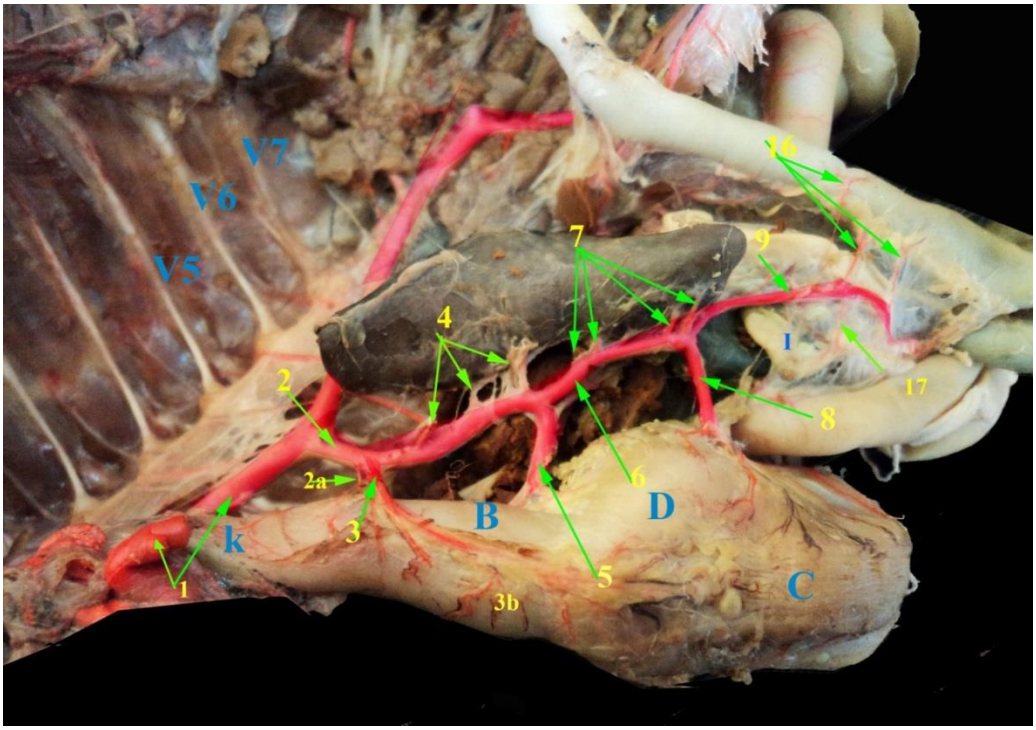

Fig. 1. A photograph showing branches of the celiac artery in Hooded crow. Right lateral view.

