Preface

I am glad to present, with great pleasure, the first volume of a new scholarly fully open access journal, Journal of Camel Health (JCH). JCH is an international publication planned for the practicing camel veterinarian, camel researcher, and other camel health care specialist. The JCH will publish worldwide contributions on all aspects of camel science and its related subjects. JCH is a new publication which strongly encourages a multidisciplinary approach to research in the camel health spectrum. Our promise is to provide an important source of information for the benefit of cameld researchers and the improvement of knowledge. The focus of our journal has to be the propagation of knowledge and support cameld researchers to interconnect their findings with the wider cameld research community worldwide. While doing this, the journal will preserve its well-recognized high standard of scientific superiority. The scope of the journal is modernized to cover nutrition, feeds and feeding; behavior, welfare and ethics; livestock production and management; meat, dairy, food Safety; microbiology; physiology, reproduction and endocrinology; surgery and clinical Sciences; epidemiology and public health; and pathology, immunology, virology and pharmacology. JCH will comprise original research, reviews, case reports, short communications, and clinical techniques from leaders in the camel field. The journal, authors and reviewers share an accountability to progress the quality and the standard of the journal, and all should be honored of what has been accomplished. I would like to take this occasion to inspire all cameld researchers, including our counterparts in Saudi Arabia, to consider the JCH for publications. We would like to read more about the dromedary camels in Saudi Arabia and learn about the progress made in better understanding the different aspects of their biology. It is our hope that this fine collection of articles will be a valuable resource for our readers and will stimulate further research into the vibrant area of camel science. I would finally like to thank all authors, who have chosen the JCH for publication, for their contribution and dedication to the journal. Thanks again to all of you and I wish you all a happy and successful 2020.

December 1, 2019

Dr. Abdullah Alsayeqh

Editor-in-Chief
Achilles tendon rupture in camel (*Camelus dromedarius*): Radiographic and Ultrasonographic findings

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**Abstract**

This study describes the clinical presentation of Achilles tendon rupture and evaluates the utility of radiography and ultrasonography in the diagnosis of such disorder in dromedary camels. Seventeen camels were included in this study based on the clinical, radiographic and ultrasonographic evidence of Achilles tendon rupture. The clinical, radiographic and sonographic findings of studied camels differ according to the type, duration, and location of the tendon rupture. Complete and incomplete rupture of the Achilles tendon was precisely diagnosed in five (29.4%) and twelve (70.6%) camels respectively; ruptured deep and superficial parts of the Achilles tendon were recorded in 10 (58.8%) and 2 (11.8%) camels respectively. Clinically, the camels exhibited an acute non-weight-bearing lameness (second to fourth-grade lameness), with swelling in the tendon near the calcaneus. Radiographs revealed swelling of the soft tissues surrounding the Achilles tendon just proximal to the calcaneal tuberosity in most of the camels with the presence of avulsion fracture of the calcaneus in few cases (n=2). Ultrasonographically, the ruptured part was precisely diagnosed as swollen, oedematous, heterogeneous structure with the presence of anechoic or hypoechoic areas (core lesion). In conclusion, lateromedial radiographs and ultrasonography were helpful in diagnosis and differential diagnosis of different types of Achilles tendon rupture and subsequent clinical decision and surgical interference in dromedary camels.

**Key words:** Achilles, radiographic, rupture, tendon, ultrasonographic.

1. **Introduction**

   The importance of dromedary camel is conferred upon them through their significant contribution in milk, meat, wool and leather production, as well as camel race in many countries [1, 8]. Achilles tendon rupture is a dramatic and often fatal injury; it has been recorded in farm animals resulting in high economic losses. The most common cause of Achilles tendon rupture is reportedly acute direct trauma with hard and sharp objects (wire or shovel), resulting in its complete or incomplete rupture [4]. Achilles tendon consists of the gastrocnemius, superficial digital flexor, and the common tendon of the biceps femoris, gracilis and semitendinosus muscles. The proximal part of superficial digital flexor tendon lies cranial to the gastrocnemius, then the tendon passes distally medial to the caudal aspect of the gastrocnemius tendon. The superficial digital flexor tendon inserted on the tuber calcis then it distally continues to insert on the proximal caudal border of the second phalanges of the digit [3].

   Gastrocnemius tendon rupture is reported in case of partial Achilles tendon rupture, while the superficial digital flexor remains intact; it is
associated with hyperflexion of the digit and tarsus due to superficial digital flexor contraction [3, 9]. Despite camel popularity and to the authors’ knowledge; few reports have assessed Achilles tendon rupture and little studies evaluated the ultrasonography as a non-invasive imaging technique in the diagnosis of Achilles tendon rupture in camels. Therefore, this study was designed to improve relevant knowledge, and to describe the clinical, radiographic and ultrasonographic features of Achilles tendon rupture in dromedary camels.

2. Materials and methods

2.1. Animals

A total of seventeen dromedary camels (11 males and 6 females) were admitted to Veterinary Teaching Hospital, Faculty of Veterinary Medicine, Qassim University, Saudi Arabia between April 2018 and May 2019. Their ages were ranged from 18 to 121 months (mean ± SD: 98 ± 13 months), weighing between 300 and 750 kg (480 ± 120, mean ± SD) and of different breeds (10 Wadeh, 1 Ashaal, 1 Asfar and 5 Mejhem). Camels were included in the study based on clinical, radiographic and ultrasonographic evidence of Achilles tendon rupture of various types. Achilles tendon rupture was classified into acute or chronic according to duration (time elapsed after rupture up to the presentation to the clinic), into partial or complete according to ruptured components (Table 1) (Fig. 1 and 2). The committee of animal welfare and ethics, Laboratory Animal Control Guidelines of Qassim University approved the study protocol.

2.2. Clinical examination

Camels were clinically examined to determine the physical characteristics of ruptured Achilles tendon including cause, type, and duration. The age, breed, and sex of the camels were recorded. These parameters were evaluated, compared and analyzed. Types of Achilles tendon rupture were detected by physical palpation, radiographic and ultrasonographic examinations. In all investigated camels, the type of Achilles tendon rupture is presented in Table 1.

Table 1: Clinical finding of complete and incomplete ruptures of the Achilles tendon (N=17) in camel.

<table>
<thead>
<tr>
<th>Case No.</th>
<th>Breed</th>
<th>Age</th>
<th>Sex</th>
<th>Type of rupture</th>
<th>Cause</th>
<th>Sharp/Blunt trauma</th>
<th>Duration</th>
</tr>
</thead>
<tbody>
<tr>
<td>1-</td>
<td>Wadeh</td>
<td>5 Yrs</td>
<td>Male</td>
<td>Left Achilles complete rupture</td>
<td>Sharp</td>
<td>2 Days</td>
<td></td>
</tr>
<tr>
<td>2-</td>
<td>Wadeh</td>
<td>2 Yrs</td>
<td>Female</td>
<td>Left Achilles complete rupture</td>
<td>Sharp</td>
<td>5 Days</td>
<td></td>
</tr>
<tr>
<td>3-</td>
<td>Asfar</td>
<td>9 Yrs</td>
<td>Male</td>
<td>Right Achilles incomplete rupture (deep part)</td>
<td>Sharp</td>
<td>3 Days</td>
<td></td>
</tr>
<tr>
<td>4-</td>
<td>Ashaal</td>
<td>4 Yrs</td>
<td>Male</td>
<td>Right Achilles complete rupture</td>
<td>blunt</td>
<td>3 Days</td>
<td></td>
</tr>
<tr>
<td>5-</td>
<td>Mejhem</td>
<td>8 Yrs</td>
<td>Female</td>
<td>Left Achilles incomplete rupture (superficial part)</td>
<td>Sharp</td>
<td>5 Days</td>
<td></td>
</tr>
<tr>
<td>6-</td>
<td>Wadeh</td>
<td>6 Yrs</td>
<td>Male</td>
<td>Left Achilles incomplete rupture (superficial part)</td>
<td>blunt</td>
<td>2 Days</td>
<td></td>
</tr>
<tr>
<td>7-</td>
<td>Mejhem</td>
<td>2 Yrs</td>
<td>Female</td>
<td>Left Achilles complete rupture</td>
<td>blunt</td>
<td>One Day</td>
<td></td>
</tr>
<tr>
<td>8-</td>
<td>Wadeh</td>
<td>8 Yrs</td>
<td>Male</td>
<td>Right Achilles incomplete rupture (deep part)</td>
<td>Sharp</td>
<td>2 Days</td>
<td></td>
</tr>
<tr>
<td>9-</td>
<td>Mejhem</td>
<td>5 Yrs</td>
<td>Female</td>
<td>Right Achilles incomplete rupture (deep part)</td>
<td>blunt</td>
<td>2 Days</td>
<td></td>
</tr>
<tr>
<td>10-</td>
<td>Wadeh</td>
<td>4 Yrs</td>
<td>Male</td>
<td>Left Achilles incomplete rupture (deep part)</td>
<td>blunt</td>
<td>One Day</td>
<td></td>
</tr>
<tr>
<td>11-</td>
<td>Wadeh</td>
<td>7 Yrs</td>
<td>Male</td>
<td>Right Achilles incomplete rupture (deep part)</td>
<td>blunt</td>
<td>One Day</td>
<td></td>
</tr>
<tr>
<td>12-</td>
<td>Mejhem</td>
<td>3 Yrs</td>
<td>Female</td>
<td>Right Achilles incomplete rupture (deep part)</td>
<td>blunt</td>
<td>2 Days</td>
<td></td>
</tr>
<tr>
<td>13-</td>
<td>Wadeh</td>
<td>8 Yrs</td>
<td>Male</td>
<td>Left Achilles complete rupture</td>
<td>Sharp</td>
<td>One Day</td>
<td></td>
</tr>
<tr>
<td>14-</td>
<td>Wadeh</td>
<td>5 Yrs</td>
<td>Male</td>
<td>Left Achilles incomplete rupture (deep part)</td>
<td>blunt</td>
<td>2 Days</td>
<td></td>
</tr>
<tr>
<td>15-</td>
<td>Mejhem</td>
<td>7 Yrs</td>
<td>Male</td>
<td>Right Achilles incomplete rupture (deep part)</td>
<td>blunt</td>
<td>2 Days</td>
<td></td>
</tr>
<tr>
<td>16-</td>
<td>Wadeh</td>
<td>10 Yrs</td>
<td>Male</td>
<td>Left Achilles incomplete rupture (deep part)</td>
<td>blunt</td>
<td>3 Day</td>
<td></td>
</tr>
<tr>
<td>17-</td>
<td>Wadeh</td>
<td>3 Yrs</td>
<td>Female</td>
<td>Right Achilles incomplete rupture (deep part)</td>
<td>Sharp</td>
<td>6 Day</td>
<td></td>
</tr>
</tbody>
</table>

2.3. Radiographic examination

Radiographic examination was carried out in lateral recumbency using Minx ray HF 100/30 generator (Toshiba, Tokyo, Japan) with a 70 kV, 2.0 mAs and a 70 cm focal film distance. Carniocaudal and 1ateromedial standard radiographs were obtained for the ruptured Achilles tendon (Fig. 1B and C). Intravenous light sedation of studied camels using 0.2 mg/kg xylazine HCl (Seton 2%, Laboratorios Calier, S.A., Barcelona, Spain) was performed. All radiographs were subjectively interpreted.

2.4. Ultrasonographic examination

Ultrasonographic examinations of ruptured Achilles tendon were carried out in lateral recumbency, using a 3.5-5 MHz sector and 7.5 MHz
linear transducers (SSD-500, Aloka, Japan). Lightly sedation of the examined camels was achieved by using an intravenous injection of 0.2 mg/kg xylazine HCl (Seton 2%, Laboratorios Calier, S.A., Barcelona, Spain). According to the site of the rupture, preparation of the examined area on each camel was performed by clipping and shaving of the skin. For evaluation of the type of rupture, it was examined ultrasonographically by moving the transducer craniocaudally begging from the healthy part of the tendon towards the ruptured one. Ultrasonographically, the evaluation of ruptured Achilles tendon depends on the echogenicity of ruptured components.

3. Results

3.1. Clinical findings

Out of the 17 studied camels, complete and incomplete ruptures of the Achilles tendon were precisely diagnosed in five (29.4%) and twelve (70.6%) camels respectively; ruptured deep and superficial parts of the Achilles tendon were recorded in 10 (58.8%) and 2 (11.8%) camels respectively. The camels suffered from rupture of the Achilles tendon exhibited an acute non-weight-bearing lameness, (second to fourth-grade lameness were reported in all studied camels) with moderate to severe swelling in the tendon near the calcaneus. In case of the absence of penetrating laceration, careful palpation revealed the disruption in the tendon at or proximal to the calcaneus. The rupture of the Achilles tendon in camels occurred due to sharp cutting wound by a sharp object such as barbed wire and due to blunt trauma as in case of car accidents. In the present study, the duration of the tendon rupture (time elapsed after rupture up to the presentation to the clinic), varied in the studied camels from one to six days. Achilles tendon rupture in camels had a higher prevalence in Wadeh camels than other studied breeds (10 vs 7) (Table. 1).

3.2. Radiographic findings

Craniocaudal and lateromedial radiographs revealed severe swelling of the soft tissues surrounding the ruptured Achilles tendon just proximal to the calcaneal tuberosity in most of the affected camels, in addition to the presence of increased density in the area of the calcaneal attachment. Avulsion fracture of the calcaneus was diagnosed in two camels (Fig. 1B and C).

