

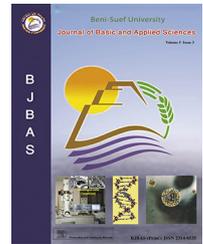
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Full Length Article

Anatomical and radiographical studies on the venous drainage of the udder in goat with special reference to the cranial superficial epigastric vein



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ABSTRACT

The present study was achieved to clarify the venous drainage of the udder in twelve healthy Egyptian Baladi goats. Gum-milk latex injection (nine specimens) and radiographic imaging technique (three specimens) were used to demonstrate the course and tributaries of the main veins draining the udder. The obtained results revealed that the udder of goat was drained through three venous circles, one at its base, while the other two were present in the form of one circle at the base of each teat. The basal venous circle was formed by the external pudendal and cranial superficial epigastric veins, as well as the dorsal labial and mammary branch of the ventral perineal vein. While the papillary venous circle was formed mainly by the cranial and caudal lateral sinus branches of the cranial mammary vein of the external pudendal vein. Also, the origin, course, distribution and termination of the cranial superficial epigastric vein were described. The venous architecture reported in this study could serve as a guide for the further surgical interference within the udder of goat.

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1. Introduction

The udder is a very important physiological and structural component of all dairy animals, so, preservation of its normal function is regarded for production of high-quality milk and vital offspring. Due to the high activity of the mammary gland throughout the lactation period, it is susceptible to several pathological conditions; gangrenous mastitis is one of the main diseases affecting the udder especially in goat (Abu-Samra et al., 1988; Kerr and Wallace, 1978).

The gross anatomical features of the udder were described during surgical interference (Fubini and Ducharme, 2004; Hofmeyer, 1990). Consequently, establishment of specific anatomical studies was required for characterization of the venous architecture of the udder. The current study tried to give a full anatomical description of the venous drainage of the udder in goat which could help as a guide for the surgical interference.

2. Materials and methods

2.1. Animal specimens

The present study included twelve healthy Egyptian Baladi female goats (age 2-5 years, weight 18-27 kg) which were purchased alive from the animals' markets in Beni-Suef Governorate.

2.2. Dissection of the specimens

Nine fresh cadavers were injected with the embalming solution through the common carotid artery (2% Formalin 40%, 2% concentrated liquid phenol, 20% Ethyl alcohol 95%, 6% Glycerin and 70% water), then the specimens were kept in formalin 10% for 7 days. The caudal vena cava was injected with gum-milk latex, colored blue (Rotring ink®). The blood vessels were secured and the whole cadavers were preserved in formalin 10% for 3 days. The specimens were eviscerated and carefully dissected in both sides for demonstration of the origin, course and tributaries of the main veins draining the udder (Hildebrand, 1968).

2.3. Preparation of the radiographic images

Three fresh udder specimens were radiographed using urographine as a contrast medium. The parameters used were 50 K. volt and 70 mAs. The system of films and screen used was C.R. AGFA.

The nomenclatures in this study were adopted according to *Nomina Anatomica Veterinaria* (2012) and the available literatures.

3. Results

The udder of goat was drained by three venous circles, one at its base, while the other two were present in the form of one circle at the base of each teat.

3.1. *Circulus venosus basalis*

This venous circle was formed by the external pudendal and cranial superficial epigastric veins, as well as the dorsal labial and mammary branch of the ventral perineal vein of the internal pudendal vein.

3.2. *V. Pudenda externa (V. Mammaria)*

The external pudendal vein was detached from the pudendoepigastic trunk and then it passed through the inguinal canal to reach the caudal third of the base of the udder as mammary vein (Figs. 1/1&2 and 5/1) just cranial to the mammary lymph node in accompaniment with its satellite artery. The mammary vein was divided into cranial and middle mammary veins. During its course, it gave: ventral labial, caudal basal and caudal mammary veins, as well as branches to the mammary lymph node.