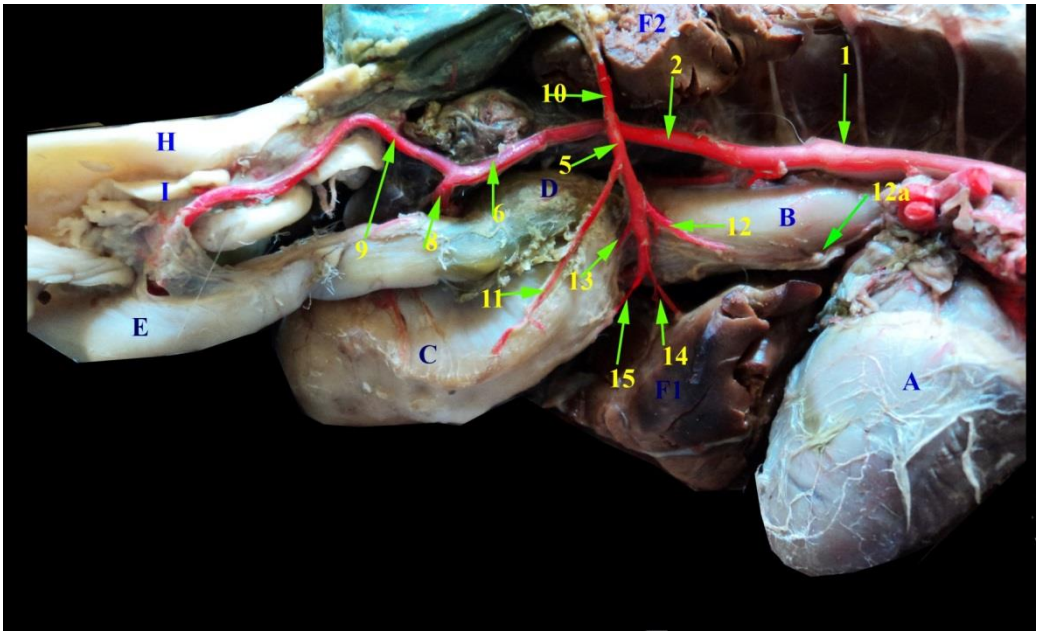

Fig. 2. A photograph showing branches of the left ramus of the celiac artery in Hooded crow. Left lateral view.

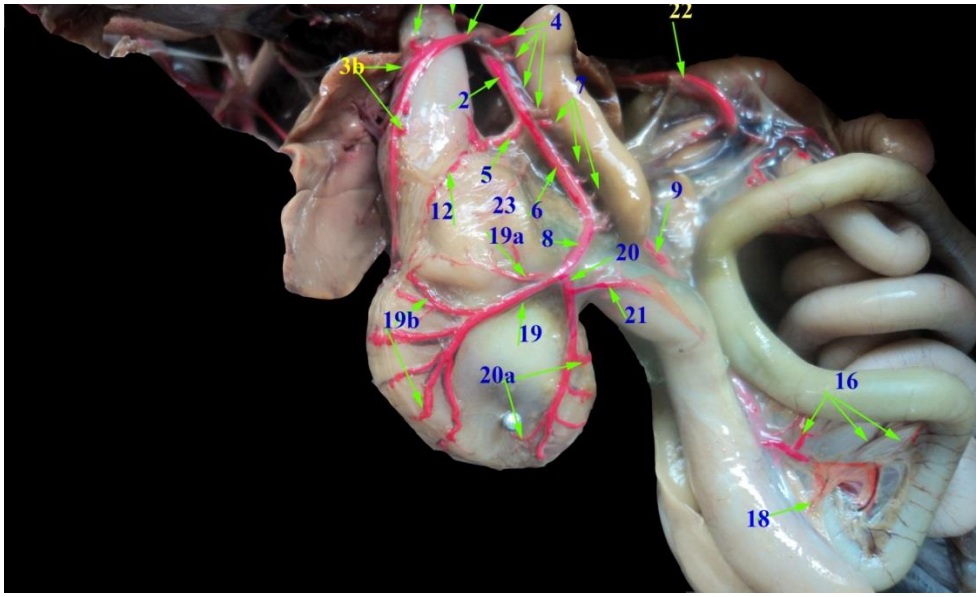

Fig. 3. A photograph showing branches of the right branch of celiac artery in Hooded crow. Right lateral view.