3.3. Ultrasonographic findings

Ultrasonographic examinations of 17 camels revealed that, the ruptured part of the Achilles tendon was typically appeared as a swollen, edematous, inhomogeneous structures, as well as presence of anechoic or hypoechoic areas and thickening of the proximal and distal edges, in addition to focal area of fibrillar interruptions and blurring of the tendon texture (Fig. 2).
4. Discussion

Achilles tendon rupture is a common serious affection in camels, it frequently required surgical interference to overcome their complications in such animals. Because of the limited knowledge about Achilles tendon rupture in camel and its incidence in the available literature. Therefore, the present study was to describe the use of clinical, radiographic and ultrasonographic findings in the diagnosis of such affection in dromedary camels.

The occurrence of Achilles tendon rupture in different breeds of the camel was reported in the present study. Wadeh camels represent the highest prevalence in comparison to other studied breeds (10 vs 7). This may be contributed to the high number of Wadeh camels among other camel breeds in the Kingdom of Saudi Arabia in relation to their productive and reproductive and economical values [1, 8].

Case history and physical examination are routinely performed for the diagnosis of Achilles tendon rupture in camels. Radiographic and ultrasonographic examinations are non-invasive imaging techniques that could be used for diagnosis and differential diagnosis of various types of Achilles rupture in such animals, especially when physical examinations do not provide an accurate and conclusive clinical decision. In the present study, the radiographic and ultrasonographic appearance of Achilles tendon ruptures varied according to their type, duration, and location. These findings were in coinciding with, Piermattei et al., 2006 [7], Hashefi, 2009 [5] and Kofler, 2009 [6].

Sonographic features of damaged Achilles tendon included areas of lower echogenicity and blurring of the tendon texture. The echogenicity differed according to the type of the Achilles rupture; it varied from anechoic to hypoechoic areas with thickening of the proximal and distal edges in superficial or in deep part in case of partial rupture or both of them in case of complete one diagnosed in this study. These findings were in coinciding with Hashefi, 2009 [5] and Kofler, 2009 [6]. Radiographs of the ruptured Achilles tendon showed severe swelling of the soft tissues surrounding the ruptured tendon just proximal to the calcaneal tuberosity in most of the studied camels. Similar results were reported by Piermattei et al., 2006 [7].

The Achilles tendon consists of three tendinous parts [2, 3]. In this study, Complete and incomplete rupture of the Achilles tendon was precisely diagnosed in five (29.4%) and twelve (70.6%) camels respectively; ruptured deep and superficial parts of the Achilles tendon were observed in 10 (58.8%) and 2 (11.8%) camels respectively. Rupture of the Achilles tendon in studied camels exhibited an acute non-weight-bearing lameness (second to fourth-grade lameness) with swelling in the tendon near the calcaneus. Similar results were reported by Fubini and Ducharme, 2017 [4].

In this study, Achilles tendon rupture is common surgical disorders mostly caused by sharp or blunt trauma such as by barbed wire and car accident respectively. Its diagnosis is considered as an important challenge for veterinarians, given their complexity on physical examinations. Therefore, the utility of radiography and ultrasonography for the evaluation of various types of Achilles tendon rupture provides a fast and reliable paradigm for their diagnosis. These findings were in coinciding with, Piermattei et al., 2006 [7] and Fubini and Ducharme, 2017 [4].

Conclusion

Ultrasoundographic and radiographic examinations are non-invasive diagnostic imaging techniques provide diagnosis, differentiation and subsequent surgical decision of various types of Achilles tendon rupture in dromedary camels.

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References


Prevalence and chemotherapy of contagious skin necrosis in dromedary camels at Qassim region, central of Saudi Arabia

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Abstract

This study was executed in Qassim region, central of Saudi Arabia to determine the clinical and therapeutic impact associated with contagious skin necrosis (CSN) in dromedary camels. One thousand dromedary camels were used in this study. The prevalence of contagious skin necrosis among examined camels was 2.70%. The prevalence of the disease was significantly (p = 0.01) higher in camels under three years (4.55%) than camels older than three years (1.49). Concerning gender predisposition, the prevalence was significantly (p = 0.0001) higher in male camels (13.78%) than females ones (1.14%). Clinically, camels infected with contagious skin necrosis showed lesions in the form of multiple circular necrotic areas of the skin and sometimes multiple abscesses in brisket and chest areas. Treatment of the infected camels using Amoxycillin and clavulanic acid gave the same results as penicillin plus streptomycin but it offers a faster cure rate. Finally, it can be concluded that contagious skin necrosis in camels is common in Saudi Arabia and Amoxycillin and clavulanic acid is the best choice for treatment.

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Key words:
Camels; Contagious skin necrosis; Prevalence; Signs; Treatment.

1. Introduction

The anatomical and physiological structure of camels makes the camels highly adapted to the difficult and adverse climatic conditions that they are exposed to in the desert. However, camels are affected by many major diseases decrease their productivity and welfare [1]. Skin health and appearance of the skin reflect are usually reflect the camel health [2].

Contagious skin necrosis (CSN) is an infectious disease affecting the skin of young dromedary camels caused mainly by Staphylococcus aureus and characterized by skin lesions mostly in the shoulder and neck regions [3,4].

Contagious skin necrosis was described for the first time by Cross [5] who ranked the disease as second to mange in term of importance in all camel disease. Also, Higgins and McGrane [6] classified contagious skin necrosis as a common disease affecting camels in all camel raising countries.

Dietary salt deficiency has been associated with the occurrence of contagious skin necrosis and regular supplemental feeding of salt may reduce the incidence of disease [7].

Transmission of contagious skin necrosis occurs mainly by direct contact with infected camels or via indirect contacts with contaminated inanimate objects, such as blankets and baggage [8, 9]. The pus exudates from infected camels are the main source of infection [10].

Diagnosis of contagious skin necrosis based on clinical examinations whereas isolation and identification of the causative agents from the lesions are necessary for confirmation [1,11, 12].

Camels are sources of milk, meat, drought power and serve as means of transportation, and
hence, they support the survival of millions of people in different areas in camel-raising countries [7].

Camel skin diseases are common in Saudi Arabia. So, this study was directed to determine the clinical and therapeutic impact associated with contagious skin necrosis (CSN) in dromedary camels in Qassim region, central of Saudi Arabia.

2. Materials and methods

2.1. Animals

One thousand dromedary camels of different ages and sexes at Qassim region, central of Saudi Arabia used in this study.

2.2. Samples

Swabs were collected from the lesions and deep necrotic tissues after disinfection for bacteriological examination.

2.3. Clinical examination

Animals under study were subjected to careful clinical examination. Temperature, pulse, respiratory rate, state of lymph nodes were recorded [13].

2.4. Epidemicological investigation

Some epidemicological parameters including prevalence rate, age and sex susceptibility were estimated [14].

2.5. Bacteriological and mycological examination

Direct microscopic examination

Smears were prepared from the affected lesions, fixed by heating, stained with Gram’s stain, and examined under the microscope [15].

2.6. Bacteriological Culturing

Swabs were collected and inoculated onto 5% sheep blood, MacConkey, Edward's and Manitol salt agars. These plates were incubated aerobically at 37°C and examined for growth at 24 - 48 hours. Hemolysis and colonial morphology were recorded after 24 - 48 hours. Identification and classification of the isolated bacteria were done based on the colonial and morphological characters [16].

2.7. Therapeutic trials:

Infected camels were divided into two groups. The first group (17 camels) was treated using Amoxycillin and clavulanic acid (Synulox®, Pfizer) once daily for 5 days as an intramuscular injection at a dosage rate of 8.75 mg/kg body weight (1 ml/20 Kg B.W). The second group was treated using penicillin-streptomycin (Pen & Strep/ NorBrook company) administered by deep intramuscular once daily for 5 consecutive days at doses of 8 mg procaine penicillin and 10 mg dihydrostreptomycin sulphate per kg bodyweight (1ml/25 Kg B.W). In both groups, flushing of the affected area of skin using povidone iodine and supplementation with sodium chloride salt were done.

2.8. Statistical analysis

Chi-Square was estimated for the obtained data using the SPSS for Windows (Version 15.0, USA) statistical software program and probability (P-values) of less than 0.05 was considered significant.

3. Results

Out of the examined 1000 camels, the prevalence of contagious skin necrosis was 2.70%. Owing to age predisposition, the prevalence in camel under three years was 4.55% and in camels over three years was 1.49% (Table 1).

Table 1. Prevalence of contagious skin necrosis in relation to camels’ age

<table>
<thead>
<tr>
<th>Camels under 3 years</th>
<th>Infected camels</th>
<th>Prevalence (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>396</td>
<td>18</td>
<td>4.55</td>
</tr>
<tr>
<td>Camels over 3 years</td>
<td>604</td>
<td>1.49</td>
</tr>
<tr>
<td>Total</td>
<td>1000</td>
<td>2.70</td>
</tr>
</tbody>
</table>

* Significant p = 0.01

Concerning sex predisposition, the prevalence of contagious skin necrosis was 1.14% among examined females and 13.38% among examined males (Table 2).

Table 2. Prevalence of contagious skin necrosis in relation to camels’ sex

<table>
<thead>
<tr>
<th>Total camels examined</th>
<th>Infected camels</th>
<th>Prevalence (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Females</td>
<td>873</td>
<td>10</td>
</tr>
<tr>
<td>Males</td>
<td>127</td>
<td>17</td>
</tr>
<tr>
<td>Total</td>
<td>1000</td>
<td>27</td>
</tr>
</tbody>
</table>

* Significant p=0.0001

Camels infected with contagious skin necrosis (Figures 1, 2 and 3) showed skin lesions in the form of multiple circular necrotic areas of the skin and sometimes multiple abscesses in brisket and chest areas. The lesions begin as small painful nodules.
These lesions developed well-demarcated necrotic center, which sloughs off exposing an ulcerated, purulent or haemorrhagic layer underneath. The size of the lesion ranged from 3 to 5 cm in diameter. The hair covers these areas are lost. Enlargement of the adjacent lymph node occurred.

Early intervention by treatment of infected camels using Amoxycillin and clavulanic acid daily for 5 days, in addition, to flush the affected area of skin using povidone iodine and supplementation with sodium chloride salt gave faster cure rate than penicillin plus streptomycin (Table 3).

<table>
<thead>
<tr>
<th>Treated group</th>
<th>No. treated animals</th>
<th>No. of cured animals at week no.</th>
<th>Total no. cured</th>
<th>Total no. cured (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>First</td>
<td>17</td>
<td>0 10 7 0</td>
<td>17</td>
<td>100</td>
</tr>
<tr>
<td>Second</td>
<td>10</td>
<td>0 2 5 3</td>
<td>10</td>
<td>100</td>
</tr>
</tbody>
</table>

4. Discussion

Camels are considered good sources of milk, meat, drought power, and used for transportation to support the survival of millions of citizens in barren areas of the world [7].

Concerning the prevalence of the diseases in relation to age, the prevalence was significantly \((p = 0.0001)\) higher in camels under three years (56.31%) than those older than three years (25.66%). This may be attributed to the ill-developed immune system of young [17].

The prevalence of contagious skin necrosis (CSN) among examined camels was 2.70%. Nearly similar prevalence reported previously by Zaitoun [18] in south Egypt who reported 1.83% prevalence in South Egypt. Higher rates were recorded by Yagoub and Mohamed [3] in Sudan who reported 5.75% prevalence rate, Megersa [19] in Ethiopia who reported 5.7% prevalence rate, AlKanzee [20] in Saudi Arabia who reported 9.6% prevalence and Megersa [21] in Ethiopia who reported 15.8% prevalence.

Concerning age predisposition, the prevalence of contagious skin necrosis was significantly \((p = 0.01)\) higher in camels younger than three years (4.55%) than those older than three years (1.49%). Similar observations recorded previously by Zaitoun [18], Megersa [19] and Yagoub [22] who reported a significant increase in the disease prevalence in young camels compared to adult ones. Previous exposure of adults to infection in addition to the immaturity of the immune system of the young camels explained the high prevalence in adult camels.

Concerning gender predisposition, the prevalence of contagious skin necrosis was
significant ($p = 0.0001$) higher in male (13.38%) camels than female ones (1.14%). Similar observation recorded by Megersa [19] who reported a significant increase in the disease prevalence in male camels compared to female ones. On contrary, Zaitoun [18] observed that CSN was not a sex-linked disease. The high prevalence in males may be attributed to that male camels were used to fetch water and transport people, huts, goods, goats, sheep, grain, firewood and building materials [23].

