



Abdominal hernias in camel (*Camelus dromedaries*): Clinical findings and treatment outcomes

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ABSTRACT. The present study was designed to describe the clinical presentation of abdominal hernias and to evaluate the efficacy of polypropylene mesh in repair of such affection in camels. Twenty-six dromedary camels were included in this study on the basis of clinical and ultrasonographic evidence of abdominal hernia. Factors associated with prevalence and clinical findings of hernia were presented and hernioplasty using polypropylene mesh was evaluated as a surgical intervention. Out of 26 studied camels, abdominal hernia was prevalent in Wadeh camels than other breeds (17 vs. 9, $P < 0.01$). Camels < 6 years of age exhibited more hernias than other age groups (18 vs. 8, $P < 0.01$). Moreover, females showed a significantly higher prevalence (19 vs. 7, $P < 0.01$) of abdominal hernia compared to males (26.9%, $n = 7$). The sensitivity (96.8%) and specificity (93.1%) of ultrasonography (US) for diagnosing hernia were higher in comparison to clinical examination (88.3%). At 3 weeks postoperatively, the clinical index score of 26 operated camels was significantly reduced in comparison with pretreated (22 vs. 4, $P < 0.005$). However, only 2 cases had recurrence of the hernia and 2 camels had slight swelling in situ. By the 6th month post treatment, all treated camels were completely recovered. In conclusion, the polypropylene mesh is a viable and consistent alternative effective treatment for abdominal hernias in camels. In addition, the clinical index scores and US provide a precise paradigm for diagnosis and preoperative planning for abdominal hernias in dromedary camels.

KEY WORDS: camel, hernia, mesh, repair, ultrasonography

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Abdominal hernia is an abnormal protrusion of a part of abdominal contents through a natural or pathological opening in the abdominal wall [5]. Though, hernias can occur in different regions of the body, the most common site is the abdominal wall, especially in the ventral and inguinal regions [10, 26]. It is commonly located low or high in the flank, along the costal arch or between the last ribs [28, 30]. Abdominal hernias occur mainly secondary to abdominal wall trauma, infection or previous surgery and occasionally as congenital malformations [13, 34]. There are several forms of hernias with a wide range of different clinical conditions in livestock; including camel [28].

Abdominal hernias have several deleterious effects on animal health and economy, such as treatment cost, lowering the productivity and reproductivity of the affected animals [18, 25]. In addition, abdominal hernias alter both conformation and distort the cosmetic appearance of the animal body. Hernias may lead to incarceration or strangulation of internal organs within the hernial sacs [10].

Abdominal hernias are common, classically taught to occur in domestic animals with a prevalence of 2.83% when compared to other types of hernias [13]. Factors significantly associated with prevalence of hernia were hernia site, management system, hereditary, environmental and/ or animal handling factors [13, 14]. The prevalence of abdominal hernia was higher in bovine and ovine (32.3%) [4, 27] and in horses, the rate of hernia is as few as 5–10% [11, 12]. However, little is known about the incidence of abdominal hernia in camels.

Diagnosis of abdominal hernia is usually made on physical examination. However, clinical diagnosis may be difficult, especially

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in large ruminants that need casting, which has a high chance of causing self-inflicted injuries to the animal [2, 36]. In these situations, abdominal ultrasonography (US) may be the first choice to the correct diagnosis and to confirm suspected complications when clinical examinations are inconclusive [6]. It can aid in the differential diagnosis of hernia from other palpable abdominal wall swellings [19]. Furthermore, the surgical decision for herniorrhaphy was based on US evaluation of the intestinal motility and adhesion degree between the hernial sac and surrounding tissue [2].

There is no spontaneous cure or medication to treat large hernia in camels. The only existing treatment is surgical repair [16, 28]. Various traditional surgical corrective procedures have been described for the treatment of hernia depends on size and location of hernia. However, effective repair of hernia in camels is a difficult task especially with the traditional sutured repair. There have been many advances in herniorrhaphy alternative techniques over the last years in human and veterinary medicine [16, 23]. Among various modalities, the use of synthetic meshes was a landmark in hernia repair, either for bridging the defect or for reinforcing the abdominal wall. However, the application of this technique in camel practice is still limited [7, 9, 24].

Many reports have described the abdominal hernia in farm animals [4, 16]. Despite the camel's popularity, little was known about the factors associated with prevalence of hernia with clinical findings as well as evaluation of polypropylene mesh for surgical herniorrhaphy of abdominal hernia in camels. Therefore, the present study was designed to describe the clinical presentation of abdominal hernias and to evaluate the efficacy of polypropylene mesh in repair of such affection in dromedary camels.