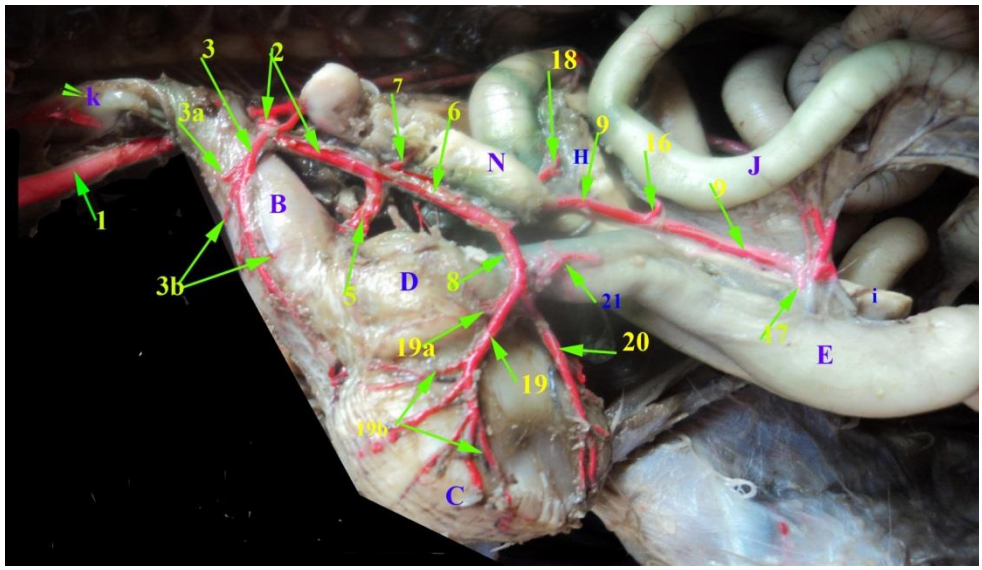

Fig. 4. A photograph showing branches of the right branch of the celiac artery in Hooded crow. Right lateral view.

Table 1. Summary for the main arteries supplying the stomach of Hooded crow.

Artery	Origin	Distribution
1-A. Proventricularis dorsalis	Celiac artery	-Dorsal aspect of the proventriculus. -Isthmus gastric. -Thoracic esophagus
2-A.Proventricularis ventralis	Left branch of the celiac artery	-Ventral aspect of the proventriculus. -Thoracic esophagus.
3-A.gastrica ventralis	Left branch of the celiac artery	Ventral aspect of the ventriculus.
4. R. pyloricus	Left branch of the celiac artery	Left surface of the ventriculus. Pylorus (third stomch)
5- Rr. Succi	Left branch of the celiac artery	Craniodorsal tenuis muscle as well as the Bulbus pyloricus
6-A. gastrica sinistra	Continuation of the left branch of the celiac artery	Distal part of proventriculus ismuth gastric Ventral aspect of the Ventriculus
7- A. dextra gastric dorsalies	Right gastric artery	Caudodorsal part of gizzard
8- Rr sccui	Dorsal right gastric artery	Craniodorsal tenuis muscle
9- A.dextra gastric ventralies	Right gastric artery	Cranioventral crassus and caudoventral tenis muscles
10-A. gastroduodenalis	Ventral right gastric artery	The pyloric initial portion of the duodenum

descendens

4. Discussion

The present study revealed that, the celiac artery in hooded crow is the first visceral branch of the descending aorta, supplied the proventriculus, ventriculus, liver, spleen, pancreas, duodenum and the initial part of jejunum. This was in agreement with Kuru (2010), Kurtul and Haziroglu (2002), Aslan and Takci (1998), Silva et al. (1997), Fowler (1991), King and McLelland (1984), Lauper et al. (1975) and Rezk and El-Bably (2013) in domestic fowls, Khalifa (2014) in cattle egret, Alan et al. (2015) in greater flamingo and Ragab et al. (2014) in geese. In geese, fowls, cattle egret, greater flamingo, the celiac artery sent a vessel to the left cecum and ileum, iliocecal artery, which could not observed in this study. In the Hooded crows, it was recorded as in domestic fowls (Baumel, 1975; Franz and Salomon, 1993; Silva et al., 1997; Dursun, 2002; Kurtul and Haziroglu, 2004; Kuru, 2010), rooster, ducks and pigeons (Kurtul, 2002; Kurtul and Haziroglu, 2002), domestic ducks (Malinovsky et al., 1973), geese (Ragab et al., 2014). The celiac artery arose from the right face of the descending aorta on a level with the last 5th to 6th vertebral rib at the junction of the esophagus with the proventriculus. In the present work, it was in the proximity of the beginning of the proventriculus. Haligur and Duzler (2010) reported that the celiac artery arose at the level of the 2-3 ribs and opposite to 3-4 vertebral rib in greater flamingo (Alan et al., 2015). On the other hand, Kuru (2010), Kurtul and Haziroglu (2002), Dursun (2002), Franz Salomon (1993), Getty (1975), Rezk and El-Bably (2013) in domestic fowls, and Khalifa (2014) in cattle egret, stated that the celiac artery was detached from the right face of the descending aorta opposite to the 4th or 5th vertebral rib, on the level with the junction of the esophagus and the proventriculus.