In this study, *Staphylococcus aureus* was isolated from all 27 cases of CSN; it isolated in pure culture from 25 cases and mixed with *Streptococcus agalactia* from two cases. Nearly similar result observed previously by Wernery and Kaaden, [24] who mentioned that staphylococcal dermatitis primarily caused by *Staphylococcus aureus*. In previous study, Yagoub and Mohamed [3] detected *Staphylococcus spp.* as the predominant bacterial species isolated from cases of CSN either as a pure isolate or mixed with other bacteria as *Corynebacterium pyogenes, Lactobacillus, E. coli, Bacillus spp, Micrococcus spp., Proteus spp., Streptococcus spp., Nocardia cameli, Erysipelothrix spp., Actinomyces spp, 1.2%, Aerococcus spp., Pasteurella spp, Actinobacter spp. and Aeromonas spp.* Also, Abdalla and Salim [10] identified thirteen species belonged to eight different genera, where, the dominant bacterial species encountered in contagious skin necrosis was *Staphylococcus aureus* (32.36%) present either as a single isolate or mixed, in variable frequencies, with other bacteria species that belonged to the genera, Actinomyces, Bacillus, Corynebacterium, Enterobacter, Escherichia, Pseudomonas Salmonella and Staphylococcus were isolated. In addition, Hamed and Abd Ellah [4] reported *Staphylococcus aureus* as the predominant bacteria isolated from cases of CSN, where, out of 10 examined cases of CSN, *Staphylococcus aureus* isolated alone from 6 cases and coupled with other bacteria from the remained 4 cases, coupled with coagulase negative staphylococci in 3 cases and coupled with *Streptococcus agalactiae* in one case. Clinically, camels infected with contagious skin necrosis showed skin lesions in the form of multiple circular necrotic areas of the skin and sometimes multiple abscesses in brisket and chest areas. Similar lesions were observed previously [3, 4, 20 and 25].

Treatment of the infected camels using Amoxycillin and clavulanic acid gave a faster cure rate than the use of penicillin plus streptomycin. Abbas and Omer [26] mentioned that, although highly contagious, the disease is not fatal, and responded well to treatment with parenteral antibiotics and local iodine tincture. Finally, it can be concluded that contagious skin necrosis in camels is common in Saudi Arabia and Amoxycillin and clavulanic acid is the best choice for treatment.

**Acknowledgement**

This work was performed at Veterinary Teaching Hospital, Department of Veterinary Medicine, Faculty of Agriculture and Veterinary Medicine, Qassim University, Saudi Arabia.

**Compliance with ethical standards**

This study was approved by the Animal Care and Welfare Committee, Deanship of Scientific Research, Qassim University, Kingdom of Saudi Arabia.

**Conflict of interest**

The author declares that he has no conflict of interest.

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The interrelationship between the occurrence of oversized follicles and the peripheral and intra-follicular concentrations of E2, P4, FSH, and LH in female dromedary camels

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Abstract

The present study aimed to clarify the phenomenon of presence of larger than normal follicles (OVGF) in female dromedary camels. Females with OVGF (n=125) were examined by manual palpation and ultrasonography. Accordingly, the OVGF were subdivided into those with thin walls and clear hypoechogenic content (OVGF-TH, n=18) and those with thick walls and fibrous trabeculae (OVGF-TK, n=107). Transvaginal follicle aspiration was performed in females with OVGF and from a control group with growing follicles (1-2 cm in diameter, GF group, n=5). Serum was collected at the same time of follicle aspiration and analyzed for Follicle-stimulating hormone (FSH), luteinizing hormone (LH), progesterone (P4) and estradiol-17β profiles (E2). The follicular fluid (FF) was analyzed for E2 and P4. The results showed that mean E2 concentration in FF and serum were lower in OVGF-TH and OVGF-TK groups than in the GF group (P < 0.05). Difference between OVGF-TH and OVGF-TK groups was not significant. P4 in FF did not significantly differ among groups. Positive correlation was found between E2 in FF and E2 in serum (r = 0.495, r = 0.03). Mean FSH concentration in serum was higher in OVGF-TH and OVGF-TK groups than in the GF group (P = 0.03). Mean LH concentration was non-significantly (P=0.1) greater in OVGF-TH and OVGF-TK groups than in the GF group. In conclusion, female dromedary camels with OVGF had endocrine characteristics differed from camels with no OVGF. It seems that the high FSH and/or LH concentration(s) stimulated the continuing growth of the developing follicles to reach these large sizes, suggesting that the phenomenon of OVGF in camels is a pathological finding.

Key words:
Dromedary camels; oversized follicles; hormones; follicular fluid; ovary.

1. Introduction
The estrus cycle in camels has certain uniqueness, it did not have a luteal phase, the cycle is strictly follicular, and the ovulation is induced [1,2]. The follicular cycle has been subdivided into growth, mature and regression phases [3-5]. In non-mating females, the dominant follicle brings into being atretic, however, in certain females the dominant follicle continued to grow to Larger than typical follicles (OVGF, >2 cm in diameter) [3,4].

There is an argument regarding the pathogenicity of this phenomenon in camels. Certain studies assumed that it does not similar to the cystic ovarian disease (COD) of cattle. If the female camel is not pregnant, large numbers of follicles can develop some form of cystic ovaries, because ovulation is induced [2,6]. Others have observed the OVGF in combination with
some reproductive disorders including ovarian hydrobursitis and clinical endometritis [7]. Biochemical and hormonal contents of the follicular fluid in camels have been investigated by some researches, mostly from ovaries collected from the slaughterhouse with no attached breeding history [8-12]. None of these studies, however, tried to associate the presence of this OVGF with the peripheral gonadotropin concentrations to understand the occurrence of this phenomenon in camels. In cattle, a transient increase in FSH preceded detection of follicular cysts [13]. Moreover, an increase in FSH secretion following a decrease in inhibin initiated revenue of cystic follicles in dairy cows [14]. Besides, during the follicular phase, the concentration of LH was higher in cows with cysts than in cows without cysts [15]. The relativeness of endocrinological changes in camels with larger than normal follicles is still unclear. In the current study, the interrelationship between the occurrence of oversized follicles and the peripheral and intra-follicular concentrations of progesterone (P4), estradiol-17beta (E2), luteinizing hormone (LH) and follicle-stimulating hormone (FSH) were investigated in female dromedary camels.

2. Materials and Methods
This study was approved by the Animal Care and Welfare Committee, Deanship of Scientific Research, Qassim University, Kingdom of Saudi Arabia.

2.1. Animals
Female dromedary camels (n=1263) were examined for reasons of failure of conception at the Veterinary Teaching Hospital of Qassim University, during the breeding season from September 2017 to March 2018. Of them, 125 were found with oversized follicles (OVGF, > 2 cm in diameter, Skidmore, 2011) with no further detectable pathological findings. Most of the females with OVGF were multipara (101/125, 80.8%), while fewer were primi-(16/125, 12.8%) or nullipara (8/125, 6.4%). They were non-lactating and aged 7 to 12-year-old. Primi- and multipara were presented for examination 8-12 months after parturition. The animals were originated from herds using natural mating, where males were running with females all the time. The body condition scores of OVGF females ranged from 3 to 4 on a 5-point scale [16]. They were grazed on open pastures. Alfalfa (Medicago sativa) was provided. The herders seldom supplemented the diet. Five female camels (multipara, 7-12 years) with growing follicles (1-2 cm in diameter) were used as a control group (GF group).

2.2. OVDF Classification
The genital tract of each animal was examined through transrectal palpation and by ultrasonographic examination using Real-time, B-mode ultrasonic apparatus (Aloka SSD 500, Tokyo, Japan) attached to a 5 MHz transrectal transducer. The examinations were carried out on specially equipped tractors, whereas the females were secured in sternal recumbence. The transducer was placed over the appropriate organ and moved a little from one side to the other to get full information on the examined organ. The ultrasonic images were frozen on the monitor, and the dimensions were estimated at the maximum size by the electronic caliper. According to manual palpation and ultrasonographic examination, the OVGF were subdivided into two main groups, those with thin walls and clear hypoecchogenic content (OVGF-TH, n=18, Figure 1A) and those with thick walls and fibrous trabeculae (OVGF-TK, n=107, Figure 1B, C).

Figure 1. Ultrasonographic images for the oversized ovarian follicles (OVGF) in female dromedary camels: (A) OVGF with thin wall, clear hypoecchogenic content and of 3.5 cm maximum diameter; (B) OVGF with thick wall, moderate transecting trabeculae and of 5.7 cm maximum diameter; (C) OVGF with thick wall, heavy transecting trabeculae and of 7.3 cm maximum diameter.

2.3. Follicle aspiration
Follicle aspiration was carried out from females with OVGF and from the GF group. When more than one growing follicle was present in the GF group, the largest one was only aspirated. The OVGF and growing follicles were aspirated transvaginally using a specially designed 1.2 mm x 500 mm cannula with 450 angle tip [17]. Briefly, the ovaries were first examined ultrasonographically to identify the location of the OVGF. After eliminating the probe, the cannula was progressed in the anterior part of the vagina being covered by an insemination pipette. The OVGF carrying ovary was manipulated per
rectum and placed over the opening of the insemination pipette. The cannula was then advanced to perforate the vaginal wall into the OVGF. Follicular fluid (FF) was aspirated under transrectal manual control using a 20 mL syringe connected with the cannula. This technique was carried out without special precaution or sedation. The FFs were stored at -20 until analyzed for E2 and P4.

2.4. Hormonal analysis

Jugular blood was collected from all OVGF and GF camels between 8.00 and 10.00 AM at the same time as follicle aspiration. The serum was harvested and stored until analyzed for LH, FSH, E2, and P4. The FSH and LH were determined by specific ELISA using kits designed for the quantitative determination of camel FSH and LH (Life Sciences Advanced Technologies Inc., 2900 72nd St, N Saint Petersburg, FL 33710, USA). Serum concentrations of E2 and P4 were determined by ELISA using commercial kits (Human Gesellschaft für Biochemica und Diagnostica, Wiesbaden, Germany). The coefficients of variation of the intra- and inter-assays were 4.4, 5.6, 3.7 and 5.1 % and 4.5, 5.9, 6.4 and 6.8%, and the sensitivity of the assay was measured at 0.1 mIU/mL, 0.1 mIU/mL, 3 pg/mL and 0.12 ng/mL for the FSH, LH, E2 and P4, respectively.

2.5. Statistical analysis

The data were presented in mean ± SE, and statistical analysis was carried out using the SPSS program, version 24 (2016). Analysis of variance (ANOVA) was used for the comparison between groups. When a significant difference was recorded, the LSD test was used to determine how the means differed. Relationships between hormonal levels were estimated by the correlation coefficient. The level of significance set at P < 0.05.

3. Results

The diameter of the OVGF ranged between 3 and 12 cm (average = 5.16 cm). Distribution of the OVGF between right and left ovary did not significantly differ (59.2% vs. 48.8%). Most of the OVGF were single (98/125, 78.4%), while few cases had double (19/125, 15.2%) or triplets (8/125, 6.4%) OVGF. The OVGF were detected in association with growing follicles in 69 cases (55.2%). The other cases had no further structures. No case with OVGF had a corpus luteum. All OVGF females had the history of repeat breeding with regular (n = 106) or irregular (n = 19) heat intervals.

Mean E2 concentration in FF was significantly lower in OVGF-TH and OVGH-TK groups than in the GF group (P = 0.006). Difference between OVGF-TH and OVGH-TK groups was not significant. P4 in FF did not significantly differ among groups (P = 0.5), (Figure 2).

Mean E2 concentration in serum was significantly lower in OVGF-TH and OVGH-TK groups than in the GF group (P=0.03). Difference between OVGF-TH and OVGH-TK groups did not reach a significant level. Mean P4 in serum tend to be greater in camels with OVGF-TK than in other groups (P = 0.09), (Figure 3). Positive correlation was found between E2 in FF and E2 in serum (r = 0.495, r = 0.03). However, no correlation was detected between P4 in FF and P4 in the serum.

Mean FSH concentration in serum was significantly higher in OVGF-TH and OVGH-TK groups than in the GF group (P=0.03). No significant difference was found between OVGF-TH and OVGH-TK groups (Figure 4). Mean LH concentration in serum was non-significantly greater in OVGF-TH and OVGH-TK groups than in the GF group (P=0.1), (Figure 4).
Figure 2. Estradiol 17β (E2) and progesterone (P4) concentrations (means ± SE) in follicular fluid (FF) of female dromedary camels having oversized follicles with thin wall and clear content (OVGF-TH, n=18) or thick walls and fibrous trabeculae (OVGF-TK, n=107) in compare to a group with growing follicles (1-2 cm in diameter, GF, n=5). a, b Significant at P = 0.006.
Figure 3. Estradiol 17 β (E2) and progesterone (P4) concentrations (means ± SE) in serum of female dromedary camels having oversized follicles with thin wall and clear content (OVGF-TH, n=18) or thick walls and fibrous trabeculae (OVGF-TK, n=107) in compare to a group with growing follicles (1-2 cm in diameter, GF, n=5). a, b Significant at P = 0.03.
4. Discussion

In the present study, female dromedary camels with follicle larger than normal (OVGF) had endocrine characteristics differed from camels with no OVGF, especially concerning the serum FSH concentration. It seems that the higher than normal FSH concentration observed in OVGF groups stimulated the continuing growth of the developing follicles to these large sizes. Supporting this opinion, an increase in FSH secretion headed the detection of follicular cysts in dairy cows [13,14]. Endogenous or exogenous factors; e.g. day length, presence of the male within the herd, nutrition, and affection of the genital tract; have been suggested to contribute to this phenomenon in camels [2,6,7]. Unlike cattle, milk production and postpartum period do not play major roles in the cyst formation in camels, because all females here were non-lactation and were at distance from parturition.

High level of pulsatile secretion of LH endorses incessant growth of the dominant follicle in cattle [18,19]. Moreover, during the follicular phase mean.
serum concentration of LH was higher in cows with ovarian cysts. Also, LH pulse frequency and amplitude were higher in cows with cysts than in non-cystic cows [15-20]. In the current study, the LH in serum tends to be higher in camels with OVGF than in those with no OVGF.