MATERIALS AND METHODS

Camels

A total of twenty-six dromedary camels (7 males and 19 females) aged between 12 and 120 months (mean \pm SD: 96 ± 12 months), weighing between 190 and 700 kg (450 ± 100 , mean \pm SD) and of different breeds (17 Wadeh, 1 Asfar, 3 Ashaal and 5 Mejhem), admitted to the Veterinary Teaching Hospital, Faculty of Veterinary Medicine, Qassim University, KSA. Camels were included in the study on the basis of clinical and ultrasonographic evidence of abdominal hernia at different levels of the abdomen (Fig. 1). Abdominal hernias were classified according to their anatomical location in the abdominal wall. The size of each hernia was measured with a tape measure of the straight-line distance between the edges of the hernia. The study protocol was approved by the committee of animal welfare and ethics, Laboratory Animal Control Guidelines of Qassim University.

Clinical index scores

Upon admission, camels were clinically evaluated for subjective assessment of the abdominal hernia to detect the cause, duration, site, nature (reducibility), size of the hernial ring, and content of the hernia. In addition, parameters for the investigated camels were assessed, including breed, age and sex were recorded. All of these parameters were recorded and scored as clinical index scores by one person to be evaluated, compared and statistically analyzed (Table 1).

Ultrasonographic examination

Ultrasonographic examination was carried out in sternal or lateral recumbency according to the site of hernia, using 3.5 MHz sector and 7.5 MHz linear transducers (SSD-500, Aloka, Tokyo, Japan). The investigated camel was lightly sedated using intravenous 0.2 mg/kg

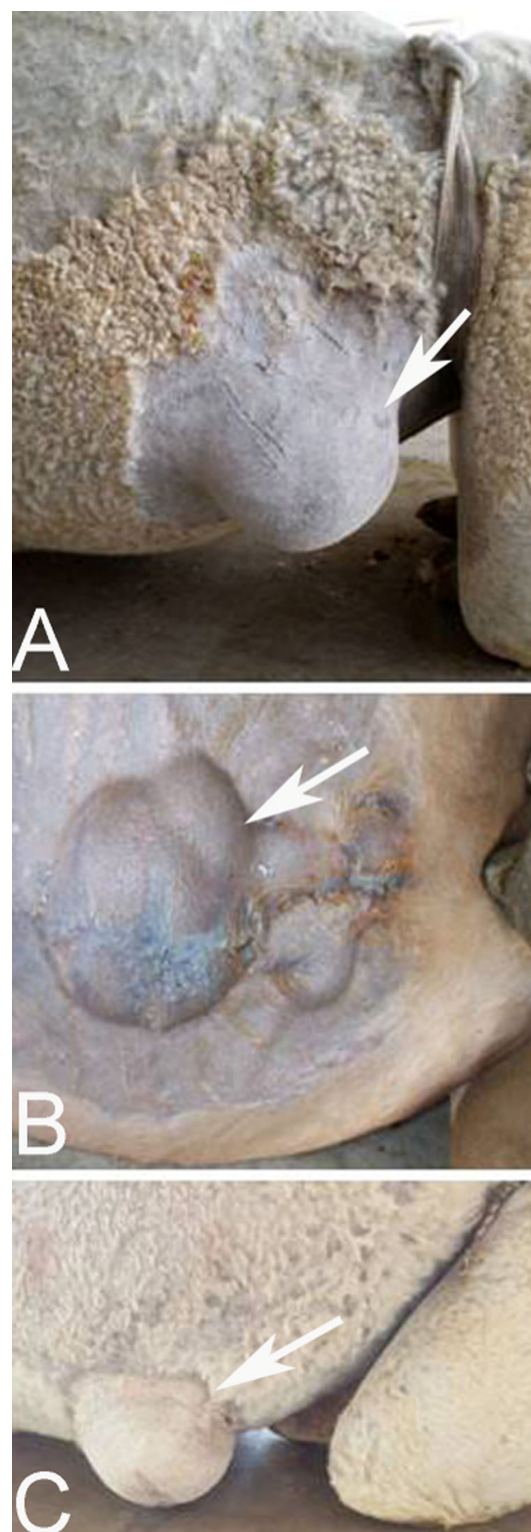


Fig. 1. A: Lateral abdominal hernia in 4-year-old female camel. B: Ventral abdominal in 3-year-old male camel. C: Ventrolateral abdominal hernia in 6-year-old female camel.