The present study revealed the origin of the esophageal artery from either the celiac artery or the dorsal proventricular artery. The same was recorded by Haligur and Duzler (2010) in the red falcon. Coinciding with previous literature, in some bird species, the first branch arising from the celiac artery is the esophageal artery in domestic ducks (Malinovsky et al., 1973), *Gallus gallu domesticus* (Silva et al., 1997), domestic fowls (Kuru, 2010; Rezk and El-Bably, 2013), domestic pigeons (Geeverghese et al., 2012), domestic geese (Ragab et al., 2013) and cattle egret (Khalifa, 2014). Meanwhile, in budgerigar and domestic chicken (Evans 1970; Goncalves et al. 2011), blue-fronted amazon (Atalgin et al., 2012), herons (Neto et al., 2013) and green-billed toucan (Alan et al., 2015), it was shown that the first branch of the celiac artery was the dorsal proventricular artery. However, it has been observed that in some species the esophageal artery and dorsal proventricular artery originated from the celiac artery as a common root (Duzler et al., 2011; Japanese quail; Vasconcelos et al., 2012; ostrich; Neto et al., 2013; green-billed toucan).

In domestic geese (Malinovsky and Visnansk, 1975) and the Nomina Anatomica Avium (Baumel et al., 1993), the esophageal artery as stemming from the aorta was described, while the rami esophageales stemmed from the celiac artery and the dorsal proventricular artery. On the other hand, in greater flamingo, the ramus esophagealis was observed to have stemmed from the dorsal proventricular artery (Alan et al., 2015). No independent artery extended to the esophagus from either the celiac artery or the aorta (no esophageal artery).

In several aves, Malinovsky and Novotna (1977) (domestic fowls), Pinto et al. (1998) (domestic ducks) Kurtul and Haziroglu (2004) (rooster, drake, and pigeons), Silva et al. (2005) (female fowls), Kuru (2010) (domestic fowls), Haligur and Duzler (2010) (red falcon), Geeverghese et al. (2012) (domestic pigeons), Vasconcelos et al. (2012) (ostrich) and Alan et al. (2015) (greater flamingo) reported that the celiac artery bifurcates into the ramus dexter and the ramus sinister. The bifurcation of the celiac artery of the Hooded crows in the present study supports those earlier findings. Interestingly, other studies (Chiasson, 1982; pigeon; Aycan and Duzler, 2000; eagle owl) did not report such a bifurcation. Aslan and Takci (1998) reported that, in geese, the ramus dexter and ramus sinister were of an equal diameter. Alen et al. (2015) (greater flamingo), Atalgin et al. (2012) (grey heron) and Ragab et al. (2013) (domestic geese) detected that the ramus dexter had a larger diameter than the

ramus sinister. Aycan and Duzler (2000) reported that the celiac artery in the eagle owls did not bifurcate and gave off nine branches.

The present investigation revealed that the dorsal proventricular artery was detached from the celiac artery just after the origin of the esophageal artery from the celiac artery. In contrast, Kuru (2010) estimated 4 mm distance and Khalifa (2014) indicated 5 mm distance, while, in the red falcon, Haligur and Duzler (2010) mentioned that this branch originated in common with the esophageal artery. Nishida et al. (1969) named this vessel as the right glandular gastric artery. The dorsal proventricular artery in crows had no change in nomenclature. On the other hand, the artery continued as dorsal gastric artery (Aslan and Takci, 1998; Aycan and Duzler, 2000; Haligur and Duzler, 2010; Kuru, 2010). Silva et al. (1997) described the dorsal gastric artery as a continuity of the pancreaticoduodenal artery in birds.

The origin and number of the splenic arteries varied among aves. It has been reported that the splenic arteries originate from the celiac artery, dorsal proventricular artery, ramus sinister and ramus dexter (Malinovsky and Novotna 1977; Silva et al. 1997; Pinto et al. 1998; Aslan and Takci, 1998; Haligur and Duzler, 2010; Kuru, 2010; Duzler et al., 2011; Goncalves et al., 2011; Atalgin et al., 2012; Geeverghese et al., 2012; Vasconcelos et al., 2012; Neto et al., 2013; Ragab et al. 2013; Khalifa, 2014). In Hooded crows, splenic arteries were represented by 6-8 branches, while they were two branches as recorded in chicken (Kuru, 1996; Kuru, 2010) and in the Eurasian eagle owl (Aycan and Duzler, 2000) and geese (Ragab et al., 2013). The number of splenic arteries in chickens was 2-8 in domestic fowl (Malinovsky and Novotna, 1977), 2-6 in ducks (Pinto et al., 1998), 3-6 in pigeons and 4-6 in rooster (Kurtul, 2002) and 5-6 in cattle egret (Khalifa, 2014).

