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Research Article

Arterial Supply of the Stomach of the Barbados Black Belly Sheep in Trinidad

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ABSTRACT

Five adult healthy Barbados Black Belly sheep of either sex were used to demonstrate the arterial supply of the stomach. Immediately after slaughtering of sheep, the thoracic part of the aorta (just prior to its passage through the hiatus aorticus of the diaphragm) was injected with gum milk latex (colored red) with carmine. The study revealed that the different parts of stomach of the sheep were supplied via the branches of the celiac artery. 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. Rumenotomy 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 cranial branches of both the left dorsal and left ventral coronaries arteries of the right ruminal artery as the blood supply was minimal, so that the incidence of bleeding will be low.

Key words: Anatomy, Stomach, Arterial supply, Black Belly sheep

INTRODUCTION

The Barbados Black Belly is a breed of domestic sheep in the Caribbean island of Trinidad. This breed is raised primarily for meat. It combines the rare attributes of adaption to the environment and high reproductive efficiency, which account for their average of two lambs per litter and an average lambing interval of eight to nine months. The anatomical studies of the arterial supply to the stomach in sheep in the available literature such as Anderson and Weber (1969), May (1970) and Kardage (1988) in different sheep species. While the present investigation may be considered as the first which describe fully the arteries of the stomach in the Barbados Black Belly in Trinidad, regarding the origin, course and ramifications in attempt to gain basic information which might be beneficial in the field of ovine surgery and also contribute to the comparative studies of ruminants.

MATERIALS AND METHODS

The investigation was carried out on five adult Barbados Black Belly sheep of both sex. The animals were collected from several farms in Trinidad and Tobago. Immediately after slaughter, the blood vessels were thorough washed with normal saline solution via the thoracic part of the aorta. Then gum red milk latex was injected via the thoracic aorta just prior to its passage through the hiatus aorticus of the diaphragm. A longitudinal incision was made in the mid-ventral line of the abdominal wall starting from the xiphoid cartilage of the sternum to the anus. Careful gross dissection of the arteries of the stomach was performed after fixation in 10% formalin solution for 2 to 3 days and the observations were recorded.

RESULTS

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

Coeliac artery

The celiac artery (Figs., 1, 2, 6, 7/1) arose from the ventral aspect of the abdominal aorta at the level of the first lumbar vertebra just behind the crura of diaphragm. It was 2-3 cm. in length. It passed between the caudal vena

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cava on the right and the dorsal sac of the rumen on the left side towards the curvature of the omasum where it continued as the left gastric artery. The celiac artery gave off splenic artery, hepatic artery and sometimes left ruminal artery.

Splenic artery

The splenic artery (Figs., 1, 2, 6/2) was a branch of the celiac artery and measured about 2-3cm. in length. It coursed cranio dorsally between the dorsal ruminal sac and left lobe of pancreas 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.

Right ruminal artery

The right ruminal artery (Figs., 1/4, 2/3, 3/1, 6/3) was detached from the splenic artery. It 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.

The dorsal ruminal branches (Figs., 1/5, 2/4) supplied the dorsal ruminal sac, ruminal atrium and caudodorsal blind sac. The ventral ruminal branches (Figs., 1/6, 2/5) 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 (Figs., 1/7, 2/6) passed in the right ventral coronary groove dividing into a caudal (Figs., 1/8, 2/7) and cranial branch (Figs., 1/9, 2/8) 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 (Fig., 3/2) curved dorsally and to the left towards the left dorsal coronary groove giving off cranial (Fig., 3/3) and caudal branches (Fig., 3/4) to the parietal face of the dorsal ruminal sac and caudodorsal blind sac. While the left ventral coronary (Fig., 3/5) artery followed the same named groove giving off cranial (Fig., 3/6) and caudal branches (Fig., 3/7) supplying the parietal face of the ventral ruminal sac and caudoventral blind sac.

Epiploic branch

The epiploic branch (Figs., 1/3, 6/4) originated from the splenic artery, 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.

Left ruminal artery

The left ruminal artery (Figs., 1/11, 2/9, 3/8, 6/6, 7/3) arose either from the splenic artery or celiac artery either individually or as a common trunk (Figs. 1/10, 6/5, 7/2) with 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 (Fig., 3/9) to the parietal face of the dorsal ruminal sac and ventral ruminal branches (Fig., 3/10) to the parietal face of ventral ruminal sac as well as deep ruminal branches to the cranial and left longitudinal grooves.

