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Original Article

Arterial supply of the stomach of the Egyptian native goat

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ABSTRACT

Objective: This study was conducted to investigate the origin, course and distribution of the arteries supplying the stomach of the goat which is of extreme clinical importance for surgeon during caprine rumenotomy.

Materials and methods: Fifteen adult goats were used in this study to demonstrate the arterial supply of the stomach by injection of the thoracic aorta with red gum milk latex after general anesthesia and slaughtering of the animals. Gross dissection of the arteries of the stomach was done to detect the origin, course and distribution of these arteries.

Results: The study revealed that the rumen was richly supplied by the right and left ruminal arteries as well as ruminal branches from the reticular artery. The reticulum was supplied with reticular branches of reticular and accessory reticular arteries. The omasum was vascularized by omasal branches of the left gastric artery. While the abomasum received its entire arterial supply from abomasal branches of the left gastric, left gastroepiploic, right gastric and right gastroepiploic arteries.

Conclusion: The stomach of the goat receives its arterial supply from the branches of the right ruminal, left ruminal, reticular, left gastric and hepatic arteries. Rumenotomy could be done in the left aspect of the dorsal ruminal sac, between the area of anastomoses of the terminal branches of the left and right ruminal arteries as the blood supply was minimal, so that bleeding will be low.

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INTRODUCTION

Goats are characterized by their smooth management, economically cheaper housing, high fertility rate, and are of great economic value, being a cheaper meat, milk and some industrial substances. Several authors have studied the ramification of the celiac artery in vertebrates (Niza et al., 2003; Abidu-figueiredo et al., 2008). Anatomical studies on the arterial supply of the stomach of the goat are necessary to know the pattern of its blood supply to gain information in the interest of experimental surgery, pharmacology and toxicology which can be applied to domestic animals. The celiac trunk supplies the stomach, liver, upper part of the duodenum and pancreas; variations of these arteries and their relationship to surrounding structures are, therefore, of particular importance from a surgical perspective in ruminant (King, 1974) and in human (Williams et al., 1995; Kahraman et al., 2001; Çiçekcibaşi et al., 2005). The knowledge of the gastrointestinal vascularization allows to prevent and detect sources of bleeding in surgery of gastrointestinal organs, for example, in cases of rumenotomy, fistulation and displacement of abomasum (Perez et al., 2015). The anatomical studies of the arterial supply to the stomach in goat in the available literature such as in the goat and other ruminants (Youssef, 1991; Dyce et al., 2010), and in the deer (Amadori et al., 2012; Perez et al., 2015). The present study aimed to investigate the arteries of the stomach in goat, regarding the origin, course and ramifications, in attempt to gain basic information which might be beneficial in the field of caprine surgery, rumenotomy and also contribute to the comparative ruminant animals.

MATERIALS AND METHODS

This study has been conducted with the goats according to the international ethical standard, by giving minimum pains to the animal.

In this study, 15 adult apparently healthy goats of different ages and both sexes, and body weight ranging from 20-30 kg were used. The animals were collected from the faculty farm and other local farms. General anesthesia was induced by xylazine (Rompun) dosed at 0.5 mg/kg body weight (bwt) and cyclohexanone (Ketalar) dosed at 10 mg/kg bwt intramuscularly (IM). Immediately after slaughtering, the abdominal cavity was opened by making a longitudinal incision in the midventral line of the abdominal wall starting from the xiphoid cartilage of the sternum till the anus. Then gum red milk latex was injected via the thoracic aorta just prior to its passage through the hiatus aorticus of the diaphragm. Careful gross dissection of the arteries of the stomach was performed either before or after embedding in 10% formalin solution for 2-3 days. Dissected stomach arteries were photographed *in situ* and after taken out the intestine with a camera a Kodak digital camera (12 mega pixels). The nomenclature employed in this study was in accordance with that of the Nomina Anatomica Veterinaria (2005) and the available literatures whenever possible.

RESULTS AND DISCUSSION

The stomach of the goat was richly vascularized via branches of the celiac artery.

