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RESEARCH OPINIONS IN ANIMAL & VETERINARY SCIENCES

Research article

Applied anatomy of the sternum bone in dromedary camels (*Camelus dromedaries*) with a special reference to the aspiration of sternal bone

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Abstract

The aim of this study was to investigate the sternum skeleton of camel, thereby making a contribution to fill the gap of knowledge in this field. The study represented that the gross anatomical features of the camel were different from other animals. The sternum had the longitudinal structure a boat shape. It consisted of three parts: the manubrium cranially, the body in middle and the xiphoid process. They were all in eight segments. The body sterni increased progressively in width caudally. The high dorso-ventral increased from the first segment to the fourth one, then decreased caudally to the seventh sternbera. The four sternebrae contributed in forming of the pad sternal. The sternebrae connected with the others by synchodroses sternales. The best aspiration site in the camel was between the 2nd and the 3rd sternebrae of the sternum bone.

Keywords: Applied; anatomy; sternum; aspiration; camel

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Introduction

The sternum bone is considered as the complement of the structure of the thorax skeleton. There are a little and very rare literature about the sternum bone of camel. The anatomy of the sternum bone was previously studied in most mammals especially in the horse (Budras et al., 2013). The sternum of ruminants (cattle, sheep and goats) was also described carefully and in detail by Getty (1976), Nickel et al. (2004) and Dyce et al. (2010), therefore, no detailed description is available in camel.

According to the current literature, the camel sternum is composed of three segments. They are manubrium, sternebrae and cartilage xiphoidea (Smuts and Bezuidenhout, 1987). In bovine, Budras and Habel (2011) mentioned that the sternum was consisted of manubrium sterni Sternebrae and xiphoid process, while the sternum of the horse is composed of praesternum (cranial), mesosternum and xiphosternum (Nickel et al., 2004; Wissdorf et al., 2010), as well as it was presented by sternebrae and xiphoid process manubrial cartilage in horse (Budras et al., 2013). Other authors identified one additional bony element and therefore divided the sternum into manubrium sterni and sternebrae 1–6 (Wissdorf et al., 2010).

The numbers of the sternebrae varied according to the species. They are seven in camels (Smuts and Bezuidenhout 1987), eight in carnivores (Nickel et al., 2004), six in pigs, horses, and humans, five in cow (Budras and Habel 2011) and six or seven in goat (Mgasa and Arnbjerg1992). The sternebrae were connected to each other by hyaline cartilage forming synchondroses sternales (Koch and Berg, 1992; Nickel

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et al., 2004). Ventrally, the cartilaginous mass formed a crest, crista sterna (Nickel et al., 2004; Wissdorf et al., 2010) in horse.

Studies reporting bone marrow sampling in domestic animals is very rare. Sternal puncture was the first technique developed for sampling bone marrow in domestic animals (Calhoun, 1954). The marrow aspiration site was the third (III) or fourth (IV) sternebera. It were determined by counting of the rib, starting from the last one (Van Merries et al., 2001) in cows, while the marrow aspiration site was the fourth and fifth sternebera (Eydt et al., 2016) in horse.

Sternal bone marrow is widely used as a source of multipotent mesenchymal stromal cells to treat orthopaedic diseases (Smith et al., 2003; Fortier and Smith, 2008; Kasashima et al., 2011). A sternal puncture is also suitable for cancellous bone biopsy, which is used for autologous cancellous bone grafts (Richardson et al., 1986; Desevaux et al., 2000), or for diagnosis and prognosis of abnormalities of blood cells (Russell et al., 1994; Sellon, 2006). The objective of the study was to provide the detail anatomy of the sternum in camel.

Materials and Methods

Sternum bones of six cadavers adult camels of both sexes and different ages (3-5 years) were used for this study. They were obtained from the veterinary teaching hospital of the Faculty of Agriculture and Veterinary Medicine in Qassim University, Saudi Arabia. The camel was sedated with an intervenous injection of xylazine hydrochloride (Seton 2%, Laboratorios Calier, S.A., Barcelona, Spain) at a dose rate of 0.2 mg/kg body weight.

The skin and subcutaneous tissues (muscles) were removed and the sternum bones were boiled in water with 30% sodium hydroxide about two hours after removing from the thorax bone. The small tissue fragments on the bone were removed by using a maceration techniques in sharp hot water and hydrogen peroxide solution that have been reported by Gram (2006) and Allouch (2014).

For aspiration, the camel was restrained in head tail position. The fore and hind limbs were unilaterally banded by rope to control the work side. A 20 cm^2 area from the ventral surface of the thorax, to the pad sternal cranially was shaved and disinfected with 20% iodine surgical rubbing. The morphology of four sternum bones were described and they was photographed digitally recorded using a 6 mega pixels, Dsc - w 50 Camera.