Intermediate level of circulating progesterone have been revealed to prevent ovulation and endorse the persistence of dominant follicles in cattle [21-22]. This subluteal progesterone levels may befall in camels from luteinization of some ovarian follicles. Follicle luteinization is frequently observed in camels [7,25]. In this study, follicle luteinization (OVGF-TK group) was associated with some increase in the peripheral progesterone levels. Treatment of cystic cows with exogenous progesterone resulted in a decrease in mean LH and LH pulse frequency and recruits ovulatory follicular growth [23,24].

Camels with the OVGF had lower E2 concentrations both in serum and follicular fluid than camels with GF. It is known that intrafollicular concentrations of E2 and P4 alter according to follicular size, degree of atresia and stage of the cycle [11,12,17]. The ability of E2 production is the outcome of the increase in the capacity of the follicular theta to produce androgen as well as the aptitude of granulosa cells to aromatize androgen into E2 [25]. Aging and degeneration of follicles are associated with a decrease in their ability for E2 synthesis [17,26]. This low follicular and peripheral E2 concentration might explain, why any of these females did not show the symptoms of continuous estrus (nymphomania) as in cattle.

P4 concentration, in contrast, did not differ between camels with GF and those with OVGF. It is known that intrafollicular concentrations of E2 and P4 alter according to follicular size, degree of atresia and stage of the cycle [11,12,17]. The ability of E2 production is the outcome of the increase in the capacity of the follicular theta to produce androgen as well as the aptitude of granulosa cells to aromatize androgen into E2 [25]. Aging and degeneration of follicles are associated with a decrease in their ability for E2 synthesis [17,26]. This low follicular and peripheral E2 concentration might explain, why any of these females did not show the symptoms of continuous estrus (nymphomania) as in cattle.

5. Conclusion
This study clarified that camels with follicles larger than normal (OVGF) have certain endocrine characteristics that may contribute to understanding the occurrence of this phenomenon in this species. Camels with OVGF had higher FSH concentration than those with no OVGF. Serum and FF of camels with OVGF had lower E2 than camels with GF. LH tends to be greater in the OVGF group than in the GF group. No differences were found between OVGF-TH and OVGF-TK groups for any of the estimated hormones. Further investigations are needed to follow each follicle and to identify the hormonal status at the time when these follicles become atretic or continue to grow to larger sizes.

Author contribution
Ahmed Ali: Supervision; Investigation; Methodology; Data curation; Formal analysis; Writing - review & editing.
Derar R Derar: Investigation; Methodology; Review.
Moustafa M. Zeitoun: Methodology.
Fahd Al-Sobayil: Funding acquisition; Review.

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Conflict of interest
Authors declare that there no conflicts of interest.

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Pregnancy diagnosis in dromedary: comparison between transrectal and transabdominal ultrasonography

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Abstract

This study aimed to compare between transrectal and transabdominal ultrasonography for visualization of camel conceptus during different stages of gestation in dromedary. A group of six pregnant female dromedary camels was used in this study. Consecutive transrectal and transabdominal ultrasonography were performed once weekly between the second and 42nd weeks of pregnancy and every 2 weeks from the 42nd week until parturition. Six areas were selected for transabdominal ultrasound examination, namely caudal abdominal (CAA, right and left, above the base of the udder), middle abdominal (MIA, right and left, from the base of the udder to the umbilicus); and cranial abdominal (CRA, right and left, from the umbilicus to the xiphoid cartilage). On each examination, attempts were made to imagine the conceptus and to estimate the biparietal diameter (BPD), eyeball diameter (EBD), abdominal diameter (ABD) and ruminal diameter (RUD). The result revealed that between the 4th and 5th weeks, the conceptus could only be visualized by the transrectal approach (100%). Between the 6th and the 12th weeks, the conceptus was mostly observed through the left CAA (100%) and the transrectal (97.6%) approaches, but less repeatedly over the right CAA (66.7%) approach. From the 13th to the 27th weeks, the conceptus was mostly observed over the left CAA (100%), but less regularly through the right CAA (50%) and transrectal (31.8%) approaches. Between the 28th and 52nd weeks, the conceptus was chiefly detected via the left CRA approach (92.3%), but less often over right CRA (69.2%) and transrectal (60.3%) approaches. The EBD was the greatest accessible fetal parameter throughout transrectal and transabdominal examinations and the ABD was the slightest. It could be concluded that the transrectal, left CAA, and left CRA ultrasonography are the preeminent techniques for pregnancy diagnosis during early, mid-, and late gestation, respectively.

Key words:
Pregnancy diagnosis, dromedary camel, transrectal examination, transabdominal examination, fetal parameters.

1. Introduction

Pregnancy diagnosis is important camel management for maintaining a high level of reproductive efficiency [1,2]. Because camel is seasonal breeding, the diagnosis of early pregnancy is necessary to get them pregnant in the same season of parturition. Furthermore, most camel herds still implement unrestrained natural mating as a breeding policy, with the consequent deficiency of data around service date and gestational ages [3]. This delays the correct management of pregnant camels at the proper times.
Transrectal palpation is the greatest widely used technique for early pregnancy diagnosis in camels, however, the method does not afford adequate information about the viability of the conceptus during the earlier stages of gestation [4]. On the other hand, by ultrasonography, it became possible to study the development and growth of the camel fetal organs and parts without risking pregnancy [5,6].

Transrectal ultrasonography has provided trustworthy data on first times of intrauterine fluid accumulation, observation of embryo proper, organization of the embryo and onset of ossification. It also supplied accurate estimation for the fetal crown-rump length, biparietal diameter, abdominal diameter, ruminal length, eyeball diameter that could be used for prediction of gestational age and time of parturition [7].

Transabdominal ultrasound is a fast substitute to transrectal ultrasound or manual palpation of the reproductive tract. This technique does not necessitate the examiner to kneel behind the animal. Furthermore, some of the fetal parameters could not be detected by transrectal ultrasonography during mid- and late gestation as the gravid uterus had progressed down during the advancement of pregnancy [6,7].

To date, no literature has been available regarding the comparison of transrectal and transabdominal ultrasound for detection of the camel conceptus during different stages of gestation. The aim of this study was, therefore, to compare between transrectal and transabdominal ultrasonography for monitoring dromedary camel conceptus during different stages of gestation.

2. Materials and Methods

2.1. Animals

A group of six pluriparous female dromedary camels was used in this study. They were aged 10 to 12 years, weighing from 392 to 438 kg with body condition scores from three to four via a scale from 1 to 5 [8]. The females were naturally mated to a known fertile male at normally occurring estrus. The last day of breeding was marked as day 0 of pregnancy. Transrectal ultrasonography was carried out 2 weeks after mating. Pregnancy was predicted via observation of non-echogenic fluid in the center of the uterine horn and by the existence of the corpus luteum on the ovary. These findings were ascertained later through detection of the embryo proper. The animals were kept at the Veterinary Teaching Hospital of Qassim University, Saudi Arabia.

2.2. Transrectal ultrasonography

Consecutive transrectal ultrasonography was performed once weekly between the second and 42nd weeks of pregnancy and every 2 weeks from the 42nd week until parturition. The examinations were carried out while the camels were in standing position in a special stanchion. The ultrasonography was performed by only one operator. Real-time, B-mode diagnostic ultrasound equipment (Aloka, SSD 500, Tokyo) with 5 MHz transrectal linear array transducers were used for examination. On each examination, attempts were made to imagine the conceptus and to estimate the following fetometric parameters: biparietal diameter (BPD; the broadest space between the outer limits of the cranium at an position of 90o to the falx cerebri), abdominal diameter (ABD, extreme diameter of the abdomen at the insert of the umbilical cord), ruminal diameter (RUD, the major intraluminal length of the rumen), and eyeball diameter (EBD, the lengthiest width of the vitreous body from medial to lateral sclera).

2.3. Transabdominal ultrasonography

The transabdominal ultrasonography was carried out at the same times of transrectal ultrasonography. It was performed while the animals were in standing position secured in a stanchion and by using a real-time, B-mode, diagnostic ultrasound (Aloka 500 SSD, Tokyo, Japan) attached with 3.5 MHz curve-linear array probes. Six areas were designated for transabdominal ultrasound examination (Fig. 1): caudal abdominal (CAA, right and left, directly above the base of the udder); middle abdominal (MIA, right and left, between the base of the udder and the umbilicus; and cranial abdominal (CRA, right and left, from the umbilicus to the xiphoid cartilage). The hair was clipped and ultrasound gel was applied to the area to be examined. The probe was then positioned and stirred perpendicularly on the skin of the pelvic and abdominal cavities. At each examination, efforts were made to detect the conceptus and its details and to measure the BPD, EBD, ABD, and RUD.

2.4. Statistical analysis

Chi-square test was used to evaluate the difference in percentages between the transrectal and transabdominal approaches in the frequency of detecting of the camel conceptus and its details.
during different stages of pregnancy. Statistical analysis was carried out using the SPSS program version 18, 2009. Level of significance was set at p < 0.05.

3. Results
Comparison between transrectal and transabdominal approaches in the frequency of detecting the camel conceptus during different stages of pregnancy is revealed in table 1. Between the 4th and 5th weeks, the conceptus could only be imagined by the transrectal approach (100%). From the 6th to the 12th weeks, the conceptus was mostly observed through the left CAA (100%) and the transrectal (97.6%) approaches, but less frequently through the right CAA (66.7%) approach. Between the 13th and the 27th weeks, the conceptus was mainly observed through the left CAA (100%), but less frequently through the right CAA (50%) and transrectal (31.8%) approaches. Between the 28th and 52nd weeks, the conceptus was mainly detected through the left CRA approach (92.3%), but less frequently through right CRA (69.2%) and transrectal (60.3%) approaches.

Table 1. Comparison between transrectal and transabdominal approaches in frequency of detecting of the camel conceptus during different stages of pregnancy (n= 6 camels, examined for 198 times).

<table>
<thead>
<tr>
<th>Stage of pregnancy</th>
<th>Transrectal</th>
<th>Transabdominal</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Frequency of detection of the conceptus</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Transrectal</td>
<td>Transabdominal</td>
</tr>
<tr>
<td></td>
<td>caudal abdominal</td>
<td>middle abdominal</td>
</tr>
<tr>
<td></td>
<td>right</td>
<td>left</td>
</tr>
<tr>
<td>4-5 weeks (n=12 examinations)</td>
<td>12/12</td>
<td>0.0/12</td>
</tr>
<tr>
<td>6-12 weeks (n=42 examinations)</td>
<td>41/42*</td>
<td>28/42</td>
</tr>
<tr>
<td>13-26 weeks (n=66 examinations)</td>
<td>21/66</td>
<td>0/66</td>
</tr>
<tr>
<td>27-52 weeks (n=78 examinations)</td>
<td>47/78</td>
<td>29/78</td>
</tr>
<tr>
<td>Total (n=198 examinations)</td>
<td>121/198</td>
<td>57/198</td>
</tr>
</tbody>
</table>

* Values at the same row differ significantly at p <0.05.
Comparison between transrectal and transabdominal approaches in the frequency of detecting different fetal parameters during different stages of pregnancy is presented in table 2. The EBD was the furthestmost accessible fetal parameter throughout transrectal and transabdominal examinations and the ABD was the least.

Table 2. Comparison between transrectal (TR) and transabdominal (TA) approaches in the frequency of detecting of different camel parameters during different stages of pregnancy (n= 6 camels, examined for 198 times).

<table>
<thead>
<tr>
<th>Stage of pregnancy</th>
<th>Frequency of detection of fetal parameters</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>EBD</td>
</tr>
<tr>
<td>4-5 weeks (n=12 examinations)</td>
<td>0.0/12</td>
</tr>
<tr>
<td>6-12 weeks (n=42 examinations)</td>
<td>17/42</td>
</tr>
<tr>
<td>27-52 weeks (n=78 examinations)</td>
<td>47/78*</td>
</tr>
<tr>
<td>Total (n=198 examinations)</td>
<td>85/198</td>
</tr>
</tbody>
</table>

* Values at the same row differ significantly at p <0.05.

4. Discussion

Based on the current data, visualization of the camel conceptus depended on the stage of gestation and changes occurring in size and location of the pregnant uterus. The gestational changes in the uterus of dromedary camels have been described [9,10]. The uterus grows into cranial and ventral after the third month of pregnancy. By the fourth month, the uterus is in anterior of the pelvic brim, but most of it can be touched. By 5 months of gestation, the uterus is totally in the abdomen and the fetus is not regularly palpable. The fetus comes to be palpable again after the sixth month of pregnancy. The head and limbs become palpable by the seventh to eighth month as the fetus begins its ascent. By 11 months, the fetal limbs can be easily detected in the pelvic cavity.

The transrectal approach was superior for the early pregnancy diagnosis. This may be due to the low frequency used during the transabdominal approach (3.5 MHz) related to that used through transrectal examination (5 MHz). Essentially, higher frequencies have a congruently shorter wavelength and can be used to make sonograms with better details. However, the weakening of the sound wave is increased at greater frequencies. Therefore, to have improved penetration of deeper tissues, a minor frequency (3 to 5 MHz) is used [11].