Coeliac artery

The celiac artery (**Figure 1-2** and **4**) arose from the ventral aspect of the abdominal aorta at the level of the first lumbar vertebra as reported in goat (Youssef, 1991) and sheep (Mohamed et al., 2016). However, Alsafy (2009) and El Gendy (2007) in goat reported that the celiac artery arisen between the first and second lumbar vertebrae. Moreover, the celiac artery in goat arose separately from the aorta as reported in sheep (Mohamed et al., 2016) and dog (Roza et al., 2012). While, the celiac and cranial mesenteric arteries arose together by a common stem in goat (Alsafy, 2009), buffalo (Machado et al., 2002) and human (Çiçekcibaşi et al., 2005). The coeliac artery gave off splenic, left ruminal, hepatic and left gastric arteries as reported in goat (Alsafy, 2009), sheep (Mohamed et al., 2016) and pampas deer (Perez et al., 2015).

Splenic artery

The splenic artery (**Figure 1-2**) coursed cranio dorsally to reach the dorsal ruminal curvature and entered the hilus of the spleen where it ramified. It gave off right ruminal artery and epiploic branch, similar results were recorded in goat (Alsafy, 2009), sheep (Mohamed et al., 2016), and buffalo (Machado et al., 2002). While the splenic artery gives only the right ruminal artery in pampas deer (Perez et al., 2015).

The right ruminal artery (**Figure 1-3**) proceeded caudo-ventrally along the visceral surface of the dorsal ruminal sac to gain the right longitudinal and caudal grooves giving off dorsal, ventral ruminal branches to and deep ruminal branches as well as right ventral coronary artery then it crossed the latter groove to reach the left side of the rumen where it terminated by left dorsal and left ventral coronary arteries; similar results were reported in goat (Alsafy, 2009) and sheep (Mohamed et al., 2016).

Figure 1. A photograph of the gastrointestinal tract showing the origin and distribution of both coeliac and cranial mesenteric arteries. (Left side), except the rumen turned to show its right side. **A-** Abdominal aorta, **B**- Dorsal ruminal sac, **C-** Ventral ruminal sac, **D**- Caudal groove, **E**- Major omentum, **F**- Spleen**, G**- Reticulum, **H-** Omasum, **I-** Abomasum, **1-** Coeliac artery, **2-** Splenic artery, **3-** Right ruminal artery, **4-** Dorsal ruminal branches, **5-** Right ventral coronary artery, **6-** Epiploic branch, **7-** Left ruminal artery, **8-** Reticular artery, **9-** Left gastric artery, **10**- Hepatic artery, **11**- Cranial mesenteric artery