Results

The sternum bone of the camel is the longitudinal structure along the centerline at the bottom of the thorax. It connects the ribs through cartilages forming the rib cage. The gross anatomical description of the camel sternum reveals that it has four surfaces; dorsal and ventral surfaces and two laterals sides. The sternum bone of camel consists of three parts: the manubrium cranially, the body in the middle and the xiphoid process caudally represented by eight pieces. They are manubrium, six sternebrae forming the body and the xiphoid process.

The manubrium sterni (Fig. 1-4) is the part of the sternum which is located cranially. It has a rectangular quadrangular shape, pointed slightly cranially. It has two dorsal and ventral surfaces and four borders. On each angle of these borders of the manubrium, there are articular facets for the 1st pair of cartilages ribs which articulate with the manubrium sterni cranially. On the other hand, the 2nd pair ribs cartilages articulete with the caudal facets of the manubrium sterni and cranial facets of the body of the sternum, on the same level, the manubrium joins with the first sternebra of the body sternum.

The body sterni (corpus sterni) is the longest part of sternum (Fig. 1-4). It has a dorsal and ventral surfaces and two lateral sides. It possesses seven bony segments which are sternebrae that are connected to each other by articular facets and connective tissue forming synchondroses sternales. The body sterni increases progressively in width toward caudally. The width where there is a cartilaginous connection with the corresponding rib, is 4cm in the first sternebra, 4.5 cm in second sternebra, 5 cm in the third sternebra, 6 cm in fourth sternebra, 8 cm in the fifth sternebra and 9 cm in the sixth sternebra. The high dorso-ventral increases from the first to the fourth segments. They are1.5 cm, 3 cm, 4 cm, 6.5 cm respectively. Then it decreases caudally to become 5.5cm at the fifth setrnmubera, 4.5cm at sixth sternumbera, 3.5 cm at the seventh sternbera, whereas the high of the xiphoid process is 0.5cm.

The dorsal surface of the segments of the body is flat and increases in the diameter caudally. It is marked by three transverse ridges, which cross the bone opposite to the third, fourth, and fifth articular depressions, while the ventral surface of the sternbera decreases its thick from the first to third sternbera. Morerver, the ventral surface of the fourth, fifth and sixth sternberae forms the pad underneath the sternum. It is called the pedestal (Fig. 1&2). It is a very strong, has heart shape. Its thickness is 3-4 cm vertically, 20 cm in diameter. It occupies area about 314 cm^2. The total attachment of the pad is at the fifth and 6ixth sternberae, though fat layer extends from the 4th to the 7th sternum.

The lateral sides of the body sternum possess ribs notches (incisurae costales) for the articulation with cartilages of ribs (Fig. 4). Each of the lateral borders had a depressions and small facet for the costales cartilages articulation.

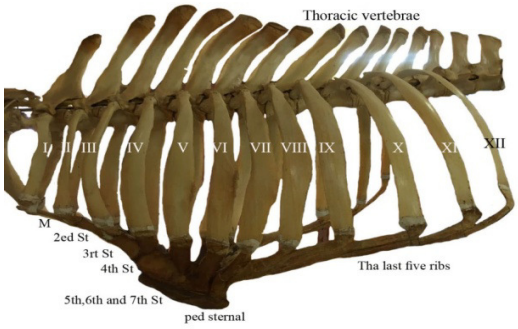

Fig 1: The photograph shows the parts thorax of the camel; sternum bone, thoracic vertebrae and ribs (I-XIII) Manubrium (M), 2nd, 3rd, 4th,5th, 6ixth and 7th sternebrae with pad sternal

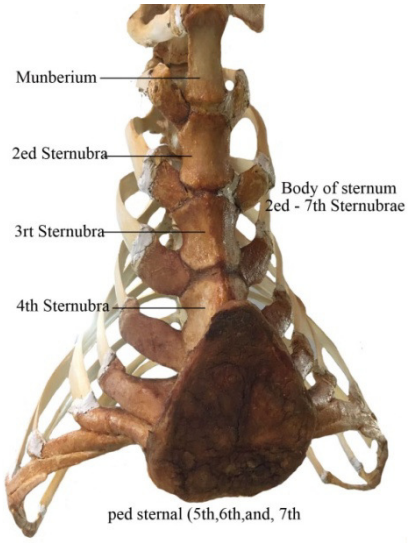

Fig 2: The photograph shows ventral surface of the sternum camel with its parts; Manubrium, 2nd, 3rd, 4th, 5th, 6ixth and 7th sternebrae with pad sterna