3.2.1. *Ramus labialis ventralis*

The ventral labial vein was one of the collateral branches of the mammary vein having a variable origin in the same specimen as it detached either from the medial aspect of the mammary vein before its bifurcation (Fig. 1/9) or from the medial aspect of the middle mammary vein (Fig. 1/8). However, this branch was not observed in one specimen (Fig. 2). The ventral labial vein passed caudomedially along the medial

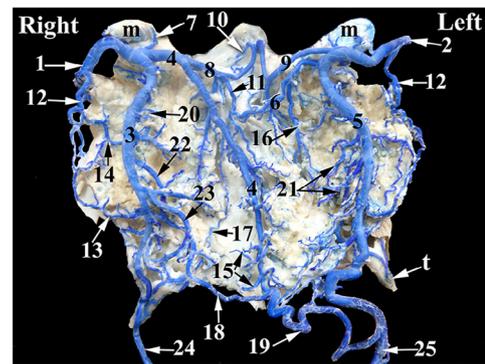


Fig. 1 – A photograph of dissected dorsal aspect of the udder of goat showing the distribution of the mammary vein; m – Mammary lymph node, t – Teat, 1 – R. mammary vein, 2 – L. mammary vein, 3 – R. cranial mammary vein, 4 – R. middle mammary vein, 5 – L. cranial mammary vein, 6 – L. middle mammary vein, 7 – Branch to the mammary lymph node, 8 – R. ventral labial vein, 9 – L. ventral labial vein, 10 – Dorsal labial and mammary branch of the ventral perineal vein, 11 – Anastomosing branch of the ventral labial vein, 12 – Caudal basal vein, 13 – Termination of 12, 14 – Anastomosing branch of the cranial mammary vein, 15 – parenchymal branches of 4, 16 – Medial sinus vein of 6, 17 – Papillary vein of 4, 18 – Anastomosing branch of 4, 19 – Cranial medial basal vein, 20 – Parenchymal branches of 3, 21 – Dorsal branches of 5, 22 – Caudal lateral sinus branch of 3, 23 – Cranial lateral sinus branch of 3, 24 – R. cranial superficial epigastric vein, 25 – L. cranial superficial epigastric vein.

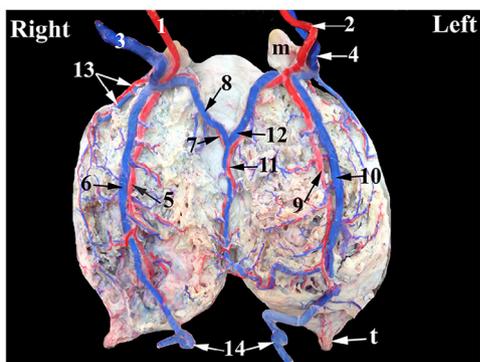


Fig. 2 – A photograph of dissected dorsal aspect of goat's udder showing different size and course of the middle mammary vessels in four specimens. Note the absence of the ventral labial vessels; m – Mammary lymph node, t – Teat, 1 – R. mammary artery, 2 – L. mammary artery, 3 – R. mammary vein, 4 – L. mammary vein, 5 – R. cranial mammary artery, 6 – R. cranial mammary vein, 7 – R. middle mammary artery, 8 – R. middle mammary vein, 9 – L. cranial mammary artery, 10 – L. cranial mammary vein, 11 – L. middle mammary artery, 12 – L. middle mammary vein, 13 – Caudal basal vessels, 14 – Cranial superficial epigastric vein.

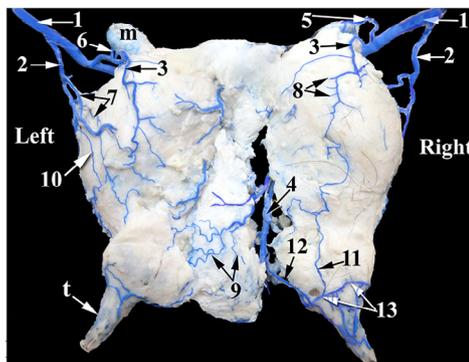


Fig. 3 – A photograph of dissected caudal aspect of goat's udder showing the distribution of the caudal mammary and caudal basal veins; m – Mammary lymph node, t – Teat, 1 – Mammary vein, 2 – Caudal basal vein, 3 – Caudal mammary vein, 4 – Middle mammary vein, 5 – Branch to the mammary lymph node from the mammary vein, 6 – Branch to the mammary lymph node from the caudal mammary vein, 7 – Parenchymal branches of 2, 8 – Parenchymal branches of 3, 9 – Parenchymal branches of 4, 10 – Caudal sinus branch of 2, 11 – Termination of 3, 12 – Anastomosing branch of 4, 13 – papillary venous circle.

border of the mammary lymph node and continued subcutaneously in the perineal region, where it received the dorsal labial and mammary branch of the ventral perineal vein (Fig. 6/1). The ventral labial vein drained the caudomedial aspect of the mammary gland and surrounding skin through 2-3 small branches. Moreover, it gave an anastomosing branch (Figs. 1/11 and 5/7) to join with the middle mammary vein.