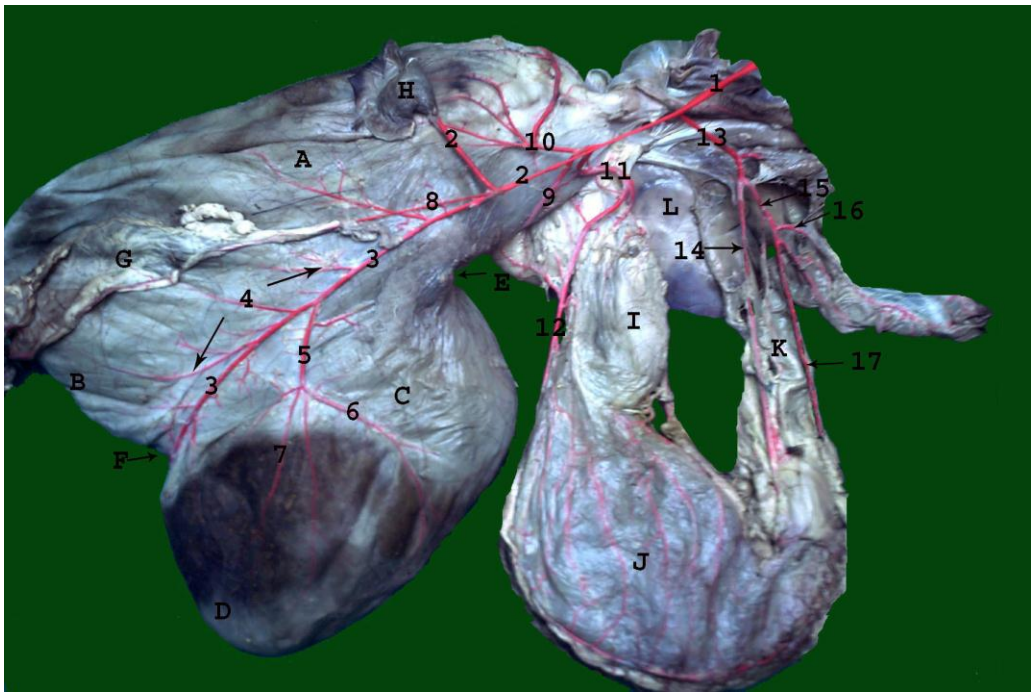

Figure 2. A photograph showing the distribution of the coeliac artery to the stomach of the goat. (Left side), except the rumen turned to show its right side: **A-**Dorsal ruminal sac, **B**-Caudodorsal blind sac, **C**-Ventral ruminal sac, **D**-Caudoventral blind sac, **E**-Cranial groove, **F**-Caudal groove, **G**- Major omentum, **H**-Spleen, **I**-Omasum, **J**-Abomasum, **H**-Cranial part of the duodenum, **L**-Liver, **1**-Coeliac artery, **2**-Splenic artery, **3**-Right ruminal artery, **4**-Dorsal ruminal branches, **5**-Right ventral coronary artery, **6**-Cranial branch, **7**-Caudal branch, **8**-Epiploic branch, **9**-Left ruminal artery, **10**-Reticular artery, **11-**Left gastric artery, **12**-Left gastroepiploic artery, **13**-Hepatic artery, **14**-Right gastric artery, **15**-Gastroduodenal artery, **16**-Cranial pancreaticoduodenal artery, **17**-Right gastroepiploic artery.