Reticular artery

The reticular artery (Figs., 1/13, 2/11, 4/2, 6/8, 7/5) originated either from the left gastric or left ruminal arteries. It entered the ruminoreticular groove giving ruminal and reticular branches as well as deep branches. The ruminal branches (Fig., 4/3) supplied the ruminal atrium and the parietal face of the dorsal ruminal sac. While, the reticular (Fig., 4/4) 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 (Figs., 1/12, 2/10, 4, 5/1, 6/7, 7/4) constituted the direct continuation of the celiac 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. 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

The accessory reticular artery arose from the left gastric artery (Figs., 5/2, 6/9), passed on the dorsal aspect of the reticulo-omasal junction giving a reticular branch (Fig., 5/3) to the visceral face of the reticulum an omasal branch (Fig., 5/4) 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 (Figs., 1/14, 6/10, 7/6) arose close to the omasal curvature to the corresponding surfaces of the omasum. The parietal and visceral omasoabomasal branches (Figs., 1/15, 6/11, 7/7) represented the termination of the left gastric artery close to the omasoabomasal junction which supplied the corresponding surfaces of the abomasum.

Left gastroepiploic artery

The left gastroepiploic artery emerged from the left gastric artery (Figs., 1/16, 6/12). It 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. In addition to small branches to both the ruminoreticular and reticuloomasal junctions.

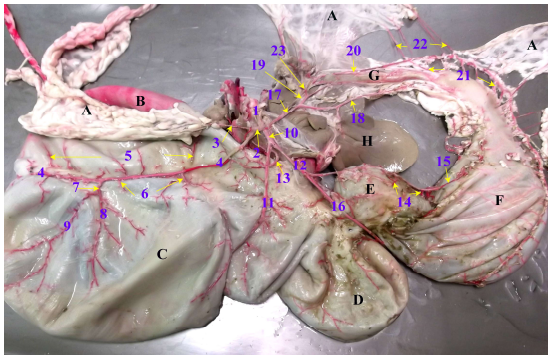

Fig. 1: A photograph of the stomach showing the origin and distribution of the coeliac artery (Left side), except the rumen turned to show its right side. **A-** Omentum; B- Dorsal ruminal sac; **C-** Ventral ruminal sac; D- Reticulum; E- Omasum; F- Abomasum; **G-** Duodenum; H- Liver; 1-Coeliac artery; 2- Splenic artery; 3- Epiploic branch; 4- Right ruminal artery; 5- Dorsal ruminal branches; 6- Ventral ruminal branches; 7- Right ventral coronary artery; 8- Caudal branch; 9- Cranial branch; 10- Common trunk of (11&12); 11- Left ruminal artery; 12- Left gastric artery; 13- Reticular artery; 14- Omasal branches; 15- Abomasal branches; 16- Left gastroepiploic artery; 17- Hepatic artery; 18- Right gastric artery; 19-Gastroduodenal artery; 20- Right gastroepiploic artery; 21- Abomasal branches; 22- Omental branches; 23- Cranial pancreaticoduodenal artery.

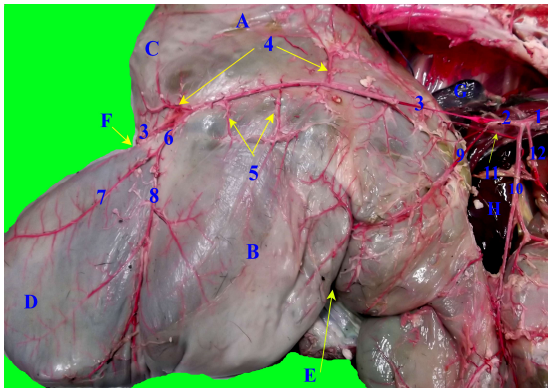

Fig. 2: A photograph of the right side of the rumen showing the course and distribution of the right ruminal artery of the sheep
A- Dorsal ruminal sac; B- Ventral ruminal sac; C- Caudodorsal blind sac; D- Caudoventral blind sac; E- Cranial groove; F- Caudal groove; G- Spleen; H- Liver; 1- Coeliac artery; 2- Splenic artery; 3- Right ruminal artery; 4- Dorsal ruminal branches; 5- Ventral ruminal branches; 6- Right ventral coronary artery; 7- Caudal branch; 8- Cranial branch; 9- Left ruminal artery; 10- Left gastric artery; 11- Reticular artery; 12- Hepatic 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 (Fig., 6/13) were parietal and visceral branches to the greater curvature of the abomasum. The omental branches (Fig., 6/14) 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.