3.2.2. *Ramus basalis caudalis*

The caudal basal branch (Figs. 1/12 and 5/8) was considered as the second collateral branch that detached from the lateral aspect of the mammary vein just cranio-lateral to the mammary lymph node. It proceeded cranio-laterally on the lateral aspect of the base of the udder, then it anastomosed with the most rostral part of the cranial mammary vein (Fig. 1/13). Along its course, the caudal basal vein detached about 3-4 small parenchymal branches (Fig. 3/7) to drain the lateral aspect of the mammary gland. It continued cranio-laterally for about 1 cm to give the caudal sinus branch (Fig. 3/10), which ran cranio-ventrally to drain the caudal aspect of the lactiferous sinus through about 3-4 sinus branches, then it terminated in the cranio-lateral aspect of the papillary venous circle (Fig. 4/10).

3.2.3. *V. Mammaria caudalis*

The caudal mammary vein (Fig. 3/3) was detached from the caudal aspect of the mammary vein as a collateral small branch about just cranial to the origin of the ventral labial one. It ran cranio-ventrally on the caudal aspect of the udder to be terminated in the papillary venous circle at the base of the teat (Fig. 3/11). Through its length the caudal mammary vein gave: a branch to the mammary lymph node (Fig. 3/6) and about 5-6 small parenchymal branches (Fig. 3/8) to drain the caudal aspect of the mammary gland.

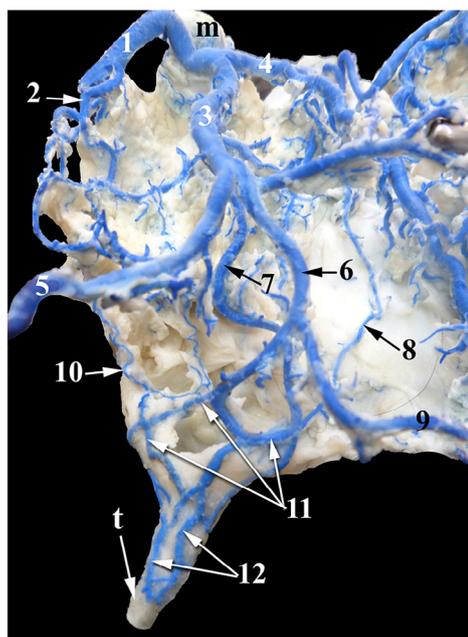


Fig. 4 – A photograph of dissected right half of Fig. 1 showing the venous drainage of its teat; m – Mammary lymph node, t – Teat, 1 – Mammary vein, 2 – Caudal basal vein, 3 – Cranial mammary vein, 4 – Middle mammary vein, 5 – Cranial superficial epigastric vein lifted by forceps, 6 – Cranial lateral sinus vein, 7 – Caudal lateral sinus vein, 8 – Papillary vein of 4, 9 – Anastomosing branch of 4, 10 – Termination of the caudal sinus vein in the papillary venous circle, 11 – Papillary venous circle, 12 – Papillary veins.