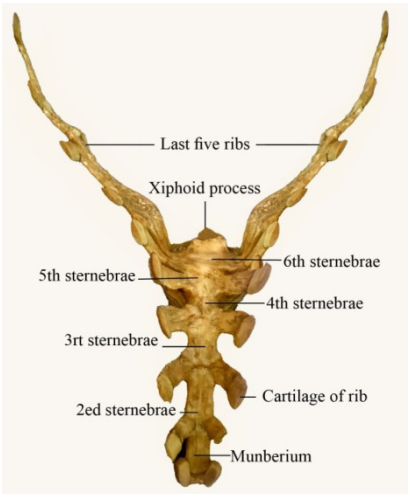

Fig 3: The photograph shows dorsal surface of the sternum with its parts; Manubrium, 2nd, 3rd, 4th, 5th, 6ixth, 7th sternebrae sternal and xiphoid process

The xiphoid process is the last part of the sternum (Fig. 3). It is located at the caudal end of the sternum. It is pointed at the top caudally. Its shape is different from the other sternebrae. It has leaf shape and consisted of two surfaces, dorsal and ventral. Its dorsal surface is provided by two depression between them weak crest, while the ventral surface is smooth and convex.

The points of the ribs cartilages articulation with the sternum are at the sternocostal joints and costocostal connaction with the different pair and position of ribs. The cartilages of the 1st and 2nd pairs ribs join with the cranial and caudal angles of the manubrium of the sternum respectively. The cartilages of the 3rd, 4th and 5th and pairs ribs join between the 1st and 2nd sternebrae. The 2nd and 3rd sternebrae and between the 3rd and 4th sternebrae respectively. The cartilages of the 7th ribs pairs join on the face articulation on the 6th sternebrae of the body. The cartilages of the 8th and 9th ribs pairs connect with the caudal face of the 7th and 8th cartilages ribs respectively.

The technical aspect of sternal bone marrow aspiration necessitates a distinct and detailed anatomical description of the equine sternum for many reasons. It needs perfection and precision. The direction of the biopsy needle to get the bone marrow must be vertical straight in the sternum. It must be done with rotation and controlled pressure. The needle was pushed upwards until a subtle plop was felt indicating that the needle entered the sternal bone marrow then apirate about about 2 ml of marrow (Fig. 6).

The following measurements were recorded:

1-The distance from the bony ventral margin to the centre of the 2nd and 3rd sternebra is 25-35mm,

2. Length of the puncture canal is 30 mm.

Discussion

The gross anatomy of the sternum in dromedary camel was different from the other ruminants. In this study, sternum was consisted of three parts: the manubrium cranially, the body in middle and the xiphoid process united eight segments. It has four surfaces; dorsal and ventral surfaces and two laterals sides. Our results agreed with Smuts and Bezuidenhout (1987) in camel, Budras and Habel (2009) in bovine, Nickel et al. (2004), Wissdorf et al. (2010) and Budras at al. (2013) in horse. On the other hand, other authors identified one additional bony element and therefore divided the sternum into manubrium sterni and sternebrae 1–6 (Wissdorf et al., 2010).

Eydt et al. (2014) mentioned that a uniform arrangement of seven sternebrae within the equine sternum was obtained, whereas the 6th and 7th sternebrae were fused in sterna. In a recent study, also seven bony elements were identified and referred to as

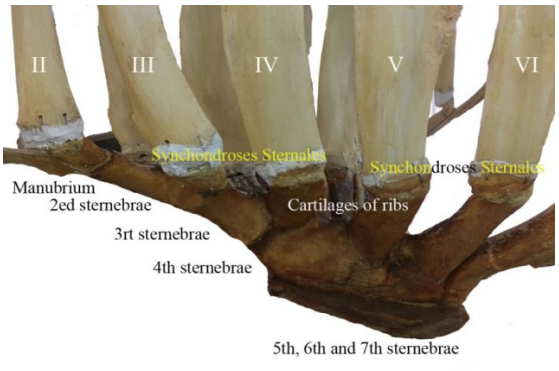

Fig 4: The photograph shows lateral surface of the sternum camel through its parts; Manubrium, 2nd, 3rd, 4th, 5th, 6ixth and 7th sternebrae with pad sternal as well as synchondroses sternales and cartilages of ribs.

Fig 5: The photograph shows the aspiration sit of the sternum between the 2nd and 3rd sternebrae.