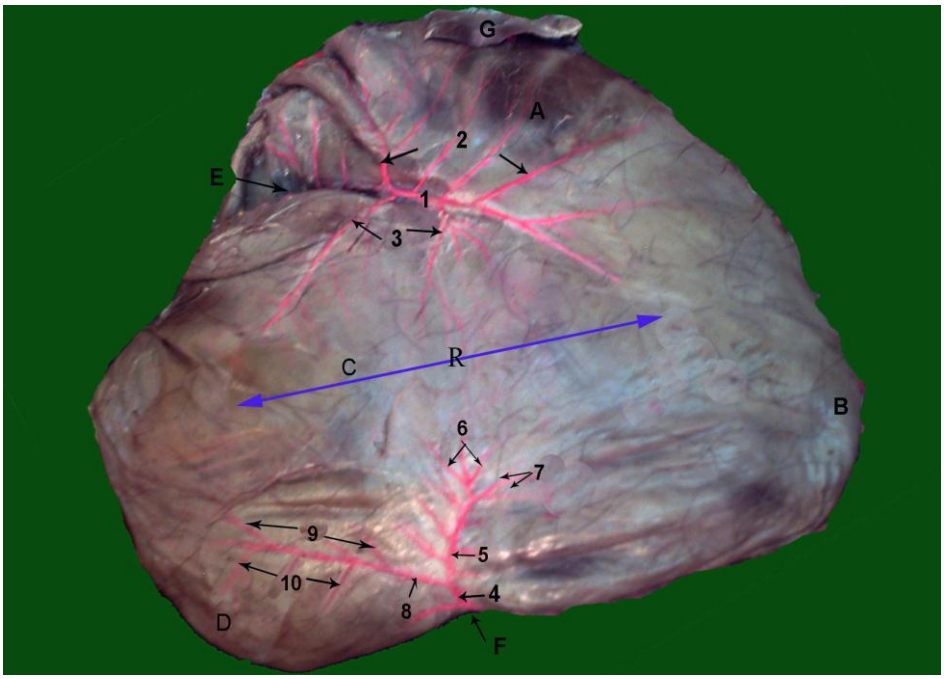

Figure 3. A photograph of the left side of the rumen of the goat showing the course and distribution of the left dorsal and left ventral coronary arteries and the distribution of left ruminal artery as well as their anastomoses : **A**-Dorsal ruminal sac, B-Caudodorsal blind sac, **C**-Ventral ruminal sac, **D**-Caudoventral ruminal sac, **E**-Cranial groove, **F**-Caudal groove, **G**-Spleen, Left ruminal artery, **2**-Dorsal ruminal branches, **3**-Ventral ruminal branches, **4**-Right ruminal artery, **5**-Left dorsal coronary artery, **6**-Cranial branches, **7**-Caudal branches, **8**-Left ventral coronary artery, **9**-Cranial branches, **10**-Caudal branches, **R**-Site for rumenotomy

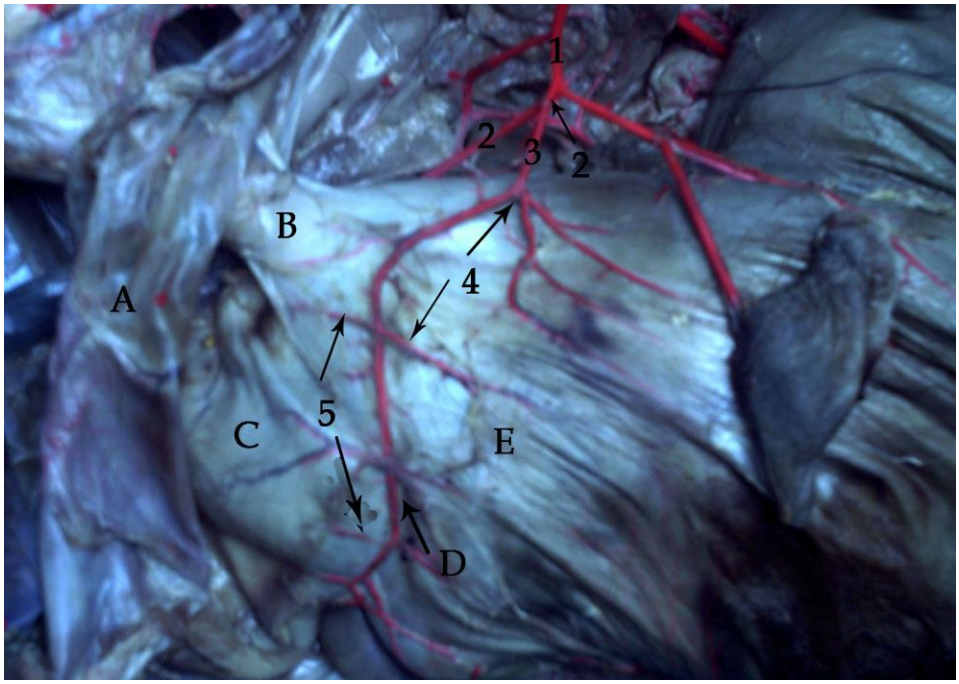

Figure 4. A photograph showing the origin and distribution of the reticular artery of the goat. (Left side): **A**-Diaphragm, **B**-Oesophagus, **C**-Reticulum (diaphragmatic surface), **D**-ruminoreticular groove, **E**-Rumen, **1**-Coeliac artery, **2**-Left ruminal artery, **3**-Reticular artery, **4**-Ruminal branches, **5**-Reticular branches