Currently, the 3rd and 4th cranial splenic branches arose directly from the celiac artery, and the 4th caudal branches, originated from the ramus dexter are similar to those reported for greater flamingo (Alan et al., 2015), but differed with what has been revealed for domestic ducks, domestic geese, Japanese quail and green-billed toucans, in which splenic arteries had their origin from the ramus dexter (Doguer and Erencin, 1964; Malinovsky et al., 1973; Aslan and Baumel et al., 1993; Takci, 1998; Dursun, 2002; Kuru, 2010; Razk and Elbably, 2013). On the other hand, the origin of the splenic arteries was directly from the celiac artery in cattle egret (Khalifa, 2014) and red falcon (Haligur and Duzler, 2010), the Eurasian eagle owl (Chiasson, 1964; Aycan and Duzler, 2000), and chicken (Baumel et al., 1993). Furthermore, Malinovsky and Novotna (1977) found that, in three different chicken breeds, the spleen was vascularised by one or more branches arising from the right hepatic artery, left branch of celiac artery, or even from the superior proventricular artery.

In all examind Hooded crows, the celiac artery gave off the esophageal artery and dorsal proventricular artery and 3-4 cranial spleinc arteries, then divided into left and right branches. Silva et al. (1997) added that the celiac artery sent a vessel to the pericardium called the cardiac artery which was not observed in this study. Aycan and Duzler (2000) reported that the celiac artery in the eagle owl did not bifurcate and gave off 9 branches.

In accordance with Baumel (1975), Malinovsky and Novotna (1977), Baumel et al. (1993), Franz and Salomon (1993), Kuru (2010) in the domestic fowls and Ragab et al. (2013) in geese, the left branch of the celiac artery gave off the ventral proventricular and ventral gastric arteries and terminated as the left gastric artery. Moreover, in Hooded crows, the left branch gave off Rr succi to the craniodorsal sac (Baumel et al., 1993; Ragab et al., 2013) as well as a pyloric branch (Nishida et al., 1969; Ragab et al., 2013) to the junction between the stomach and duodenum. Moreover, in red falcon, Haligur and Duzler (2010) reported that the left branch of the celiac artery started at the right and gave off the right hepatic artery before coursing to the left. In accordance with Baumel et al. (1993) (ducks), Nickel et al. (1977) (chickens), Malinovsky and Novotna (1977) (red falcons) and Haligur and Duzler (2010), the left hepatic artery arises from the left branch of the celiac artery. In a Eurasian eagle owl, Aycan and Duzler (2000), the left hepatic artery has been reported to stem from the celiac artery. In contrast with Dursun (2002) in domestic fowls, Kurtul (2002) in rooster, Malinovsky and Visnanska (1975) in geese and Kuru (2010) in domestic fowls, the left hepatic artery was reported to be a branch of the ventral gastric artery in the domestic fowls. The origin of the ventral proventricular artery was in agreement with those given by Malinovsky and Visnanska (1975) in geese, Aslan and Takci (1998) in geese, kurtul (2000), Dursun (2002) in rooster and

Baumel et al. (1993), and Kuru (2010) in domestic fowls (it arose from the left branch of celiac artery).