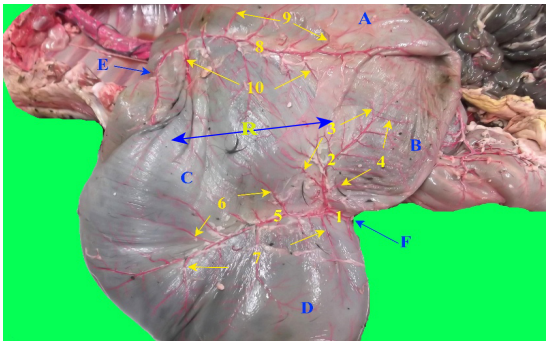

Fig. 3: A photograph of the left side of the rumen of the sheep showing the course and distribution of the left dorsal and left ventral coronaries arteries and the distribution of the left ruminal as well as their anastomoses; **A-** Dorsal ruminal sac; B- Caudodorsal blind sac; C- Ventral ruminal sac; **D-** Caudoventral blind sac; E- Cranial groove; D- Caudal groove; R- Site for rumenotomy; 1- Right ruminal artery; 2- Left dorsal coronary artery; 3- Cranial branches; 4- Caudal branches; 5- Left ventral coronary artery; 6- Cranial branches; 7- Caudal branches of; 8- Left ruminal artery; 9- Dorsal ruminal branches; 10 Ventral ruminal branches

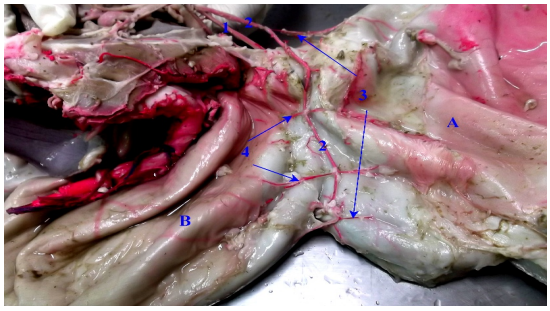

Fig. 4: A photograph showing the origin and distribution of the reticular artery in the sheep. **A-** Rumen; B- Reticulum; 1-Left gastric artery; 2- Reticular artery; 3- Ruminal branches; 4- Reticular branches.

Hepatic artery

The hepatic artery originated from the right aspect of the celiac artery (Figs., 1/17, 2/12, 6/15. 7/8) preceded on the visceral surface of the liver toward the porta hepatis where it continued as the gastroduodenal artery (Figs., 1/19, 6/17, 7/10) which passed within the lesser omentum terminating in right gastroepiploic (Figs., 1/20, 6/8, 7/11) and cranial pancreaticoduodenal arteries (Figs., 1/23, 6/21, 7/13). 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 (Figs., 1/21, 6/20) to the pylorus and greater curvature of the abomasum and omental branches (Figs., 1/22, 6/20) 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 branch. The former one gave origin to the right gastric artery (Figs., 1/18, 6/16, 7/9) 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.

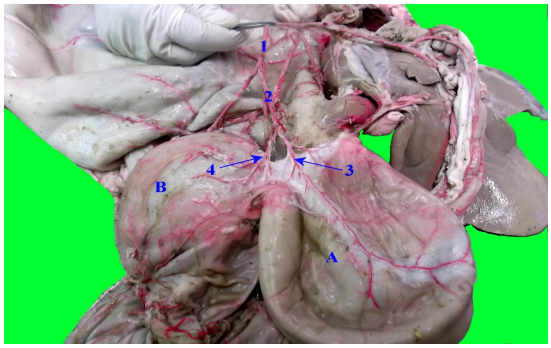

Fig. 5: A photograph showing the origin, course and distribution of the accessory reticular artery in the sheep; **A**- Reticulum; **B**- Omasum; 1- Left gastric artery; 2- Accessory reticular artery; 3- Reticular branch; 4- Omasal branch.