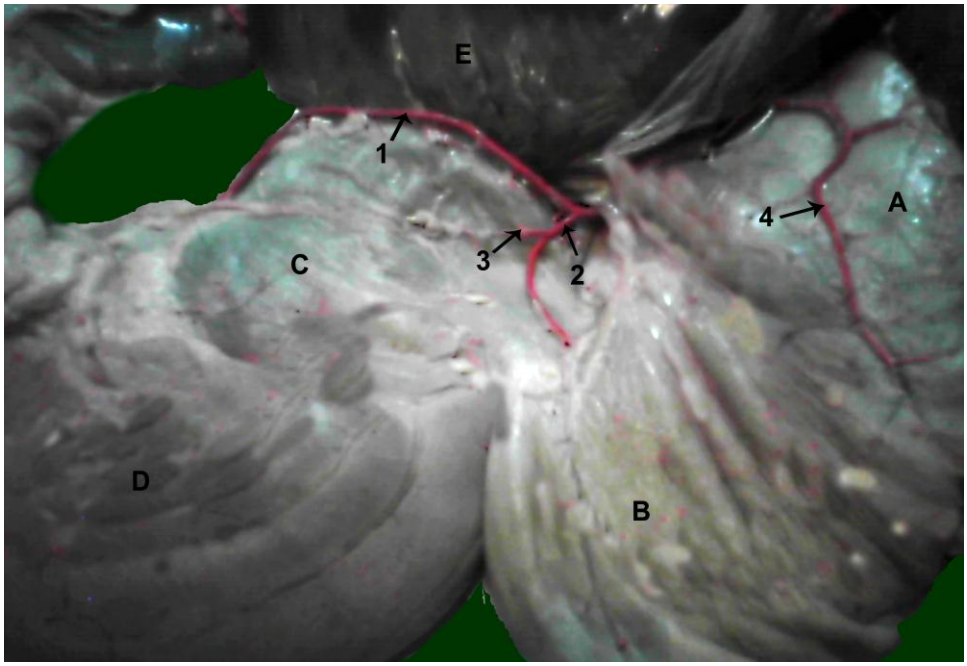

Figure 5. A photograph showing the origin, course and distribution of the accessory reticular artery of the goat. (right side): **A**-Rumen, **B**-Reticulum, **C**-Omasum, **D**-Abomasum, **E**-Liver, **1**-A. gastrica sinistra, **2**-Accessory reticular artery, **3**-Omasal branch, **4**-Reticular artery

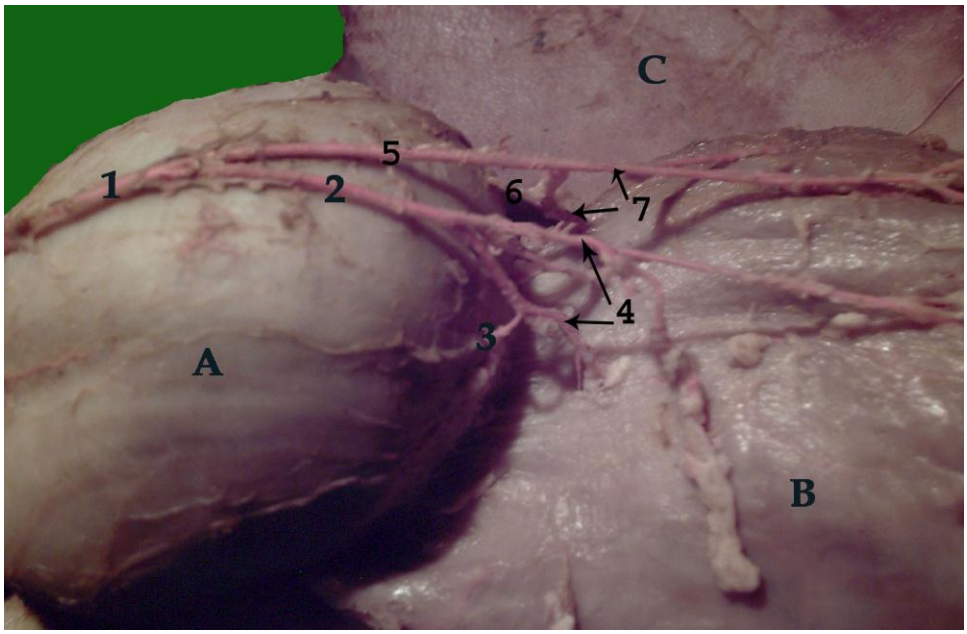

Figure 6. A photograph showing the termination of the left gastric artery of the goat. (Left side): **A**-Omasum, **B**-Abomasum, **C**-Liver, **1**-Left gastric artery, **2**-Visceral omasoabomasal branch, **3**-Visceral omasal branches, **4**-Visceral abomasal branches, **5**-Parietal omasoabomasal branch, 6-Parietal omasal branches, **7**-Parietal abomasal branches.