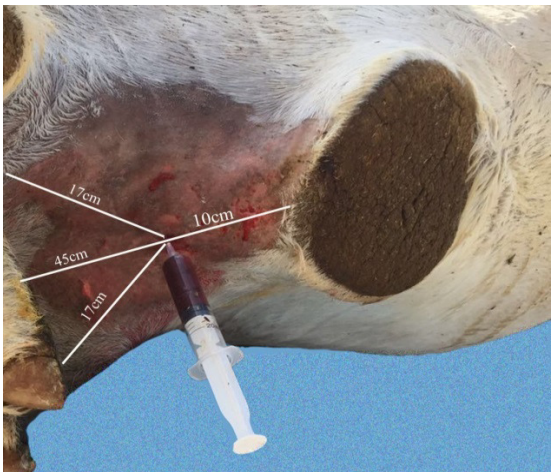

Fig 6: The photograph shows the dimensions of the aspiration sit of the sternum between the 2nd and 3rd sternebrae.

sternebrae 1–7, omitting the term manubrium sterni (Kasashima et al., 2011). Moreover, the number of the sterneberae had seven segments in camel (Smuts and Bezuidenhout, 1987), five segments in bovine (Budras and Habel, 2009) and seven segments in horse (Budras at al., 2013).

The manubrium of the sternum camel has the rectangular quadrangular shape, pointed slightly cranially from the top, which gives it two dorsal and ventral surfaces and four borders. This result agreed with Smuts and Bezuidenhout (1987) in camel and disagreement with results mentioned by Budras and Habel (2009) in bovine (Dyce at al., 2010). The human manubrium sterni was connected to the corpus sterni by fibrocartilage, called symphysis manubriosternalis (Benninghoff and Drenckhahn, 2008).

These results agreed generally with Eydt et al. (2014) who reported that the dorsoventral extension increased from the first to the third sternebrae and then decreased from the fourth to the seventh sternebrae in horse and disagreement with Dyce et al. (2010) who recorded that the body was cylindrical in dog, wide and flat in ruminants, and carries a ventral keel in horse.

Kasashima et al. (2011) recorded that high dorsoventral and the diameter from side to other side increases from the first to sixth segments resulting in a wedge-shaped transverse diameter in human.

In this study, the xiphoid process had leaf shaped. Its dorsal surface was provided by two depression between them weak crest. We found that the xiphoid process was different from other animals that was usually lacked a bony structure in horse (Koch and Berg1992; Nickel et al., 2004; Wissdorf et al., 2010). Pasquini et al. (1997) reported the xiphoid process was a thin, horizonital bone capped by the xiphoid cartilage. On the other hand, It only consisted of a cartilaginous structure (cartilago xiphoidea) and had a flat shape expanding laterally in a caudal direction (Konig and Liebich, 2007).

Budras at al. (2013) mentioned that the xiphoid process was dorsoventrally flattened. Its ventral border formed a cartilaginous crest. While the xiphoid process was smaller than that in the horse (Budras and Habel, 2009). In the current study, ventral surface of the fourth, fifth and sixth sternberae form the pad underneath the sternum.

Concerning the dimensions and the topographical relations of the individual sternebrae might help to identify the most suitable positions for sternal puncture and might help to obviate risks.

The results revealed that the aspiration site was on the ventral margin of the sternebrae. This site was determined through the right and left imaginary lines, that extended from axillae until the middle between the second and third sternebrae of the sternum bone. Our

results disagree with Van Merries et al. (2001) who recorded that the marrow aspiration site was the third (III) or fourth (IV) sternebera. It was determined by counting of the rib, starting from the last one (Van. Merries et al., 2001) in bovine and horse (Eydt et al., 2016). The presented that the bone marrow aspirates from the fourth sternebra and the fifth sternbera were collected at two different positions within the sternebrae, either from 10 mm or from 30 mm dorsal from the ventral margin of the fourth sternebrae.The fifth sternebra appeared most suitable for bone marrow aspiration in horse (Eydt et al., 2016).

Conclusion

The obtained data provide a sufficient basis to establish a standard aspiration of the camel sternum. Puncturing the camel sternum utilizes a different approach than with other domestic animals. The gross anatomical features of the camel were different from other animals,the gross anatomical description of the sternum was the longitudinal structure as boat shaped. It consisted of three parts: the manubrium cranially, the body in middle and the xiphoid process united eight segments. The sternebrae were connected with other by synchodroses sternales. The best aspiration site in the camel was between the second and the third sternebrae of the sternum bone.

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Competing interests

The authors declare that it has no financial or personal relationships which may have inappropriately influenced them in writing this article.

Authors contributions

G. A. (Syri) planned and conceived the search. the data. G. A. (Syri), interpreted the results and designed the figures. wrote the manuscript. The author read and approved the final manuscript.

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