The accessibility of the different fetal parameters detected in this study related to the stage of pregnancy and the area of examination. The EBD was the most accessible fetal parameter due to the head and eye could be detected throughout the gestation period beginning from the sixth week onwards, (2) this technique does not require the sonographer to kneel behind the animal, (3) in advanced pregnancy it gives some fetal details that could not be noticed by transrectal ultrasonography [6].

Data revealed that the left side approach was more favorable for imagining of the conceptus than the right side. This may be recognized to the fact that all the observed pregnancies were found in the left horn. In dairy cattle, transabdominal ultrasound in the right flank has not been commended as an exact method for early pregnancy diagnosis [12].

The accessibility of the different fetal parameters detected in this study related to the stage of pregnancy and the area of examination. The EBD was the most accessible fetal parameter due to the head and eye could be detected in most stages of gestation. The RUD and ABD were the tiniest accessible organs because, with the progress of gestation, it became too long to be presented efficiently on the screen.

5. Conclusion

In dromedary camels, the transrectal, left CAA, and left CRA ultrasonography are the best approaches for pregnancy diagnosis during early, mid-, and late gestation, respectively.

Author contribution
Ahmed Ali: Supervision; Investigation;
Methodology; Data curation; Formal analysis; Writing - review & editing.
Derar R Derar: Investigation; Methodology.

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Conflict of interest
Authors declare that there no conflicts of interest.

References
Anatomical study of the external ear muscles of the camel with special reference to the external acoustic meatus and the blood and nerve supply

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Abstract

The purpose of this study was to describe the muscle anatomy of the external ear. Twelve head clinically healthy camels, 1-4 years old, were used in this study. They obtained from the Buraidah slaughterhouse. The study revealed that many ear muscles, which were responsible for the movement of the ear. These muscles distributed as dorsal, ventral, rostral and caudal muscles. The current study presented the external acoustic meatus, which has two parts cartilaginous, and osseous parts and it is covered with skin. The study indicated an external acoustic canal. The canal was long and oblique in camel; it prevents the rapid spread of epidemics, infections and the wounds or lesions of the tympanic membrane. As well as this study showed the external ear derived the nerves supply from the cranial auricular branch and caudal auricular branch. While the blood supply was given by caudal auricular and the rostral auricular arteries.

Key words: Muscles, ears, camels, blood and nerve supply.

1. Introduction

The ear is considered as a sensory organ with distinction and responsible hear and equilibrium. It also acts for the collection of sound waves together with the external acoustic meatus, which conveys these waves to the tympanic membrane [1]. The anatomical study of the external ear was little researched among the domestic animals especially in camel, some authors mentioned the anatomical features of the muscles of ear, Smut [2,3] in camel [4] in bovine, [5] in Buffalo, and [6] in cattle and buffalo [7] in horse and [8,9,10] in domestic animals.

The knowledge anatomy about the auricular muscles and the external acoustic meatus can help in understanding in sheep may be a useful model for surgical training and experimentation in some external and middle ear [11,12] in human and sheep and [13] in human in pig. The shape of the ear is designed by the auricular cartilage in most domestic animals; this is sufficiently stiff to keep the auricle standing permanently [14]. Many of ear muscles is responsible for the movement of the ear these muscles attach the base of the auricle to the bones of the skull adjacent of the ear, these muscles were described in groups according to their position [2, 3] in camel [4] in bovine, [6] in cattle and buffalo, [7] in horse and [8,9,10] in domestic animals.

2. Materials and Methods

Twelve head camels of both sexes and different ages from (1-4 years) were used for this study. They were obtained from the Buraidah slaughterhouse, Qassim Region, KSA and used in this study. Ten heads were preserved in 10 % formalin solution, then they were washed by water consequently, these heads were dissected to investigate morphological anatomical study of the auricle including the muscles, cartilage, and ligament, blood, and nerve supply as well measurement the auricle. Two heads were prepared in the normal methods (boiling with 30% NaOH, soaking, drying, immersing in hydrogen peroxide...
solution [15]. To describe the shape, dimension of the external acoustic meatus, the measurements of external acoustic meatus were down as following: length of meatus is distance between annular ligament to the internal acoustic meatus, diameter of external acoustic meatus is distance between the two lateral borders of attachment with depth of external acoustic meatus. The nomenclature used was adopted by [16].

3. Results

The anatomy of the external ear of camel include; the pinna (auricle) which is the outer, three cartilages and four sets of muscles, the external acoustic meatus, and the tympanic membrane. The study revealed that many ear muscles, which were responsible for the movement of the ear. These muscles classified into four groups of muscles; rostral, dorsal, ventral and caudal. These muscles are responsible for moving the ears; the camel as like the animals can move of their ears, on the contrary of the human.

A- Musculi auralis rostrales contains:

1- Musculus Scutuloauricularis Superficialis (Figures 1, 3): The superficial scutuloauricular muscle is almost circular. It origins from the dorsal face of the scutiform cartilage. It is partly covered by interscutlaris. It covers the most dorsal aspect of the scutulum without its some area, especially in its cranial border. It extends from the caudal border to rostral border of the cartilage and run caudally to attach to the concha and inserted in distal part of the auricular cartilage.

2- Musculus Scutuloauricularis Profundus (Figure 2): The deep scutuloauricular muscle is similar to the previous muscle in shape. It origins from the deep surface of the scutiform cartilage. It places on the deep surface of the scutulum. It is well developed and has a circular shape. Its fibers run caudally to insert in the craniodental part of the auricular cartilage.

3- Musculus Frontoscutularis (Figures 1, 3, 6): The frontoscutular muscle has a trapezoidal shape with its smaller base located rostrally. It has two parts: cranial part is frontal and caudal part is temporal) which are arising from the zygomatic process of the frontal bone and temporal line and inserted in the rostral border of the scutiform cartilage.

4- Musculus Zygomatic auricularis (Figures 1, 3, 6): The zygomatic auricular muscle has a rectangular shape. It arises from the zygomatic arch directly to the rostolateral border of the scutiform cartilage. It extends on the zygomatic bone, it fuses partially to the scutuloauricularis superficialis ventrally, and inserts in the lateral border of the auricular cartilage. It can be extending to the auricular cartilage.

5- Musculus Zygomaticoscutularis (Figures 1, 3, 6): The zygomaticoscutular muscle. It is located ventrally to the zygomatic auricular muscle. It has a triangular shape. It’s compared to the previous two muscles. It arises from the base of the zygomatic process of the frontal bone to insert on the rostral border of the scutiform cartilage.

B- Musculi auralis dorsalis consists of:

1- Musculus interscutularis (Figures 4, 8): The interscutular muscle locates on the parietal bone. It is a thick, elongated muscle. It connects right and left scutiform cartilages that arise from the base of the auricular cartilage, and inserts in the external sagittal crest and temporal line.

2- Musculus cervicoscutularis (Figure 4): The cervicoscutular muscle takes specially shaped, triangle with a hypotenuse in the form of arch. It arises from the base of the occipital bone and is inserted in the sagittal crest and temporal line.

3- Musculus Scutoauricularis dorsalis (Figures 5, 6): The dorsal scutoauricular muscle extends from the scutiform cartilage to inserted in rostolateral on auricle.

4- Musculus Scutoauricularis medius (Figures 5, 6): The middle scutoauricular muscle extends from the scutiform cartilage to inserted in the middle of the distal part of auricle. These muscles attach the scutiform cartilage to the auricular cartilage.
Figure 1: A photograph shows the rostral muscles of the ear in camel; superficial scutuloauricular muscle (s sa.m), frontoscutular muscle (f s.m), zygomaticoauricular muscle (z a.m) and zygomaticoscutular muscle (z s.m).

Figure 2: A photograph shows deep scutuloauricular muscle (s p.m) and temporal muscle (t.m).

Figure 3: A photograph shows the rostral muscles of the ear in camel; superficial scutuloauricular muscle (s sa.m), frontoscutular muscle (f s.m), zygomaticoauricular muscle (z a.m), zygomaticoscutular muscle (z s.m) and auricular cartilage (a.c).

Figure 4: A photograph shows the interscutolar muscle (in s.m) and the cervicoscutolar muscle (ce s.m). Auricle cartilage (a c) and scutiform cartilage (sc).

Figure 5: A photograph shows dorsal scutoauricular muscle (d sa.m), middle scutoauricular muscle (m sa.m) and auricle cartilage (a c).

Figure 6: A photograph shows the rostral and dorsal muscles of the ear in camel; superficial scutuloauricular muscle (s sa.m), frontoscutular muscle (f s.m), zygomaticoauricular muscle (z a.m), zygomaticoscutular muscle (z s.m), dorsal scutoauricular muscle (d sa.m), middle scutoauricular muscle (m sa.m) and auricular cartilage (a.c).
C- Musculi auriculars ventrals comprises:
1- Musculus Parotidoauricularis (Figure 7): The Parotidoauricular muscle is superficial muscle. It covers the lateral surface of the parotid gland. It is narrow and thin in a ribbon-like muscle. It originates from the ventral part of the parotid fascia and passes dorsally to insert to ventrolateral on the base of the auricular cartilage.

D- Musculi auricularis caudals:
Theses muscles are very developed and clear. They pull the scutulum caudally.

1-Musculus cervicoauricularis superficialis (Figure 8): The superficial (superior) cervicoauricular muscle is thin and has a rectangular shape. This muscle extends from the dorsal part of the neck nearly the auricle, which arises from the Atlanta fascia near appendicular part of the nuchal ligament. It locates superficially to the other caudal muscles of the external ear. It inserts in the distal part of the caudal surface of the auricular cartilage

2-Musculus cervicoauricularis medius (Figure 8): The middle cervicoauricular muscle has a spindle shape with clear muscle belly. It fuses with deep cervicoauricular muscle at the origin. It originates from the atlantal fascia near the appendicular part of the nuchal ligament ventral to the superficial cervicoauricular muscle. It locates between superficial cervicoauricular muscle and deep cervicoauricular muscle. It inserts below the superficial cervicoauricular muscle at the level of the previous muscle in the distal part of the caudal surface of the auricular cartilage

3-Musculus cervicoauricularis profundus (Figure 8): The deep (inferior) cervicoauricular muscle arises from the atlantal fascia near the appendicular part of the nuchal ligament ventral to the middle cervicoauricular muscle. It locates below the middle cervicoauricular muscle. It inserts below the middle cervicoauricular muscle in the distal part of the caudal surface of the auricular cartilage.

The ligament auricularia (Figure 9):
They connect the auricle to the side of the head. It is the external and annular ligaments. The annular ligament wraps around the distal part of the auricle to the root of the zygomatic process of the temporal bone forming ring around the concha. While the other ligaments connect the auricle o the side of the head.

Meatus caustic externa (Figure 10):
The external acoustic meatus is the passage which extends from the floor of the auricle to the tympanic membrane. It directs ventrally and then rostomedially. It is supported by the rolled-up part of the annular cartilage. It forms the tube beginning from the external ear opening at the to the tympanic membrane. It has two parts; the cartilaginous and the osseous part. The cartilaginous part is the outside of the canal wall. It consists of cartilage, it is covered by hair. While the osseous part is the inner part of the wall, it consists of bone. It is formed by the petrous portion of the temporal bone and leads to the tympanic membrane. This part separates the external ear from the middle ear. The external acoustic meatus is oval and has a large oval opening caudal located to the zygomatic arch. Its average length it's about 4 cm, and its diameter is 0.8 cm respectively. The meatus are related laterally and ventrally to the parotid gland and the facial nerve which crosses on the ventral surface of a caustic meatus deeply to the parotid gland. It covers the proximal of the vertical portion of the external a caustic meatus.

Figure 7: A photograph shows the parotidoauricular muscle (pa.m) and auricle (a).
Figure 8: A photograph shows the caudal auricular muscles presented by superficial cervicoauricular muscle (s ce a.m), middle cervicoauricular muscle (m ce a.m), deep cervicoauricular muscle (d ce a.m), interscutolar muscle (in s.m) and auricle cartilage (a c).

Figure 9: A photograph shows the external ligament of the auricle (a.l) auricle cartilage (a c).

Figure 10: A photograph shows the external acoustic meatus in camel.

The Nerve and Blood supply of the ear in camel (Figures 11,12):

The external ear and auricular muscles derive the nerves supplying from the cranial auricular branch and caudal auricular branch given by auriculotemporal nerve from the facial nerve as well as some cutaneous auricular branches given by the vagus nerve to the skin of external acoustic meatus.

The blood supplying of the external ear muscles given by two arteries; the caudal and rostral auricular arteries. The caudal auricular artery arises from the external carotid artery directly, while the rostral auricular artery emerges from the superficial temporal which arises from the external carotid artery. The caudal auricular artery gives off three arteries on the convex surface of the auricle, the medial, intermediate and lateral auricle branches supply the caudal surface of the auricle. While the veins draining of the ear from the caudal auricular vein comes from the external carotid vein. It drains lateral auricular, intermediate auricular vein and medial auricular vein. While the rostral auricular vein drains the superficial temporal vein.

Figure 11: A photograph shows the nerve supply of the camel auricle; the cranial auricular nerve (cr a.n) and caudal auricular nerve (ca a. n).

Figure 12: A photograph shows the blood supply of the camel auricle; superficial temporal artery (s t.a) rostral auricular artery (r a.a) and maxillary artery (m.a).
4. Discussion

The gross anatomy of the external ear in dromedary camel was somewhat similar to the domestic animals. In this study, the external ear was consisted of the pinna included (auricle, external cartilage), internal cartilages, muscles, the external acoustic meatus, and the tympanic membrane.