The dorsal ruminal branches (**Figure 1-2**) supplied the dorsal ruminal sac, ruminal atrium and caudodorsal blind sac. The ventral ruminal branches (**Figure 3**) supplied the ventral ruminal sac and caudovental blind sac. The deep ruminal branches supplied left dorsal coronary groove, right longitudinal and caudal grooves as well as the right and left ventral coronary ones. The right ventral coronary artery (**Figure 1-2**) passed in the right ventral coronary groove dividing into a caudal and cranial branch to supply the caudoventral blind sac and ventral ruminal sac.

The right ruminal artery terminated by dividing into the left dorsal and left ventral coronary arteries. The former one (**Figure 3**) curved dorsally and to the left towards the

left dorsal coronary groove giving off cranial and caudal branches to the parietal face of the dorsal ruminal sac and caudodorsal blind sac. While the left ventral coronary artery (**Figure 3**) followed the same named groove giving off cranial and caudal branches supplying the parietal face of the ventral ruminal sac and caudoventral blind sac.

The epiploic branch arose from the splenic artery (**Figure 1-2**). It entered the visceral lamina of the greater omentum to continue its course caudally then arched to the left where the visceral lamina changed into parietal lamina. It terminated by 2-3 branches which extended to anastomose with the omental branches of left and right gastroepiploic arteries within the greater omentum, as described by Alsafy (2009) in goat, McCarthy (1984) in ox and Machado et al., 2002 in buffalo. However, Koch and Berg (1985) in sheep reported that the epiploic artery arisen from the celiac artery.

Left ruminal artery

The left ruminal artery (**Figure 1-4**) arose from the coeliac artery, as mentioned by Mohamed et al. (2016) in sheep and Machado et al. (2002) in buffalo where the left ruminal artery was arisen from the celiac artery or from the splenic artery, as reported by Alsafy (2009) in the goat and Machado et al. (2002) in the buffalo. On the other hand, Machado et al. (2002) in buffalo and Perez et al. (2015) in pampas deer stated that the left ruminal artery springs from the left gastric artery. It arched caudo-ventrally on the right face of the ruminal atrium to reach the cranial groove of the rumen where it continued caudo-dorsally deeply in the left longitudinal groove. The left ruminal artery terminated on the parietal face of the dorsal sac of the rumen. Along its course, the left ruminal artery gave off dorsal ruminal branches (**Figure 3**) to the parietal face of the dorsal ruminal sac and ventral ruminal branches (**Figure 3**) to the parietal face of ventral ruminal sac, as mentioned by Mohamed et al. (2016) in sheep and Machado et al. (2002) in the buffalo.

The reticular artery (**Figure 1-2** and **4**) arose from the left ruminal artery, as mentioned by Alsafy (2009) in goat and Mohamed et al. (2016) in sheep. While it originated from the left gastric artery, as mentioned by Horowitz and Venzke (1966) and Nayar et al. (1983) in goat, Machado et al. (2002) in buffalo, Smuts and Bezuidenhout (1987) in camel and Perez et al. (2015) in pampas deer. The reticular artery entered the ruminoreticular groove giving ruminal and reticular branches as well as deep branches. The ruminal branches (**Figure 4**) supplied the ruminal atrium and the parietal face of the dorsal ruminal sac. While the reticular (**Figure 4**) branches supplied the left caudal aspect of the cardia and diaphragmatic face of the reticulum. The deep branches were given off within the ruminoreticular groove to supply the preceding groove.

Left gastric artery

The left gastric artery (**Figure 1-2**) constituted the direct continuation of the celiac artery similar to that described by Boccaletti and Borelli (1981) in sheep. However, Simoens et al. (1981) in goat and sheep reported that the left gastric artery arose from the hepatic artery. It passed between the liver and the dorsal ruminal sac and then it arched caudally on the omasal curvature to reach the lesser curvature of the abomasum where it terminated by visceral and parietal omasoabomasal branches to the lesser curvature of abomasum (**Figure 6**). Collateral branches were given off from the left gastric artery during its course such as accessory reticular artery, omasal branches and left gastroepiploic artery.