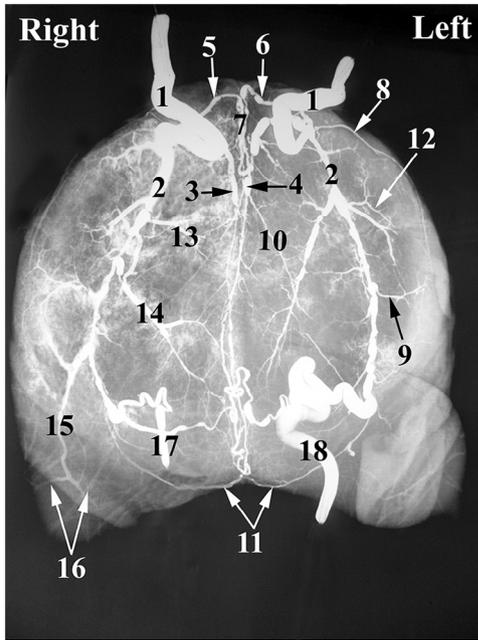


Fig. 5 – A radiographic image of the udder of goat using radio-opaque urographine to show the distribution of the mammary vein; 1 – Mammary vein, 2 – Cranial mammary vein, 3 – Right middle mammary vein, 4 – Left middle mammary vein, 5 – Right ventral labial vein, 6 – Left ventral labial vein, 7 – Anastomosing branch of ventral labial vein, 8 – Caudal basal vein, 9 – Termination of 8, 10 – Medial sinus vein of 4; 11 – Anastomosing branches of 4, 12 – Anastomosing branch of the cranial mammary vein, 13 – Dorsal branches of 2, 14 – Caudal lateral sinus vein of 2, 15 – Cranial lateral sinus vein of 2, 16 – Papillary venous circle, 17 – R. cranial superficial epigastric vein, 18 – L. cranial superficial epigastric vein.

3.2.4. V. *Mammaria media*

The middle mammary vein was one of the terminal branches of the mammary one. The right middle mammary vein (Fig. 1/4) passed ventromedially along the medial suspensory lamina, where it received the small left middle mammary one (Fig. 1/6), and then it continued to drain the medial aspect of both halves of the udder. However, in four out of the investigated specimens the right middle mammary vein (Fig. 2/8) crossed the medial suspensory lamina to be joined with the large left one (Fig. 2/12). Just cranial to the base of the udder, the middle mammary vein continued subcutaneously as cranial medial basal vein (Fig. 1/19) which joined the cranial superficial epigastric vein.

Along its course, the middle mammary vein gave about 7–9 fine parenchymal branches (Fig. 1/15) which drain the mammary gland and lactiferous ducts of the medial aspect of both halves of the udder. About 2.5–3 cm from its origin, it detached a medial sinus vein (Figs. 1/16 and 5/10) which passed cranioventrally to drain the medial aspect of the lactiferous sinus through about 3–4 fine sinus branches. The papillary vein (Figs. 1/17 and 4/8) was given either from right or left middle mammary veins about 2 cm cranial to the origin of the medial sinus vein; it ran

cranioventrally to be joined with the caudomedial aspect of the papillary venous circle at the base of the teat.

At the most cranial part of the base of the udder, the middle mammary vein gave anastomosing branches (Figs. 1/18 and 4/9) that proceeded laterally, then it anastomosed with the cranial lateral sinus branch and papillary venous circle.

3.2.5. *Mammaria cranialis*

The cranial mammary vein (Figs. 1/3&5 and 5/2) was considered the direct continuation of the mammary vein having a superficial course than the middle mammary one through the parenchyma of the mammary gland. Cranial to the base of the udder, it continued subcutaneously as cranial superficial epigastric vein (Figs. 1/24&25 and 5/17&18), that received the cranial medial basal vein. Through its course, the cranial mammary vein gave: about 6–7 parenchymal branches (Fig. 1/20) to drain the udder tissue and about 3–5 dorsal branches (Fig. 1/21) to drain the udder tissue and the lactiferous ducts of the dorso-lateral aspect of the udder. Moreover, about 2 cm from its origin, the cranial mammary vein gave a considerable anastomosing branch of (Figs. 1/14 and 5/12) which ran laterally and received a branch from the caudal basal vein forming a venous plexus to drain the lateral aspect of the udder tissue and lactiferous ducts.

The cranial mammary vein proceeded cranially for about 2.5 cm, then it gave the caudal lateral sinus vein (Fig. 4/7) which passed cranioventrally to drain the caudolateral aspect of the lactiferous sinus. About 1.7 cm cranial to the caudal lateral sinus vein, the cranial lateral sinus one (Fig. 4/6) was given to drain the cranial aspect of the lactiferous sinus. The cranial lateral sinus vein deviated medially toward the base of the teat, where it divided into two papillary veins which received the caudal lateral sinus vein and papillary branch of the middle mammary vein, as well as branches from the caudal mammary and caudal basal veins forming a papillary venous circle (Fig. 4/11), from this circle, about 4–5 papillary veins (Fig. 4/12) were given to drain the teat.

3.3. V. *Labialis dorsalis et mammarius*

The dorsal labial and mammary branch of the ventral perineal vein (Figs. 6/1 and 11/14) passed about 3 cm ventral to the vulva, then it continued subcutaneously in the perineal region for about 4 cm to be joined with the ventral labial branches of both sides at the caudal aspect of the base of the udder, providing an additional route for its venous drainage.