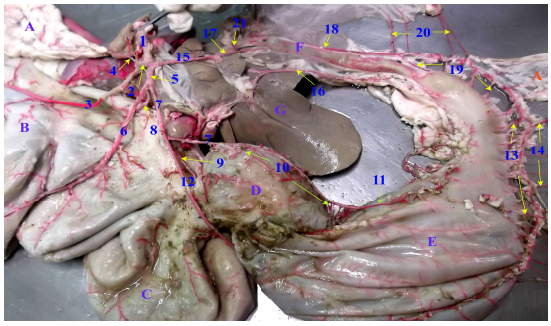

Fig. 6: A photograph showing the origin and distribution of the left gastric artery of the sheep (Left side): A- Omentum; B- Rumen; C- Reticulum; D- Omasum; E- Abomasum; F- Duodenum; G- Liver E- Omentum; 1-Coeliac artery; 2- Splenic artery; 3- Right ruminal artery; 4- Epiploic branch; 5- Common trunk for (6&7); 6- Left ruminal artery; 7- Left gastric artery; 8- Reticular artery; 9- Accessory reticular artery; 10- Omasal branches; 11- Abomasal branches; 12- Left gastroepiploic artery; 13- Abomasal branches; 14- Omental branches; 15- Hepatic artery; 16- Right gastric artery; 17- Gastroduodenal artery; 18- Right gastroepiploic artery; 19- Abomasal branches; 20- Omental branches; 21- Cranial pancreaticoduodenal artery.

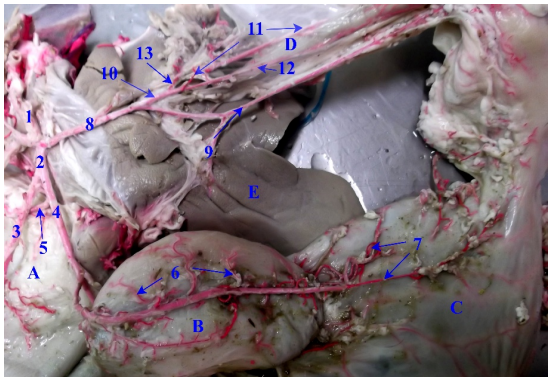

Fig. 7: A photograph showing the termination of the origin, course and distribution of the hepatic artery of the sheep. (Left side): A- Rumen; B- Omasum; C- Abomasum; D- Liver; 1- Coeliac artery; 2- Common trunk for (3&4); 3- Left ruminal artery; 4- Left gastric artery; 5- Reticular artery; 6- Omasal branches; 7- Abomasal branches; 8- Hepatic artery; 9- Right gastric artery; 10- Gastroduodenal artery; 11- Right gastroepiploic artery; 12- Duodenal branch; 13- Cranial pancreaticoduodenal artery.

DISCUSSION

The current investigation revealed that the celiac artery originated from the ventral aspect of the abdominal aorta at the level of the first lumbar vertebra which is similar that reported in sheep (Habel, 1975), goat (Mohamed, 2008), ox (Wilkens and Munster, 1981) and camel (EL-Gaafary and Youssef, 1979). However, Alsafy (2009) in goat reported that the celiac artery arises between the first and second lumbar vertebrae.

The celiac artery arose separately from the aorta before the origin of cranial mesenteric artery. While, the celiac and cranial mesenteric arteries arose together by a common stem in some cases as mentioned by Kardage (1988) in sheep, Alsafy (2009) in goat, Habel (1975) in ox and Machado *et al*., (2002) in buffalo.

The current study showed that the celiac artery gave off splenic, left gastric and hepatic arteries as reported in goat (Alsafy, 2009) , in ox (McCarthy, 1984) as well as in the camel (Smuts and Bezuidenhout, 1987). On the other hand, Koch and Berg (1985) stated that the celiac artery in the goat detaches a hepatogastric trunk for hepatic and left gastric arteries and a common stem for the splenic and right ruminal arteries, in addition to a stem for left ruminal and reticular arteries as well as an epiploic artery.

Our findings are in accordance with those of Alsafy (2009) in goat, Habel (1975) in ox and Machado et al., (2002) in buffalo who reported that the splenic artery gave off right ruminal artery and an epiploic branch.