The accessory reticular artery (**Figure 5**) passed on the dorsal aspect of the reticulo-omasal junction giving a reticular branch to the visceral face of the reticulum an omasal branch to the parietal face of the omasum and as well as three small twigs to the reticuloomasal junction.

The parietal and visceral omasal branches of the left gastric artery arose close to the omasal curvature to the corresponding surfaces of the omasum. The parietal and visceral omasoabomasal branches represented the termination of the left gastric artery close to the omasoabomasal junction which supplied the corresponding surfaces of the abomasum.

The left gastroepiploic artery (**Figure 2**) coursed cranioventrally between the omasum on the right and the ruminal atrium and reticulum on the left then it crossed the visceral face of the reticuloomasal junction to reach the greater curvature of the abomasum on which it continued towards the pylorus to anastomose with the corresponding right one. Along its course, the left gastroepiploic artery gave off reticular, omasal, omasoabomasal, abomasal and omental branches. However, Machado et al. (2002) in buffalo reported that the left gastroepiploic artery gives off the accessory reticular artery.

The reticular branches passed towards the visceral face of the reticulum. The omasal branches passed to the visceral face of the omasum where they terminated. The omasoabomasal branches were represented by visceral and parietal branches which passed to the respective aspect of the omasum, abomasum and omasoabomasal junction. The abomasal branches were parietal and visceral branches to the greater curvature of the

abomasum. The omental branches passed within the major omentum where they anastomosed with the omental branches of the right gastroepiploic artery and with the twigs of the epiploic branch of the splenic artery.

Hepatic artery

The hepatic artery originated from the right aspect of the celiac artery (**Figure 1-2**) preceded on the visceral surface of the liver toward the porta hepatis where it continued as the gastroduodenal artery. However, Machado et al. (2002) in buffalo reported that the gastroduodenal artery originates from the left branch of the hepatic artery. The gastroduodenal artery passed within the lesser omentum terminating in right gastroepiploic and cranial pancreaticoduodenal arteries, similar to the report of Wilkens and Munster (1981) in ruminants. The former one entered the parietal lamina of the greater omentum, then passed towards the pylorus along the greater curvature of the abomasum and anastomosed with the left gastroepiploic artery. During its course, it gave off parietal and visceral abomasal branches to the pylorus and greater curvature of the abomasum and omental branches to the greater omentum to supply the latter and anastomosed with the omental branches of the left gastroepiploic artery and the epiploic branch of the splenic artery.

At the lesser omentum, the hepatic artery gave off a left and right branches. The former one gave origin to the right gastric artery (**Figure 2**) which coursed cranioventrally in the lesser omentum towards the pylorus and it divided into visceral and parietal branches along the lesser curvature of the abomasum. The right gastric artery supplied the lesser omentum via small omental branches. Rumenotomy in the goat could be done in the left aspect of the dorsal ruminal sac, between the area of anastomoses between the ventral ruminal branches of the left ruminal artery as well as the branches of the coronaries arteries of the right ruminal artery (**Figure 3/R**) as the blood supply was minimal, so that the incidence of bleeding will be low as mentioned by Mohamed et al. (2016) in sheep.

CONCLUSION

The celiac artery supplied the different parts of the stomach of the goat. The rumen was supplied by the right and left ruminal arteries as well as ruminal branches. The reticulum was supplied by reticular branches. The omasum was vascularized by omasal branches. While the abomasum received its entire arterial supply from abomasal branches. Rumenotomy could be done in the left aspect of the dorsal ruminal sac.

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CONFLICT OF INTEREST

The authors declare that they have no conflict of interest.

AUTHORS' CONTRIBUTION

This work is a product of the intellectual environment of the whole team; and that all members have contributed in various degrees to the research concept, to the experiment design of the work, drafting the article, critical revision of the article and final approval of the version to be published.

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