This study has shown that the muscles of the ear in camel were four groups: rostral, dorsal, ventral and caudal group, each one includes one or more muscles were responsible for the movement of the ear. The origin, position, direction, and insertion of these muscles similar to these muscles in domestic animals similar observation finding by [2,3] in camel [4] in bovine, [6] in cattle and buffalo [7] in horse. [8,9] in domestic animals, On the contrary, we did not find the styloauricular muscle in this work which was described by the [2] in camel, [4] in bovine [6] in cattle and buffalo and [7] in horse. The styloauricular and parotidoauricular muscles are united therefore the styloauricularis appears to be absent morphology similar findings were also report by [17] in ruminant and pig. Also in our finding the interscutolar muscle was protracted, thick, elongate muscle, while the cervicoscutolar muscle was taken specially shaped, triangle with a hypotenuse in the form. These results were under [6] in cattle and buffalo reported that the interscutularis is well-developed muscle in cattle and buffalo, however [17] that showed that this muscle was weak in the ox.

The current study explained that the external acoustic meatus was long tube extends from the floor of the auricle to the tympanic membrane. It was long and curved directed ventrally and then rostomedially. It was oval, had two parts cartilage and bone, long due to the external ear fairly long in camel as the most mammals. In this study, the shape of the external acoustic meatus was oval in camel that similar finding we investigated by [18] in camel, [6] in buffalo but not similar in cattle where it was circular. Our results agreed with [2] in camel and [8,9] reported that the external acoustic meatus was curved in sheep, goat, and dog. On the other hand; we found were disagree with [6] in cattle and buffalo that mentioned the external acoustic meatus was short in length and striated. They were added the length and diameter of external acoustic meatus in buffalo more than in cattle.

The external acoustic meatus had an anatomical significance where the tympanic cavity could be easily examined and the length and width of the external acoustic meatus this explains the prevention and obstruction of the rapid spread of any epidemics or infections or lesions of the tympanic membrane.

We found in this study the external ear and auricular muscles derived the nerves supply from the cranial auricular branch and caudal auricular branch given by auriculotemporal nerve from the facial nerve as well as the cutaneous branches from the vagus nerve to the skin of the external ear. While the blood supply was given by caudal auricular and the rostral auricular arteries from the superficial temporal from the external carotid artery. While the veins draining of the cartilage and muscles ear of the camels by the veins accompanying the arteries, which have the same name as the arteries. Similar finding was observed by [2] in camel, [4] in bovine, [6] in cattle and buffalo, [7] in horse, [8,9] in domestic animals and [19,20] in human. Whilst my results disagree with [1] that reported that the skin of the ear canal is innervated by four cranial nerves: the trigeminal; the facial; the glossopharyngeal; and the vagus nerves and added [21] vertical ramus of the mandible in equine. On the other hand, [22] stated that The arrangement of nerves and blood vessels in association with the ridges on the rostral (concave) surface was observed. The spaces between the ridges were relatively free of larger blood vessels, nerves, hair.in cattle, sheep, and deer. While [23] statement that the caudal auricular branch was not observed, except as a small vessel supplying the rostral auricular base in a rabbit.

Conclusion

The finding of the current study showed the anatomical features of muscles external ear and external acoustic meatus of camel with special reference to its blood and nerve supply. This important for determining the areas of the nerve block to attain successful regional anesthesia of this region and avoid injury blood vessels supply of the ear during the surgery in this region.

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

References
Advances in application of dromedary camel tissue culture research

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Abstract

The dromedary camels have a great economic value in Asia and Africa, where they are kept for production of milk, meat, wool and leather; they are also used for transportation in some areas. Recently, the camel racing practice in the Middle East has added to the cultural value of dromedary camels, which lead to increased interest in improving their genetic makeup, reproductivity and treatment efficiency. Tissue culture-based therapy in domestic animals is described as safe with considerable welfares to the animals. Tissue culture application is currently growing in the fields of vaccine production, virus cultivation and study, cancer research, gene therapy, Immunological studies and molecular biology. In veterinary medicine tissue culture technique has been used for the study of viral infection dynamics and vaccine development and for treatment of many affection including musculoskeletal system injuries, liver disease and mastitis. However, in dromedary camels such applications are relatively less. The current work reviewed the available research on tissue culture in dromedary camels. Our review shed light on the therapeutic, genetic, preventive and reproductive contribution of tissue culture application in dromedary camels.

Key words: Dromedary camel, Tissue culture.

1. Tissue and cell culture

It has been established that tissue or cell culture refers to a method by which fragments of tissue or cells taken from an animal are kept alive into a new artificial environment, where they might differentiate and their function architecture are preserved [1-2]. Tissue culture technique made it possible for new specialized cells and tissues to be maintained, and thus the possibility to address many important biological problems in new ways [5]. According to the latter authors cell culture can be classified as primary cell culture (cells are obtained from a host tissue) and secondary cell culture (cells obtained from primary culture are sub-cultured to form cell lines). It has earlier been mentioned that cell banks are of extreme importance in mammalian species preservation [6] by reserving their cells, tissues, semen, embryos, cDNA libraries and genomic libraries. At the cell bank somatic cell line is produced and saved by cryopreservation method [7]. The use of cell lines in research could overcome the limitations of animal experiments and provide a viable, practical and timely genetic material backup. Additionally, cell lines are considered as a versatile tool for animal cloning studies in the fields of virology, toxicology, and epidemiology. Cell lines could perform finite or infinite divisions.

Cell culture application has been investigated in many fields including pharmacology, medicine, reproduction, stem cell therapy and regenerative medicine [8]. Stem cell application is a branch field of tissue culture research, which provides promising issues, both in vitro and in vivo in animals, and also rendering speculation regarding its future therapeutic and preventive applications in human [9-11]. Stem cells have been described as un-specialized cells, which have the ability to renew, and if correctly stimulated, they can differentiate into specialized cells [12]. They have been classified into two types: embryonic stem cells (obtained from inner-cell mass
of the blastula of developing embryos) and adult stem cells (obtained from different adult tissues) [13].

2. Tissue Culture application in veterinary medicine

In domestic animals stem cell therapy has been reported in some studies noting that the process is safe giving considerable welfare to animals treated [14]. Thus, many clinics are nowadays using autologous or allogenic stem cell injection in fresh or cultured forms in their laboratory in treatment of various veterinary diseases. In addition to direct clinical stem cell application, a number of animal models have also been tested for these purposes [15]. This included treatment of tendons, bones and cartilage injuries in horse [16–18], cardiac diseases in dog [10, 14, 19], rodents and canine nervous system injuries [20–25], liver injuries in lab animals [26—29], wound in ruminants [30-31] and mastitis [15,32].

3. Tissue culture application in dromedary camels

The dromedary camel is the main food supplier in the desert regions as it is highly adaptable to the desert harsh environment [33]. Traditionally, camels are also used in racing in the Arabian Gulf countries which results in injuries of many valuable camels ([34]. Therefore, development of research regarding tissue regeneration techniques has become highly demanded.

3.1. Stem cells

Studies on dromedary camel stem cells are rare in the literature reviewed and this field seems to be its early stages. Adipose-derived stromal cell frequencies and growth characteristics have been isolated and studied in camel [35]; their osteogenic, chondrogenic and adipogenic differentiation potentials have been assessed concluding that as in human, camel adipocytes also contain multi-potent cells and many of them represent an important source of stem cells, both for preclinical studies and veterinary cell therapy.

Skin fibroblast cell line called “DUBCA” has earlier been established and characterized in dromedary camels [36]; however, that line has not been labelled. Furthermore, generating camel fibroblast cell lines that express green fluorescent protein (GFP) would be important as a tool to monitor camel cell growth, migration and other processes [37]; transfection of GFP into the Arabian camel skin and lung fibroblasts did not change their observed properties. Thus, GFP-labelled cell lines may represent a new tool for convenient monitoring of live primary camel fibroblasts. Arabian camel skin fibroblast cell line (SACAS) was also used in the expression of small heat shock proteinbeta-1((HSPB-1) from in dromedary camel [38]. Recently, various differentiated cells have been isolated from the dromedary camel dermis including fibroblasts and keratinocytes, cyst-forming cells, as well as multipotent dermal stem cells [39]. Those stem cells are capable of forming spheres that form osteoblasts, neurons and adiposities. Therefore, dermal stem cells constitute a reservoir for skin repair elements in camel which could be involved physiologically and pathologically in tissue repair. Further studies are essentially needed to isolate and propagate different skin.

Embryonic stem cells (ESCs) are known as pluripotent cells which have the ability to differentiate into all types of tissue and cells comprising the animal and human tissues, such as liver, muscle, brain, cartilage and bone tissues. ESCs originate from the embryonic inner cell mass (ICM) at early of blastula stage; they give rise to the three germ layers: the endoderm, mesoderm and ectoderm, from which originate the different tissues of the animal body [40]. The ovarian cumulus cells from dromedary camels has been obtained for the first time in 2018 [41] showing that cumulus of camel can express stem cell mRNA transcript (PO5A1, KLF4, SOX2 and MYC) and are able to differentiate giving other non-ovarian follicular cells in vitro like osteoblast, neurons and adipose cells. Similarly, embryonic stem like cells have recently been isolated from dromedary camel embryo [42] which is considered highly promising for biomedical research, genetic engineering and early developmental biology. Embryonic stem cells (ESCs) and trophoderm stem cells have been isolated from camel embryos for the first time on feeder-free conditions and showing the expression of all pluripotency genes (Sox2,Oct4, and Myc, Klf4) in the established cell lines through the conventional and real-time relative quantitative polymerase chain reactions [42]. Those isolated ESCs were differentiated into neuron-like cells successfully. Differential expression of certain genes such as Klf4 was also found; it presented significant increase in trophoblasts as compared to the ESCs; this raises the question as to whether Klf4 or other transcripts are essential for pluripotency in camels. Consequently,
the whole gene sequences responsible for the pluripotency have been sequence and identified in camels and these genes have also been cloned to be easily used to transform differentiated somatic cells into pluripotent stem cells after transfection of the cells with pluripotency transcription factors.

3.2. Cloning
Cloning holds the promise of allowing creation of genetically superior or engineered animals in one generation [43]. Clonal samples of genetic material, especially the skin cells from unique animals, may be very important for conservation of the available genetic diversity of threatened animal genetic resources [44, 45]. Fibroblast isolated from male Bacterian camel skin were cultured and in vitro multiplied in the laboratory, and cryopreserved to be later used for the revival of this breed using nuclear transfer and animal cloning [46].

In dromedary camels cloning might also be highly beneficial due to their seasonal breeding, prolonged gestation, inter-calving period as well as the difficulty in semen sampling and storage for artificial insemination. The first report of pregnancies and of cloned Camelid (Camelus dromedarius) has been established using cultured somatic cell nuclear transfer [47]. The latter authors also reported, for the first time, that fetal and adult fibroblasts could be frozen, cultured and expanded without any effect regarding their capability for supporting the development of nuclear transfer embryo. The birth of cloned Bactrian camel was reported for the first time by inter-species somatic cell nuclear transfer (iSCNT) using a dromedary camel as an oocyte source and a surrogate for carrying [48]. A recent study [49] concludes that cell type, cell donor together with their treatment affect the cloning outcome by somatic cell nuclear transfer in camels.

Conclusion
The knowledge gained so far on the mechanism of tissue culture-based application in dromedary camels is still in its early stages. However, successful use seems to be promising in some fields such as cloning, veterinary regenerative medicine of musculoskeletal disorders as well as embryonic and Mesenchymal stem cell-based treatment.

Conflict of Interest: None declared.

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Ultrasonography of the Cardiopulmonary System in Camels (Camelus dromedarius)

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Abstract

This article reviews the normal cardiac chamber appearance and quantitative dimensions in healthy dromedary camels. Besides, it shows results of ultrasonography of the lungs and pleura and its dimensions in camels. First part of the review deals with technique of echocardiography of the normal camel heart and cardiac dimensions, echocardiographic protocol and the results of the right and left parasternal ultrasonograms. It also reviews the minimum, maximum, mean values, standard deviations and coefficient of variation for the internal echocardiographic measurements in healthy camels. Second part of this review article deals with pulmonary ultrasonography and its technique and ultrasonographic finding in healthy camels. It also reviews the measurements for the dorsal and the ventral lung borders and the resulting dorsoventral dimensions of the right and left lungs. Both first and second parts are then followed by practical application of cardiopulmonary ultrasonography in camel medicine. This section shows in order the ultrasonographic findings in camels with white muscle disease (Vitamin E/Selenium deficiency), chronic pneumonia and pleuropneumonia in diseased camels.

Key words: Camels, Cardiovascular, Cardiopulmonary, Echocardiography, Ultrasonography.

Echocardiography of the normal camel heart: technique and cardiac dimensions

In the camel, heart diseases include pericarditis, vegetative valvular endocarditis, hypertrophic cardiomyopathy, necrotic myocarditis and congenital defects including septal defects, patent ductus arteriosus, transposition of the aorta and pulmonary artery, persistent aortic trunk, and persistent right aortic arch and sarcocystosis [1-7]. These heart diseases are mostly diagnosed at slaughterhouses or incidentally discovered at postmortem examination [8], showing that the diagnosis of camel heart disease is a challenging task especially when typical clinical signs of heart failure are absent. For these reasons, ancillary tests are required to confirm the diagnosis in the living animal. This is of particular importance to avoid further therapeutic investments in a low-value patient when the prognosis is perceived to be poor or to early initiate treatment in valuable animals [7].