3.4. V. *Epigastrica cranialis superficialis*

The cranial superficial epigastric vein (milk vein) was the direct continuation of the cranial mammary vein, it ran subcutaneously cranial to the base of the udder in the ventral abdominal wall with a tortuous course about 2.2 cm on both sides of the linea alba (Fig. 7). Along its course, it received cutaneous tributaries from the skin and cutaneous trunci muscle (Fig. 7/3). The right cranial superficial epigastric vein deviated laterally from the linea alba about 6 cm caudal to the xiphoid cartilage, where it pierced the outer rectal sheath at the level about 8 cm ventral to the twelfth costal cartilage (Fig. 8/F). However the left one

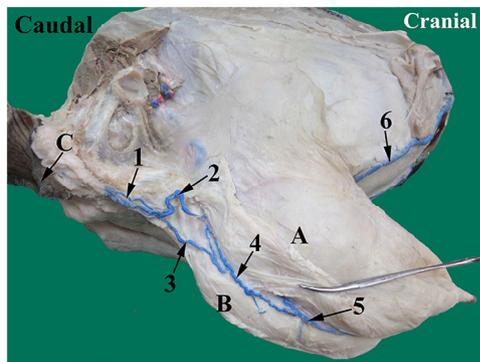


Fig. 6 – A photograph of dissected perineal region in a lateral recumbent goat after removal of the right pelvic limb showing: A – Right half of the udder, B – Left half of the udder, C – Vulva, 1 – Dorsal labial and mammary branch of the ventral perineal vein, 2 – Right ventral labial vein, 3 – Left ventral labial vein, 4 – Anastomosing branch of 2, 5 – Middle mammary vein, 6 – Cranial superficial epigastric vein.

also deviated laterally, but it pierced the outer rectal sheath at the level about 8.8 cm ventral to the tenth costal cartilage (Fig. 9/F).

The cranial superficial epigastric vein of both sides passed between the external and internal laminae of the rectus abdominal muscle, where it received the caudal (deep) epigastric one (Fig. 10/3) to be continued as cranial epigastric vein (Fig. 10/4). The latter vein proceeded rostrally between the two laminae of the rectus abdominal muscle, then it penetrated the internal lamina passing between the xiphoid process of the sternum and the eighth costal cartilage; this penetrating point was known as milk well (Figs. 10/5 and 11/17). The cranial epigastric vein passed through the sternal part of the diaphragm to be continued as internal thoracic vein (Fig. 11/18).

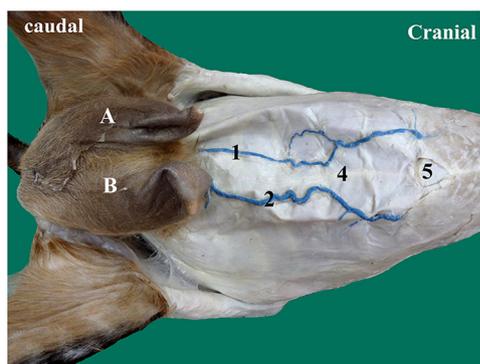


Fig. 7 – A photograph of dissected ventral abdominal wall in a dorsal recumbent goat showing the course of the cranial superficial epigastric vein; A – R. half of the udder, B – L. half of the udder, 1 – R. cranial superficial epigastric vein (milk vein), 2 – L. cranial superficial epigastric vein (milk vein), 3 – Cutaneous tributaries of 1, 4 – Linea alba, 5 – Xiphoid cartilage.

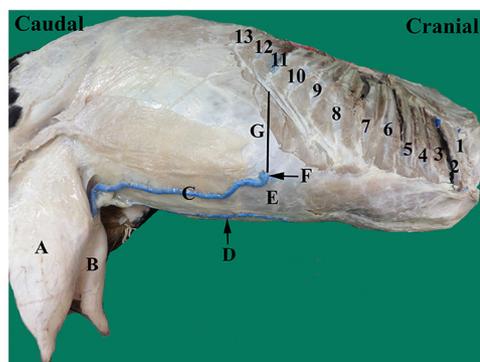


Fig. 8 – A photograph of dissected lateral thoracic and abdominal walls in a lateral recumbent goat showing: A – Right half of the udder, B – Left half of the udder, C – Right cranial superficial epigastric vein, D – Left cranial superficial epigastric vein, E – Outer rectal sheath, F – Right cranial superficial epigastric vein piercing the outer rectal sheath, G – Distance between F and the twelfth costal cartilage, 1-13 represent the corresponding ribs.

