

Proceeding Paper

Diaphragm Bone in Dromedary (*Camelus dromedarius* L., 1758): Anatomy and Investigation Using Computed Tomography Imaging [†]

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Abstract: The aim of this work is to provide some anatomical data using a non-invasive method. Nine entire diaphragms of adult dromedaries were collected randomly at the slaughterhouse, and the bones prepared at the anatomy laboratory of Ouargla (Algeria). The CT examinations were performed on a 16-section CT device made by Siemens (Sensation 16, dedicated to the environment and the veterinary industry by Image-ET (Mordelles, France)). This bone is flat on one side and protruding on the other. The central part of the bone has an average HU value of -176 (-684 to 88), which clearly corresponds to the cancellous bone, and the external surface of the bone has an average HU value of 2320 (1979 to 2664), which corresponds to the compact bone. This study allows us to have a better understanding of the variability and structure of the dromedary diaphragm bone.

Keywords: diaphragm; bone; dromedary; anatomy; scan



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1. Introduction

In arid regions, the dromedary is a domestic animal raised in the same way as other farm animals (cattle, sheep, goats, horses, etc.) for its production of milk and meat, and for its ability to bat [1]. Its hardiness in a low productivity environment, its milk, its meat, and its work are very appreciated by breeders, whose life depends on it in the desert [2], even if this species has long remained marginal for scientific studies [3]. The bone of the diaphragm in the dromedary has always been present (Figure 1). Few studies about this bone exist [4,5], and nearly no morphometric study has evaluated its characteristics. Namshir [5] just indicates that the diaphragm bone is 0.6–1.4 cm thick, 1.7–2.2 cm wide, and 3.3 cm long. The aim of this work is to provide some anatomical data using a non-invasive method, i.e., CT scanning. The scanner is widely used in human and veterinary medicine as a complementary examination. It allows 3D reconstructions of the organs. Here, it allows access to the internal structure of the bones without damaging them.

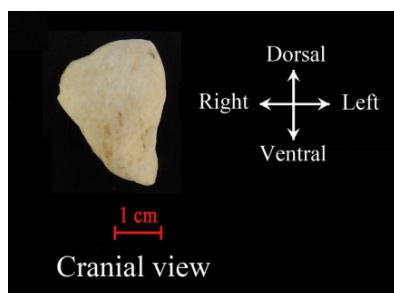


Figure 1. Dromedary diaphragm bone.

2. Materials and Methods

A total of nine entire diaphragms of the dromedary were collected randomly at a slaughterhouse and prepared at the anatomy laboratory of Ouargla. The diaphragm bones (Figure 2) were sent to France for CT scan analysis. CT examinations were performed on a 16-slice computed tomography device manufactured by Siemens (Sensation 16, dedicated to the veterinary environment and industry by Image-ET (Mordelles, France)). The CT scanning was performed with a thickness of 750 µm per acquisition. Herein, 3D reconstructions were made from 100 to 200 images according to the bone size.

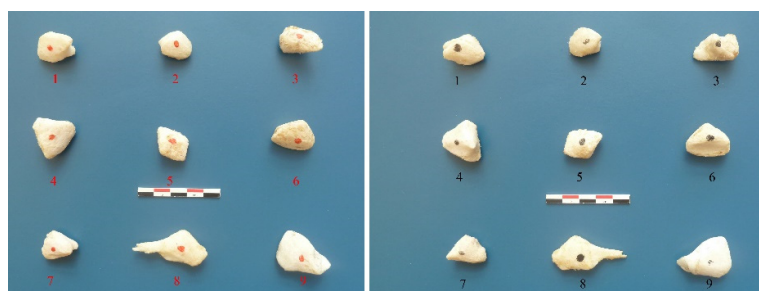


Figure 2. Cranial (left side) and caudal (right side) views of the nine diaphragm bones.

3. Results and Discussion

This bone is flat on one side and protuberant on the other. The central part of the bone has a mean HU value of -176 (-684 to 88), which corresponds clearly to the spongius bones, and the external surface of the bone has a mean HU value of 2320 (1979 to 2664), corresponding to a compact bone (Table 1). Few studies about this bone exist [4,5], and nearly no morphometric study presents its characteristics. These results are the first obtained on this bone using CT scans. No comparison studies have been published to our knowledge.

Table 1. Size (CC [thickness], PD [length] and LR [width]) in cm and CT scan density in Hounsfield Unit (UH).

Bone	CC (cm)	PD (cm)	LR (cm)	UH max (ext.)	UH max (int.)	UH min (int.)	UH mean (int.)
1	0.99	2.45	1.75	2664	584	-981	-60
2	1.00	1.55	1.78	2334	654	-1024	-65
3	1.09	1.61	2.39	1979	381	-1024	-263
4	1.40	2.38	2.45	2470	509	-1024	-684
5	0.89	1.78	2.43	2597	915	-1012	-58
6	1.24	1.92	2.65	2315	605	-1024	-274
7	1.06	1.95	2.21	2328	526	-1024	-325
8	0.81	2.22	4.49	2063	761	-1007	59
9	1.08	2.34	3.21	2127	938	-884	88

Table 1. Cont.

Bone	CC (cm)	PD (cm)	LR (cm)	UH max (ext.)	UH max (int.)	UH min (int.)	UH mean (int.)
Mean	1.06	2.02	2.59	2320	653	−1000	−176
Max	1.40	2.45	4.49	2664	938	−884	88
Min	0.81	1.55	1.75	1979	381	−1024	−684
SD	0.18	0.34	0.84	234	187	46	240

It consists of a central part with the marrow and a peripheral compact cortex. The size of the bone is 0.81–1.40 cm thick, 1.55–2.45 cm wide, and 1.75–4.49 cm long.

4. Conclusions

These preliminary results give us a better understanding of the variability and the structure of the dromedary diaphragm bone.

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References

- Guintard, C.; Babelhadj, B. Morphotypes et force animale développée. Comparaison de deux populations de dromadaires algériens: La Sahraoui et la Targui (*Camelus dromedarius*, L.). In *Animal Source D'énergie: Enquêtes dans l'Europe Pré-Industrielle*; Guizard, F., Beck, C., Eds.; Presses Universitaires de Valenciennes: Valenciennes, France, 2018; pp. 133–147.
- Faye, B. *Statut Nutritionnel du Bétail Dans la République de Djibouti*; Ministère de la Coopération: Paris, France, 1989.
- Narjisse, H. Nutrition et production laitière chez le dromadaire. *Options Méditerranéennes-Série Séminaires* **1989**, *2*, 163–166.
- Maskar, U. Bones of the diaphragm in camels. *Acta Anat.* **1957**, *30*, 461–471. [[CrossRef](#)] [[PubMed](#)]
- Namshir, N. Regional anatomy of camel internal organs. *J. Agric.* **1982**, *3*, 25.

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