Echocardiography is a good ancillary tool to assess the heart in other ruminant species. It has been used extensively in cattle and can be used as a prognostic tool in some diseases since the extension and importance of the disease are better assessed [9-12]. The procedure is a non-invasive, straightforward method for assessment of the bovine heart [13]. It has been used extensively in cattle and can be used as a prognostic tool in some diseases since the extension and importance of the disease are better assessed [10, 14]. The procedure is a widely used imaging tool in small animals, horses, and cattle for evaluation of morphologic changes, abnormal wall thickness, chamber size and valvular appearance and
function [15, 16]. This section of this article reviews normal cardiac chamber appearance and quantitative dimensions in adult camels.

**Echocardiographic protocol**

The forelimb of the camel should be firstly bent and tied with a rope on the carpal joint. The head is then held and the animal is pushed until it is positioned in sternal recumbency. The fore-and-hind limbs are then tied by a rope near the carpal and hock joints, respectively. All echocardiographic examinations are best performed in the recumbent animal. Camels, if nervous, maybe lightly sedated using xylazine (0.02mg/kg IV). Echocardiographic examinations are performed using an ultrasound machine with a 3.5 MHz sector transducer [17].

In preparation for the echocardiography, the intercostal spaces (3rd to 6th) on both sides of the thorax are clipped, shaved and swabbed with alcohol to remove excess oil, and coupling gel is applied. The third, fourth and fifth intercostal spaces in the cardiac region are then examined ultrasonographically on the right and then the left sides of the thorax. The thoracic limbs are moved cranially to facilitate better contact between the probe and the intercostal space. In the cardiac area, the heart, valves, and major blood vessels are imaged. Four two-dimensional (2-D) parasternal images are obtained from the right and three 2-D parasternal images from the left. Additionally, M-mode images are obtained from the right and left sides of the thorax. Two-dimensional images from both the right and left hemithorax are used to guide the placement of the probe and obtain accurate M-mode recordings (Figure 1).

Coupling gel is applied to the transducer, and this is applied to the skin approximately in the 3rd and 4th and 5th right and left intercostal spaces. On the right side, the images are obtained in the following order: a caudal long-axis view of the right and left ventricles, a caudal long-axis view of the left ventricular outflow tract (LVOT), a caudal short-axis view of the ventricles and a cranial long-axis view of the right ventricular outflow tract (RVOT). On the left side, a caudal long-axis view of the heart (four-chamber view), a caudal long-axis view of the LVOT and a cranial long axis-view of the RVOT are obtained. The intercostal space and probe orientation used to obtain each image are recorded at the end of each examination. Echocardiographic measurements are performed using the electronic ultrasound calipers [17].

Three non-consecutive cardiac cycles are measured and later measurements are averaged in order to eliminate some of the measurement errors. Eighteen measurements are recorded from the 2-D images. Right ventricular diameter in systole (RVs) and diastole (RVD), right atrial diameter in systole (RAs) and diastole (RAd), right ventricular wall thickness in systole (RVWt) and diastole (RVWd), interventricular septal thickness in systole (IVSt) and diastole (IVSd) and tricuspid valve diameter in systole (TVDs) are measured from the right parasternal caudal long-axis four-chamber view with the probe placed in the 5th intercostal space (ICS) with a slight clockwise rotation or perpendicular in the 4th ICS. Left ventricular diameter in systole (LVs) diastole (LVD), left atrium diameter in systole (LAs) and diastole (LAd), left ventricular wall thickness in systole (LVWt) and diastole (LVWd) and mitral valve diameter in systole (MVDs) are measured from the left parasternal view with the transducer positioned in the 5th or 4th ICS and directed slightly caudodorsally. Aortic diameter in diastole (AoD) is measured from the left parasternal view with the transducer placed in the 4th ICS turned slightly more cranially and rotated slightly counterclockwise. Pulmonary artery diameter in diastole (PAd) is measured from the left parasternal view with the transducer placed obliquely in the 3rd ICS. Systolic measurements are measured during the closure of the atrioventricular valves and opening of the semilunar valves, whilst diastolic measurements were measured during the opening of the atrioventricular valves and closure of the semilunar valves. Ventricular measurements are measured at the level of the papillary muscles close to the chordae tendinae, whilst atrial measurements were measured at the widest part of the atria [17].

**Right parasternal ultrasonograms**

When the probe is placed longitudinally in the 5th intercostal space with a slight clockwise rotation or perpendicular in the 4th ICS, the caudal long-axis four-chamber view of the ventricles, atria, and the interventricular septum is imaged (Figure 2). In this position, the right and left ventricles, tricuspid valve and right and left atria are visible [17]. Placing the probe slightly more cranially in the 4th ICS with the transducer rotated cranially, the caudal long-axis view of the LVOT (the left ventricle, left atria, aortic...
valve, and the aortic root) can be imaged (Figure 3). From this position, the right and left ventricles and interventricular septum (IVS), the right and atria and the tricuspid valve are visible [17]. A hybrid view between a “four-chamber” and “LVOT view” could be imaged from the same position (Figure 4). A slight clockwise rotation in the 4th ICS, the short-axis view of the cardiac ventricles is obtained (Figure 5). The right ventricle, interventricular septum, and left ventricle are visible [17]. Placement of the transducer in the 3rd ICS allowed the visualisation of the RVOT in which the right ventricle, the pulmonary valve, pulmonary artery, aorta, and aortic valve are imaged [17] (Figure 6).

**Left parasternal ultrasonograms**

When the probe is placed longitudinally in the 5th or 4th ICS and directed slightly caudodorsally, a view of the ventricles, atria, and the atrioventricular valves is obtained (Figure 7). In this position, the right and left ventricles, the mitral and tricuspid valves, and the interventricular septum are visible [17]. The LVOT is imaged in the 4th ICS and the probe is turned slightly more cranially and rotated slightly counter clockwise (Figure 8). In this position the right ventricle, tricuspid valve, and the right atrium are imaged. The **ossa chordis** is also visible in the same position as a sub-aortic hyperechoic thin shadowing area [17]. The RVOT is seen from the 3rd intercostal space (Figure 9). In this position, the right ventricle, tricuspid valve, right atrium, and pulmonary artery are visible. An oblique section of the aorta is also visible. The minimum, maximum, mean values, standard deviations and coefficient of variation for the measured variables are summarized in Table 1 [17].

**Ultrasonography of the lungs**

In camels, pulmonary diseases are common. The most important include atelectasis, bronchiectasis, pneumoconiosis, pneumonia, hydatidosis, pleuritis, emphysema, pneumothorax, hydrothorax, haemothorax, empyema and pulmonary tumors [4, 7, 8, 18]. In a study carried out on the lungs of 387 slaughtered camels, one or more gross lesions were encountered on 300 lungs (77.5%). The gross and histopathological examination of these lesions had revealed 60.2% emphysema, 21.2% hydatidosis, 18.6% pneumonia, 10.6% atelectasis, 4.9% aspiration of blood, 3.9% pneumoconiosis, 2.6% pulmonary oedema and congestion, 1.6% abscess, 1% pleurisy, and 0.8% granulomatous pneumonia [19]. Thus a clinical examination of the lungs and pleura is important in camels. Methods for examining the lungs and pleura are invasive and noninvasive. Noninvasive methods include auscultation of the lungs before and after interruption of breathing by manual occlusion of mouth and nostrils, the percussion of the thoracic wall, lung function tests, radiography, ultrasonography, and endoscopy. Pulmonary biopsy and thoracocentesis are examples of invasive methods [4, 7, 20].

In human medicine, ultrasonography of the lungs is one of the important tools in the management of critical patients and urgent cases, not only for the detection of pleural effusion but also for the identification of pneumothorax, alveolar consolidation, and interstitial syndromes [21]. In cattle, ultrasonography of the lungs and pleura is particularly useful for the detection and characterization of pleural effusion, especially small amounts, the detection of superficial pulmonary lesions or consolidation, pulmonary atelectasis, and pneumothorax [20, 22-27]. This section of this article reviews ultrasonography of the lungs and pleura and its dimensions in healthy camels. Informative ultrasonography of the lungs and pleura in the camel should provide reliable data about the condition of the pleura, the pulmonary surface and the dimensions of the lungs.

**Technique of pulmonary ultrasonography**

Firstly, the camel should be maintained as for echocardiography. Both sides of the thorax are clipped and the skin shaved. Ultrasonographic examination is carried out using a 3.5 MHz sector transducer. After the application of transmission gel to the transducer, the lungs are examined transcutaneously on the right and then the left sides beginning at the 11th through the 4th intercostal space (ICS). Each ICS is examined dorsal to ventral with the transducer held parallel to the ribs. Visualization of the pleura and lungs is assessed. The pleural space is then examined for possible fluid accumulation, and attempts are made to differentiate between the parietal (costal) and visceral (pulmonary) pleura. To estimate the position and dorsoventral dimension of the lungs, the dorsal and ventral lung borders are assessed. The position of the dorsal and ventral lung margins are measured in relation to the dorsal midline. Measurements are made in each ICS; they included determinations of the dorsal and ventral lung borders and the
dorsoventral dimension of the lung. All measurements are taken at maximal inspiration. Measurements of distance from the dorsal midline are taken afterwards, using ultrasound to identify the pertinent inner points [28].

**Ultrasonographic findings**

The different layers of the thoracic wall appear as narrow bands of variable echogenicity. Medial to the thoracic wall was an echogenic line that represents the costal and pulmonary pleurae. Lung borders can be easily differentiated from the parietal pleura during inspiration/expiration in real time. Reverberation artefacts appear as lines of variable echogenicity that run parallel to the pulmonary surface medial to the pleura (Figure 10). They result from reflection of the ultrasound waves by air in the lungs. The reverberation artefacts become progressively weaker as distance from the body surface increased; they were no longer seen at depth of 7 to 8 cm. The pulmonary parenchyma cannot be visualized because of its air content [28].

On the right side, back musculature, thoracic wall with pleura and pulmonary surface and parts of the liver and the omasum are seen (Figure 11). The pulmonary surface is seen in the 5th through the 10th ICSs in all camels. Additionally, it is imaged in the 11th ICS in 20 camels and the 4th ICS in 3 camels. The dorsal lung border is approximately the same distance from the dorsal midline. In the 7th through the 4th ICSs, the dorsal part of the lung is hidden by the scapula, thus increasing the distance to the dorsal midline. The ventral lung border has a caudodorsal course, so that the distance between the dorsal midline and the ventral lung border progressively decreased from cranial to caudal. The ventral lung border is largest at the 4th ICS and smallest at the 11th ICS. The dorsoventral dimension of the lung is largest at the 8th ICS and progressively decreased posterior to the 11th ICS and anterior to the 4th ICS. It should be noted that the lung size in these ICSs is not the actual dimension of the lung; therefore it is only the ultrasonographically examinable part of the lungs. The echogenic line on the surface of the lung, consisting of the costal and the parietal pleurae, is 1 to 4 mm thick [28].

On the left side, from dorsal to ventral, back musculature, thoracic wall with pleura and pulmonary surface, and depending on the ICS, rumen is seen (Figure 12). The pulmonary surface and the pleurae are imaged with approximately the same frequencies on the right side. There is a difference in the 11th ICS where only the pulmonary surface and the pleurae are imaged in 15 of the 22 camels. This difference is caused by cranial displacement of the lung by the rumen. The measurements for the dorsal and the ventral lung borders and the resulting dorsoventral dimensions of the lungs are similar to those on the right side (Table 2) [28].

**Practical application of cardiopulmonary ultrasonography in camel medicine**

**White muscle disease (Vitamin E/Selenium deficiency)**

White muscle disease or nutritional muscular dystrophy (NMD) is most common in fast growing young animals and is associated with an inadequate intake or utilization of vitamin E or selenium (Se), or both. The disease occurs in all farm animal species, especially in rapidly growing neonates. The disease is characterized by subacute skeletal muscle degeneration and acute cardiac muscle degeneration. Deficiencies of Se and vitamin E induce lipoperoxidation in the tissues, which results in hyaline degeneration with calcification and severe necrosis in myocardial and skeletal muscle [29]. Many cases have been reported in camels in their natural habitat [30, 31]. Camel selenium supplementation is often necessary and different methods are used: injection, drenching and trace minerals salt mixture. But, selenium requirements in this species are extrapolated from those of other ruminants [32, 33]. The biological role of selenium in the dromedary is identical to that of the other ruminants, but the metabolism seems different [34]. Due to lack of references, the present synthesis aimed to give more details on the serum selenium values based on four experiments focused on selenium intake [35], excretion [36] and tolerance [36, 37] achieved for a better understanding of the selenium metabolism in this species. Ultrasonographic examination of the heart reveals tachycardia and an elevated myocardium echogenicity (Figure 13).