The internal thoracic vein continued rostrally between the thoracic surface of the sternum and the transverse thoracic muscle to open in the cranial vena cava (Fig. 11/19).

4. Discussion

The present study revealed that the udder of goat was drained by three venous circles, one at its base, while the other two were present in the form of one circle at the base of each teat. Concerning the basal venous circle, it was formed by the external pudendal and cranial superficial epigastric veins, as well as the dorsal labial and mammary branch of the ventral perineal vein was matching the findings of [Konig and Liebich \(2009\)](#)

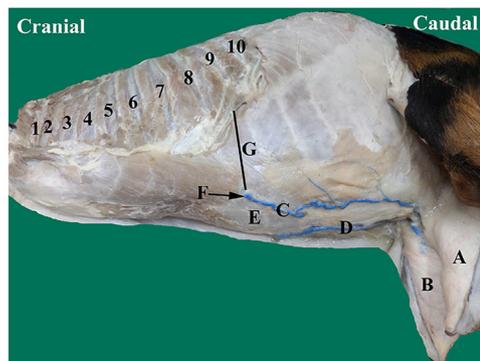


Fig. 9 – A photograph of dissected lateral thoracic and abdominal walls in a lateral recumbent goat showing: A – Left half of the udder, B – Right half of the udder, C – Left cranial superficial epigastric vein, D – Right cranial superficial epigastric vein, E – Outer rectal sheath, F – Left cranial superficial epigastric vein piercing the outer rectal sheath, G – Distance between F and the tenth costal cartilage, 1-10 represent the corresponding ribs.

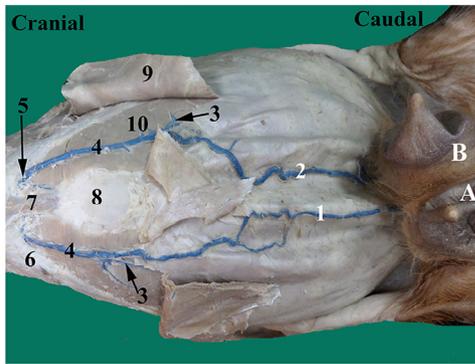


Fig. 10 – A photograph of dissected ventral abdominal wall in a dorsal recumbent goat showing the penetration point of the right and left cranial superficial epigastric veins: A – Right half of the udder, B – Left half of the udder, 1 – Right cranial superficial epigastric vein, 2 – Left cranial superficial epigastric vein, 3 – Caudal (deep) epigastric vein, 4 – Cranial epigastric vein, 5 – Penetration point of 4 (milk well), 6 – Costal cartilage of eighth rib, 7 – Xiphoid process, 8 – Xiphoid cartilage, 9 – External lamina of the rectus abdominis muscle, 10 – Internal lamina of the rectus abdominis muscle.

and Dyce et al. (2010) in ruminants. On the other hand, Saleh et al. (1999) in goat and ewe observed that this circle was formed by the external pudendal, caudal mammary and caudal basal veins.

The terminal division of the external pudendal vein in the current study, into cranial and middle mammary veins was confirmed by the results of Schummer et al. (1981) and Saleh et al. (1999) in goat and ewe, Goshal et al. (1981) in ewe and Badawi et al. (1985) in buffalo. On the other hand, the external

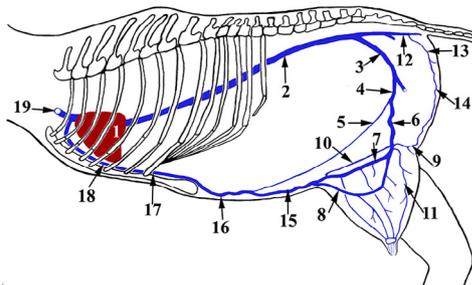


Fig. 11 – A diagram showing the venous drainage of the udder of goat; 1 – Heart, 2 – Caudal vena cava, 3 – External iliac vein, 4 – Pudendoepigastric trunk, 5 – Caudal (deep) epigastric vein, 6 – External pudendal vein, 7 – Cranial mammary vein, 8 – Middle mammary vein, 9 – Ventral labial vein, 10 – Caudal basal vein, 11 – Caudal mammary vein, 12 – Internal pudendal vein, 13 – Ventral perineal vein, 14 – Dorsal labial and mammary branch of 13, 15 – Cranial superficial epigastric vein, 16 – Cranial epigastric vein, 17 – Penetration point of 16 (milk well), 18 – Internal thoracic vein, 19 – Cranial vena cava.

pudendal vein is divided into cranial and caudal mammary veins in goat (Goshal et al., 1981) and cow (Goshal et al., 1981; Schummer et al., 1981).