In the present study as well as in domestic fowls (Kuru, 2010; Razk and Elbably, 2013) and in geese (Ragab et al., 2013), the ventral gastric artery originated from the left branch of the celiac artery, and extended caudally along the ventral aspect of the ventriculus. In red falcon, Haligur and Duzler (2010) recorded that the ventral gastric artery was represented by 2-3 vessels. Nickel et al. (1981), in fowls, mentioned that the ventral gastric artery continued as the A. gastropancreaticoduodenalis from which arise a branch to the muscular stomach and rami ileocaecales to the middle section of the caeca and the ileum then it continued as the A. pancreaticoduodenalis. Previous literature suggested that hepatic arteries stem, either independently or in the form of a common root, from the ramus sinister, ramus dexter and ventral gastric artery. It was observed that in the Hooded crow, the hepatic arteries have a species-specific hepatic artery distribution that differs from that of other avian species reported previously.

The present work revealed the right hepatic artery arose from left branch of the celiac artery just its origin. From the later, it supplied the right lobe of the liver and gall bladder (a. vesicae biliaris). The same as recorded in the red falcon (Haligur and Duzler, 2010) and greater flamingo (Alan et al., 2015) or from celiac artery at the bifurcation. However, the hepatic artery originated from the celiac artery before its bifurcation (Aycan and Duzler, 2000) in Eurasian eagle owls and in cattle egret (Khalifa, 2014). On the other hand, McLeod et al. (1964), Malinovsky (1965), Malinovsky et al. (1973), Malinovsky and Visnanska (1975), Malinovsky and Novotna (1977), Nickel et al. (1981), Baumel et al. (1993), Aslan and Takci (1998), Dursun (2002), Kurtul (2002), Kuru (2010) and Ragb et al. (2013) recorded that the right hepatic artery detached from the right branch of the celiac artery. It has been found that in the red falcon, the a. vesicaebiliaris arose from the ramus sinister (Haligur and Duzler 2010). The majority of literature reports referred to the artery supplying the gall bladder as a branch of the right hepatic artery (Baumel et al., 1993; various avian species; Aycan and Duzler, 2000; eagle owls; Kuru, 2010; domestic fowls; Duzler et al., 2011; Japanese quail; Vasconcelos et al., 2012; ostrich). The findings of the present study support these earlier reports. However, in one crow, an additional branch to the gall bladder arose from the duodenojejunal artery was found. In the Hooded crow, the left hepatic arteries were represented by one vessel and originated from the left branch of celiac artery. However, a single left hepatic artery from the ventral gastric artery was recorded in domestic geese (Malinovsky and Visnanska, 1975), domestic fowls (Kuru, 1996; Dursun, 2002; Kuru, 2010), and pigeons (Kurtul, 2002). In a Eurasian eagle owl, the same vessel has been reported to stem directly from the celiac artery (Aycan and Duzler, 2000). On the other hand, the left hepatic was represented by two large vessels and 1-2 relatively smaller ones that originated from the ventral gastric artery (Ragab et al., 2013).

The present study as well as those given by Kuru (2010) in domestic fowls revealed that the left gastric artery was the direct continuation of the left branch of the celiac artery beyond the detachment of the left hepatic artery. It passed in the groove between the pars pylorica (third stomach) and ventriculus. The left gastric artery had a fan-like distribution as it terminated into 4-6 rami in the left ventral aspect of the ventriculus to supply the gizzard. Along its course, it gave off 2-3 collateral branches (to supply the ismuth and the distal part of proventriculus). However, Haligur and Duzler (2010) in red falcon, Kuru (2010) in the domestic fowls and Ragab et al. (2013) in geese revealed that the left gastric artery divided into two branches, the dorsal left and ventral left gastric arteries. Mahdy (2009) in ostrich added that the left gastric artery gave off 5-7 dorsal twigs and 4-6 ventral collateral twigs before its bifurcation into dorsal and ventral terminal branches.

In Hooded crows, the right branch of the celiac artery was the direct continuation of the latter giving off the fourth splenic arteries (caudal group), right gastric arteries and then continued as pancreaticoduodenal artery. In other literature, the right branch of the celiac artery gave off the ileocecal, gastroduodenal, right gastric arteries and then continued as pancreaticoduodenal artery (Khalifa 2014 in cattle egret). Baumel (1975), Franz and Salomon (1993), Silva et al. (1997), Aslan and Takci (1998); Kuru (2010) and Khalifa (2014) added that, the splenic arteries, right hepatic artery, ileal arteries also originated from the right branch of the celiac artery. Moreover, the right branch of the celiac artery gave off the jejunal artery and branch to pars pyloric and the ileocecal artery in cattle egret