**Chronic pneumonia**

Inflammation of the lung is common among camels of various ages. It may involve the bronchi and lung parenchyma, which is called bronchopneumonia. If the inflammation involves the interstitial tissues of the lung it is called interstitial pneumonia. Pneumonia is a frequent diagnosis at a gross necropsy because the normal lung tends to be
slightly edematous and hyperemic. That pneumonia occurs there is no doubt, but a thorough examination and evaluation are necessary to exclude diseases of other organ systems. Pulmonary edema is a common terminal lesion seen in animals dying from numerous diseases. The causal bacterial agents of camalid pneumonia are similar to those causing pneumonia in livestock and horses. Most infectious cases result from opportunistic bacteria. Septicemic animals usually develop pneumonia, and the most common agent isolated in the author’s practice has been *Escherichia coli*. Other causes of pneumonia include inhalation of toxic vapors. Signs are exaggerated in the neonate and include dyspnea, coughing, elevated body temperature, variable nasal exudation, depression, and anorexia. Sounds heard at auscultation vary with the degree of exudation and consolidation [18, 38]. Broad-spectrum antibiotic therapy is recommended until sensitivity results are available, because Gram-negative organisms are frequently involved. General nursing care and supportive treatment are indicated [4, 7]. In a calf, the left lung contained a capsulated 7.6×6.8 cm lesion that contained anechoic fluid. Acoustic enhancement was imaged below the lesion (Figure 14). Aspiration of the lesion revealed a purulent material confirming abscess formation [18].

The camel calves with lung consolidation are presented because of decreased appetite, weakness, dyspnea, and dry cough. Dry rales is heard over the right lung at the cranioventral lung lobes. An increased vesicular sound is heard over the left lung. Thoracic ultrasonography shows consolidation of the right apical lung lobes with sub-pleural anechoic fluids [18]. Ultrasonography of the left lung detected numerous comet-tail artifacts in the form of bright, closely situated echo bands starting at the lung surface and running perpendicular to the pleura in the lung tissue are observed upon ultrasonography, a picture of pulmonary emphysema (Figure 15). Thoracic ultrasonography may also shows consolidation of the right and left apical lung lobes (Figure 16). Thoracic ultrasonography in camel calves with drenching pneumonia shows a bilaterally consolidated apical lung lobes with sub-pleural hyperechoic fluid (Figure 17).

**Pleuropneumonia**

Inflammation of the pleura is known as pleuritis or pleurisy. It is usually associated with inflammation of the lung, the condition is called pleuropneumonia [4]. Pleural effusion is usually secondary to pleuritis, pericarditis, or right heart insufficiency. Inspiratory dyspnea is the most prominent sign. The absence of sounds in the lower thorax and a dull sound on percussion in the same area are diagnostic. A definitive diagnosis is based on radiography and thoracocentesis. The nature of the pleural fluid must be be determined, because it may be a modified transudate or exudate. Therapy is determined by the etiology. Excess fluid may be removed via thoracocentesis, but the critical factor is to prevent recurrence. The prognosis for a neoplasm is grave. Infectious pleuritis should be treated with broad-spectrum antibiotics until results of culture and sensitivity tests are known [7]. The camel calves with pleuropneumonia were presented because of anorexia, difficult respiration and progressive weight loss. The vesicular lung sounds were hardly audible. Thoracic ultrasonography revealed anechoic fluid with fibrin net of the and right and left pleurae with consolidation of the anetrio-ventral lung lobes. Approximately 500 mL of slightly reddish fluid was aspirated (Figure 18).

**Figure 1.** B-M mode images obtained from both the right (a) and left (b) hemithorax. Ds, dorsal; Vt, ventral; IVS, interventricular septum; LA, left atrium; LV, left ventricle; MV, mitral valve; RA, right atrium; RV, right ventricle; TV, tricuspid valve.
Figure 2. Right parasternal caudal long-axis view of the left and right ventricles (four-chamber view). The chordae tendinae of the tricuspid valve are also seen as echoic lines (arrow). Ds, dorsal; Vt, ventral; IVS, interventricular septum; LA, left atrium; LV, left ventricle; MV, mitral valve; RA, right atrium; RV, right ventricle; TV, tricuspid valve; CT, chordae tendinae.

Figure 3. Right parasternal caudal long-axis view of the left ventricular outflow tract showing both ventricles and interventricular septum together with the aorta and the aortic valve. Ds, dorsal; Vt, ventral; Ao, aorta; Av, aortic valve; IVS, interventricular septum; LA, left atrium; LV, left ventricle; RV, right ventricle.

Figure 4. Right parasternal caudal long-axis view showing the four-chamber view together with the left ventricular outflow tract view. The chordae tendinae of the mitral valve are also seen as echoic lines Ds, dorsal; Vt, ventral; Ao, aorta; Av, aortic valve; IVS, interventricular septum; LA, left atrium; LV, left ventricle; MV, mitral valve; RA, right atrium; RV, right ventricle; TV, tricuspid valve; CT, chordae tendinae; PM, papillary muscles.

Figure 5. Right short-axis view of the cardiac ventricles. Both ventricles are seen in a transverse section. Ds, dorsal; Vt, ventral; RVW, right ventricular wall; RV, right ventricle; IVS, interventricular septum; LV, left ventricle.

Figure 6. Right parasternal cranial long-axis view of the right ventricular outflow tract on the third intercostal space. Ds, dorsal; Vt, ventral; RV, right ventricle; PA, pulmonary artery; PV, pulmonary valve; Ao, aorta; AV, aortic valve.

Figure 7. Left parasternal caudal long-axis view of the heart. In this view, the four cardiac chambers are observed as well as the atrioventricular valves. Ds, dorsal; Vt, ventral; LA, left atrium; LV, left ventricle; MV, mitral valve; RA, right atrium; RV, right ventricle; TV, tricuspid valve; IVS, interventricular septum.
Figure 8. Left parasternal caudal long-axis view of the left ventricular outflow tract. The left ventricle and aorta are observed. The transversa view of the aortic valve is recognized as a thin echoic line. Ds, dorsal; Vt, ventral; RV, right ventricle; LV, left ventricle; RA, right atrium; IVS, interventricular septum, Ao, aorta; AV, aortic valve; Oc, ossa chordis.

Figure 9. Left parasternal cranial long-axis view of the right ventricular outflow tract. The left ventricle and aorta are observed. The transversa view of the aortic valve is recognized as a thin echoic line. Ds, dorsal; Vt, ventral; RV, right ventricle; RA, right atrium; TV, tricuspid valve; Ao, aorta; PA, pulmonary artery; PV, pulmonary valve.

Figure 10. Ultrasonogram of the normal camel lung obtained from the 8th intercostal space on the right side. 1 = Thoracic wall; 2 = Pleura; 3 = Reverberation artifacts; DS = Dorsal; VT = Ventral.

Figure 11. Ultrasonogram of the normal camel lung, liver and omasum obtained perpendicular from the middle 6th intercostal space on the right side. 1 = Thoracic wall; 2 = Pleura; 3 = Reverberation artifacts; 4 = liver; 5 = omasum; DS = Dorsal; VT = Ventral.

Figure 12. Ultrasonogram of the normal camel lung and rumen obtained from the upper 10th intercostal space on the left side and slightly rotated caudally. 1 = Thoracic wall; 2 = Pleura; 3 = Pulmonary parenchyma; 4 = rumen; DS = Dorsal; VT = Ventral.

Figure 13. Echocardiography of a camel calf with vitamin E/selenium deficiency during systole (left) and diastole (right). RV, right ventricular diameter; LV, left ventricular diameter; RA right atrium diameter; LA, left atrium diameter; IVS, interventricular septum; TV, tricuspid valve; MV, mitral valve.
Figure 14. Ultrasonographic findings in a camel calf with chronic pneumonia. Left image shows consolidated right apical lobes with sub-pleural anechoic fluid (F). Right image shows a capsulated 7.6×6.8 cm abscess.

Figure 15. A camel calf with chronic pneumonia and compensatory emphysema. Ultrasonographic findings included consolidation of the right apical lung lobes with sub-pleural anechoic fluids (F) (left image). Right image shows numerous comet-tail artifacts in the form of bright, closely situated echo bands starting at the lung surface and running perpendicular to the pleura in the lung tissue were observed upon ultrasonography, a picture of pulmonary emphysema.

Figure 16. A camel calf with chronic pneumonia. Right image shows consolidation of the right lung apical lobes.

Figure 17. A camel calf with severe drenching pneumonia showing an orange vomitus. Right image shows thoracic ultrasonography in the same where a bilaterally consolidated apical lung lobes with sub-pleural hyperechoic fluid was imaged.

Figure 18. A female camel with pleuropneumonia. Thoracic imaging (right) shows anechoic fluid with fibrin net within the pleura.

Table 1. Internal echocardiographic measurements in healthy adult camels (n=22).

<table>
<thead>
<tr>
<th>Variable</th>
<th>Min</th>
<th>Max</th>
<th>Mean</th>
<th>SD</th>
<th>CV</th>
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<tr>
<td>RVd (cm)</td>
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<td>1.2</td>
<td>22%</td>
</tr>
<tr>
<td>RVs (cm)</td>
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<td>10%</td>
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<td>LVd (cm)</td>
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<td>11.8</td>
<td>1.6</td>
<td>14%</td>
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<td>LVs (cm)</td>
<td>7.8</td>
<td>9.4</td>
<td>8.2</td>
<td>0.6</td>
<td>10%</td>
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<td>RAD (cm)</td>
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<td>5.9</td>
<td>0.5</td>
<td>10%</td>
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<tr>
<td>RAs (cm)</td>
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<td>3.9</td>
<td>0.4</td>
<td>10%</td>
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<tr>
<td>LAd (cm)</td>
<td>6.8</td>
<td>8.8</td>
<td>7.6</td>
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<td>10%</td>
</tr>
<tr>
<td>LAs (cm)</td>
<td>4.7</td>
<td>6.4</td>
<td>5.6</td>
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<td>10%</td>
</tr>
<tr>
<td>RVWd (cm)</td>
<td>2.5</td>
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<td>2.8</td>
<td>0.4</td>
<td>14%</td>
</tr>
<tr>
<td>RVWs (cm)</td>
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<td>0.3</td>
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<tr>
<td>IVSd (cm)</td>
<td>1.7</td>
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<td>14%</td>
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<tr>
<td>IVSs (cm)</td>
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<td>LVWd (cm)</td>
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<td>14%</td>
</tr>
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<td>LVWs (cm)</td>
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<td>0.4</td>
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<td>AOD (cm)</td>
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<tr>
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<td>8.1</td>
<td>1.2</td>
<td>15%</td>
</tr>
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<td>TVDs (cm)</td>
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<td>1.1</td>
<td>27%</td>
</tr>
<tr>
<td>MVDs (cm)</td>
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<td>7.8</td>
<td>6.2</td>
<td>1.0</td>
<td>16%</td>
</tr>
</tbody>
</table>

N, number of the camels; Min, minimum value; Max, maximum value; SD, standard deviation; CV, coefficient of variation; RV, right ventricular diameter; LV, left ventricular diameter; RA, right atrium diameter; LA, left atrium diameter; RVW, right ventricular wall thickness; IVS, interventricular septal thickness; LVW, left ventricular wall thickness; AO, aortic diameter; PA, pulmonary artery diameter; TVD, tricuspid valve diameter; MVD, mitral valve diameter; d, diastole; s, systole.
Table 2. Dimensions (means ± SD) of the right and left lungs obtained at the 4th through the 11th intercostal spaces in healthy camels (n=22) as estimated by ultrasound.

<table>
<thead>
<tr>
<th>Intercostal space</th>
<th>11th</th>
<th>10th</th>
<th>9th</th>
<th>8th</th>
<th>7th</th>
<th>6th</th>
<th>5th</th>
<th>4th</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Right lung</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dorsal margin*</td>
<td>34±2</td>
<td>33±3</td>
<td>29±2</td>
<td>29±2</td>
<td>53±6</td>
<td>55±4</td>
<td>62±5</td>
<td>62±2</td>
</tr>
<tr>
<td>Ventral margin*</td>
<td>43±9</td>
<td>46±7</td>
<td>51±7</td>
<td>60±5</td>
<td>64±3</td>
<td>69±4</td>
<td>75±6</td>
<td>76±6</td>
</tr>
<tr>
<td>Size (cm)</td>
<td>9±4α</td>
<td>13±3α</td>
<td>22±4b</td>
<td>31±2b</td>
<td>11±4α</td>
<td>14±4α</td>
<td>13±7α</td>
<td>14±7α</td>
</tr>
<tr>
<td><strong>Left lung</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dorsal margin*</td>
<td>35±4</td>
<td>34±2</td>
<td>28±2</td>
<td>28±2</td>
<td>51±5</td>
<td>52±4</td>
<td>60±6</td>
<td>64±4</td>
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<td>Ventral margin*</td>
<td>46±4</td>
<td>43±8</td>
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<td>57±7</td>
<td>63±5</td>
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<td>72±7</td>
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</tr>
<tr>
<td>Size (cm)</td>
<td>11±1α</td>
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<td>20±6b</td>
<td>29±4b</td>
<td>12±3α</td>
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<td>12±5α</td>
<td>12±5α</td>
</tr>
</tbody>
</table>

*Centimetres ventral to the dorsal midline.

In conclusion, echocardiography and scanning of the lungs and pleura is a useful supplement to the existing methods of examination of the thorax of camels can be easily translated in the field. The study provides information about the normal cardiac chamber appearance and quantitative dimensions in adult camels. Besides, ultrasonography provides information about the condition of the pleura and lungs and could be used as a reference for further studies concerning camels with respiratory diseases.

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**Conflict of interest**
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**References**