Similar to the findings of Badawi et al. (1985) in buffalo, the external pudendal vein detached: caudal basal, caudal mammary and ventral labial veins, as well as branches to the mammary lymph node. On the contrary, Saleh et al. (1999) in goat and ewe denied the ventral labial vein.

The ventral labial vein in our investigation was originated either from the external pudendal vein or from the middle mammary one. However, Badawi et al. (1985) in buffalo reported its origin either from the external pudendal vein or by a common stem with the caudal basal one.

Regarding the caudal basal vein, it drained the lateral aspect of the udder in the current data, then it anastomosed with the most rostral part of the cranial mammary vein. On the other hand, it either drains the dorsolateral aspect of the hind quarter, then it joins the ventral labial and caudal mammary veins in buffalo (Badawi et al., 1985), drains the base of the udder sharing in the basal venous circle in goat and ewe (Saleh et al., 1999), or drains the mammary lymph node in ewe (Goshal et al., 1981). Moreover, the caudal basal vein, in our findings, gave a caudal sinus branch to drain the caudal aspect of the lactiferous sinus. The latter branch was detached from the caudal mammary vein in buffalo (Badawi et al., 1985).

Concerning the caudal mammary vein in our study, it drained the caudal aspect of the mammary gland and also the mammary lymph node, then it terminated in the papillary venous circle at the base of the teat. However, in goat and ewe, it shares in the formation of the venous circle at the base of the udder (Saleh et al., 1999). Meanwhile, Badawi et al. (1985) in buffalo revealed that the caudal mammary vein anastomoses with the caudal basal vein and caudal branch of the middle mammary vein, as well as with the caudal mammary vein of the other side.

The anastomosis between the middle mammary veins of both halves through the medial suspensory ligament which was observed in our findings should be highlighted during unilateral mastectomy. These results did not come in line with the study of Frandson et al. (2009) in ruminants who denied any connection between the two halves.

According to the findings of Goshal et al. (1981) in ewe the middle mammary vein gave medial sinus branch to drain the lactiferous sinus. However, Saleh et al. (1999) in goat observed the origin of the latter branch from the cranial mammary vein. The middle mammary vein terminated as cranial medial basal vein which joined with the cranial superficial epigastric vein as reported in buffalo (Badawi et al., 1985).

The cranial and caudal lateral sinus branches of the cranial mammary vein that drained the lactiferous sinus were observed in our study and also in buffalo by Badawi et al. (1985). However, Goshal et al. (1981) and Saleh et al. (1999) observed that the cranial mammary vein detaches only the lateral sinus branch in goat and ewe.

The papillary venous circle in our data was formed by the papillary veins of the cranial and lateral sinus branches of the cranial mammary vein, which received a papillary branch of the middle mammary vein, as well as branches from the caudal mammary and caudal basal veins. A similar circle is observed in goat and ewe by Saleh et al. (1999) and in ewe by

Goshal et al. (1981), which was formed by the medial and lateral sinus branches. On the other hand, Goshal et al. (1981) in goat observed that the teat is drained by the lateral sinus branch of the cranial mammary vein without forming a venous circle.

The course of the cranial superficial epigastric vein was described according to Goshal et al. (1981) in ruminants. This vein pierced the rectus abdominis muscle about 8 cm ventral to the twelfth costal cartilage in the right side, and 8.8 cm ventral to tenth costal cartilage in the left side, meanwhile, Goshal et al. (1981) in goat and ewe reported that it pierces the rectus abdominis muscle at the level of tenth or eleventh rib. Moreover, the penetration point of the cranial epigastric vein to the ventral abdominal wall and the sternal part of the diaphragm was referred as milk well in ruminants (Dyce et al., 2010). This milk well was found caudal to the eighth costal cartilage as proved by Goshal et al. (1981) in ruminants.

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