(Khalifa, 2014). Such finding was not detected in examined Hooded crows. Accordingly, the branches of the right branch of the celiac artery differed and the ileal and ileiocecal arteries were not found. However, the ileocecal artery arose from the cranial mesenteric artery in pigeons (Kurtul and Haziroglu, 2002). In fowls, Baumel (1975), Malinovsky and Novotna (1977) and Nickel et al. (1977) recorded 1-5 ileocecal arteries were arising from the duodenojejunal artery. However, the ilieocecal artery originated from the pancreaticodudenal artery in domestic fowls (Silva et al., 1997; Kuru, 2010) and the red falcon (Haligur and Duzler, 2010). The ileocecal artery supplied the ileum in pigeons (Silva et al., 1997; Kurtul and Haziroglu, 2002) and the red falcon (Haligur and Duzler, 2010), while, in cattle egret (Khalifa, 2014) and domestic fowls (Kuru, 2010), the ileocecal artery supplied the left cecum and the terminal part of the ileum.

According to the present study, the right gastric artery was considered as one of the terminal branch of the right branch of the celiac artery at the level of the ascending part of duodenum and was divided into two branches the dorsal right and ventral right gastric arteries. However, the last two rami could be matched favorably with the right superior and right inferior gastric arteries arising from the right branch of the celiac artery without forming stem right gastric artery as recorded in the N.A.A. (Baumel et al., 1993) and in the red falcon (Haligur and Duzler, 2010). Similar pattern was observed in three specimens in the present study and 6 geese (Ragab et al., 2013).

Furthermore, the gastroduodenal artery originated from the ventral right gastric artery or the right branch of the celiac artery. It was distributed to the pylorus and the initial portion of the duodenum descendens. Similar results were recorded by Kuru (2010) in domestic fowls and by Haligur and Duzler (2010) in the red falcon. On the other hand, Baumel et al. (1993) reported the corresponding vessel in the chicken as arising from the left branch of the celiac artery. It has been found that the pancreaticoduodenal artery represented the continuation of the right branch of the celiac artery (Kuru, 2010) in fowls and in cattle egret (Khalifa 2014), while Mahdy (2009) in the ostrich revealed the bifurcation of the right branch of the celiac artery into the right gastric and pancreaticoduodenal arteries. On the other hand, Nickel et al. (1977) recorded that the pancreaticoduodenal artery was formed by the continuity of the gastropancreaticoduodenal artery.

In Hooded crow, the pancreaticoduodenal arteries run in the mesentery connecting the ascending and descending parts of the duodenum to the flexura duodeni, giving off Rr. pancreatici and Rr. duodenales,& A, jujnal (Kuru 2010 in fowls and Khalifa 2014 in cattle egret). In concern, in the red falcon, Haligur and Duzler (2010) recorded that the artery was divided into two branches, one of the bifurcated branches extended along the flexura duodeni and pars descendens duodeni while the other branch was ascertained to run along the pars ascendens duodeni. Meanwhile, the jejunal artery was one vessel arose from the pancreaticodudenal artery but in cattle egret (Khalifa, 2014), jejunal arteries were two in number, the former arose from right branch of the celiac artery, and the second from the pancreaticodudenal artery. The duodenojejunal artery was arisen from the pancreaticoduodenal artery and from the right hepatic in two birds and was determined to be one of the last branches originating from the right branch of the celiac artery at the level of the junction of the gaster with the duodenum in two birds crossing to the left side to supply the duodenojejunal flexure. On the other hand, in fowls, Baumel (1975), Franz and Salomon (1993) and Malinovsky and Novotna (1977) mentioned that the duodenojejunal artery was the continuation of the right branch of the celiac artery between the ascending and descending part of the duodenum. In fowls, Razk and Elbably (2013) and in geese (Ragab et al., 2103) the pancreaticoduodenal artery detached from the right hepatic artery.

5. Conclusion

Features of the celiac artery, which were specific to the Hooded crows, were determined and compared to the literature available for other avian species.

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