The findings of Alsafy (2009) in goat affirmed our results as the right ruminal artery gives off right ventral, left dorsal and left ventral coronary arteries as well as dorsal, ventral and deep ruminal branches. While, May (1970) in sheep stated that the right ruminal artery gives off right dorsal and right ventral coronary arteries and an epiploic branch. However, EL-Gaafary and Youssef (1979) in camel reported that the right ruminal artery divides into the right branch to the ventral glandular sac area and epiploic branches.

Our investigations, Alsafy (2009) in goat, McCarthy (1984) in ox and Machado et al., (2002) in buffalo reported that the epiploic branch arose from the splenic artery. However, Koch and Berg (1985) in sheep reported that the epiploic artery arises from the celiac artery. On the other hand, EL-Gaafary and Youssef (1979) reported that the epiploic artery in the camel arises from the right ruminal artery

The results showed that the left ruminal artery arose from the coeliac artery as mentioned by Anderson and Weber (1969) in sheep, Sisson and Grossman (1969) in ox and Machado et al (2002) in buffalo where the left ruminal artery arises from the celiac artery or from the splenic artery as reported by Alsafy (2009) in the goat, McCarthy (1984) in the ox and Machado *et al*., (2002) in the buffalo. On the other hand, Horowitz and Venzke (1966) in goat, May (1970) in sheep, Habel (1975) in ruminants, Machado *et al*., (2002) in buffalo as well as Smuts and Bezuidenhout (1987) in camel stated that the left ruminal artery springs from the left gastric artery or with a common trunk with the left gastric artery which not mentioned by the authors.

Our observations agreed with those of Youssef (1991) in the goat, Habel (1975) in the ox, and Machado

et al., (2002) in the buffalo, that the left ruminal artery detached dorsal and ventral ruminal branches. While, Horowitz and Venzke (1966) in the goat l stated that the left ruminal artery divides into cranial, caudal and deep branches. On the other hand, EL-Gaafary and Youssef (1979) in the camel reported that the left ruminal artery terminates into two left branches of the craniodorsal and ventral glandular sacs

In the present findings, the reticular artery arose either from the reticular artery was detached from the left gastric artery simulated that reported by Kowatcheve (1968) in sheep, Horowitz and Nayar *et al*., (1983) in goat, Machado *et al*., (2002) in buffalo and Smuts and Bezuidenhout (1987) in camel or from the left ruminal artery as mentioned by Alsafy (2009) in goat. While, Koch and Berg (1985) in goat and sheep, Raghavan and Kachroo (1964) in ox stated that the reticular artery arises by a common stem with the left ruminal artery from the celiac artery itself.

Our findings, showed that the reticular artery gave off ruminal, reticular and deep branches, as observed by Youssef (1991) in goat and Raghavan and Kachroo (1964) in ox.

The present work showed that the left gastric artery represented the direct continuation of the celiac artery similar to that described by Boccaletti and Borelli (1981) in sheep, Alsafy (2009) in goat, Sisson and Grossman (1969) in ox. However, Simoens *et al*., (1981) in goat and sheep reported that the left gastric artery arises from the hepatic artery.

This study showed that the left gastric artery gave off omasal branches as well as accessory reticular and left gastroepiploic arteries, similar to that reported by Mohamed (2008) in goat. On the other hand, Habel (1975) in ruminants stated that the left gastric artery gives off hepatic and left gastroepiploic arteries.

The results showed that the left gastric artery terminated as a parietal branch and a visceral omasoabomasal branch, similar to that reported by Mohamed (2008) in goat.

In agreement with that reported by Mohamed (2008) in goat, 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.

According to this study, the gastroduodenal artery was the direct continuation of the hepatic artery, as in the goat (Mohamed, 2008). However, Horowitz and Venzke (1966) in goat and Machado *et al*., (2002) in buffalo reported that the gastroduodenal artery originates from the left branch of the hepatic artery.

Our observations agreed with those May (1970) in sheep, Mohamed (2008) in goat, Raghavan and Kachroo (1964) in ox, Wilkens and Munster (1981) in ruminants, that the gastroduodenal artery divided into right gastroepiploic and cranial pancreatico-duodenal arteries. On the other hand, Smuts and Bezuidenhout (1987) in camel showed that the gastroduodenal artery divides into right gastroepiploic and cranial duodenal arteries.

According our study, rumenotomy 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 cranial branches of both the left dorsal and left ventral coronaries arteries of the right ruminal artery (Fig., 3/R) as the blood supply was minimal, so that the incidence of bleeding will be low.

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