Table 1. Clinical index score for the clinical findings and treatment outcome of abdominal hernias in the cohort of dromedary camels

Criteria	Score and description
Breed	0=Wadeh; 1=Mejhem; 2=Ashaal; 3=Asfar
Age (Year)	0=1–3; 1=4–6; 2=7–10
Sex	0=Male; 1=female
Cause	0=Congenital; 1=Abdominal trauma; 2=Postoperative; 3=Unknown/suspected trauma
Duration (Month)	0=3–9; 1=10–16; 2=17–22; 3= \geq 23
Location	0=Ventral; 1=Ventrolateral; 2=Lateral
Side	0=Right; 1=Left
Size (cm)	0=4–9; 1=10–15; 2=16–21; 3= \geq 22
Nature	0=Reducible; 1=Irreducible
Content	0=Intestine; 1=Rumen; 2=Omentum
Treatment outcome	0=Recovered without complication; 1=Recovered with complication; 2=Recurrence

xylazine HCl (Seton 2%, Laboratorios Calier, S.A., Barcelona, Spain). According to the site of the hernia, the abdomen was clipped and the skin shaved. After the application of transmission gel to the transducer, the abdominal hernia was examined for evaluation of the size, contents and adhesions.

Hernioplasty

Based on clinical and ultrasonographic examinations, surgical repair of the hernia was applied as a curative decision. For camels undergoing surgery, routine clinical and hematological evaluations were carried out. Feed and water were withheld 12 hr preoperatively. Preoperative antibiotic, penicillin-streptomycin (Pen & Strep, Norbrook Laboratories, Newry, Northern Ireland, U.K.) at a dose rate of 30,000 IU/kg for the penicillin and 10 mg/kg streptomycin and flunixin meglumine (Finadyin, Schering-Plough, Welwyn Garden City Hertfordshire, U.K.) at 1.1 mg/kg were intravenously (IV) administered. Deep sedation was conducted via IV injection of xylazine HCl at dose rate of 0.3 mg/kg. The animal was placed in lateral recumbency with the operative site uppermost, which subsequently clipped and aseptically prepared for surgery. The incision site was anaesthetized with local infiltration analgesia using lidocaine HCl 2% (Norbrook Laboratories, Newry, Northern Ireland, U.K.). When the appropriate depth of anesthesia had been achieved; a 20 cm elliptical skin incision was made approximately 2 cm medial and lateral to the axial edge of the hernia. The incision was continued down with a combination of blunt and sharp dissection in order to separate the skin and subcutaneous tissues from the internal hernial sac (Fig. 2C). Subsequently, the hernial contents were reduced gently into the abdominal cavity, hernial ring was identified and the muscles defect was repaired using a double layered polypropylene mesh (SMI AG Belgium). The polypropylene mesh was cut in the fitting shape and size, so that it overlapped the margins of the hernial ring by the same amount. The mesh was placed by on-lay technique and sutured to the abdominal wall using braided coated polyglactin 910 No. 2 (United medical industries Co., Ltd., Riyadh) in interrupted horizontal mattress pattern (Fig. 2D). These sutures were placed 1.5 cm from the edges of the hernial ring. The redundant edge of the mesh was trimmed, and the subcutaneous tissues were closed over the mesh using coated polyglactin 910 No. 2 in a simple interrupted pattern. The excessive skin was trimmed, and the skin was closed with silk No. 2 (United medical industries Co., Ltd.) in a horizontal mattress pattern

Postoperative care and follow-up

After surgery, the preoperative antibiotic was continued for 10 days and anti-inflammatory were continued for 5 successive days in addition to intramuscular (IM) injection of 10 ml vitamin AD₃E (ADVIT-DE, Morvel Laboratories P. Ltd., Mehsana, Gujarat, India). The camel was confined in a stall rest for 4 weeks and monitored daily for healing progress. Camels were discharged from the clinic approximately 4 weeks postoperatively. To evaluate the long-term results (6 months) of abdominal hernias repair with the polypropylene mesh a telephone contact with the owners, was carried out. They were asked about recurrence of herniation, discharge from the surgical site, and final functional results of the surgery.

Statistical analysis

Statistical analyses were performed using GraphPad Prism statistical software program (GraphPad Prism for win. version 5.0, San Diego, CA, U.S.A.). χ^2 was used as the statistical method to evaluate the association between breed, age, sex, cause, duration, size, site, nature, content of the hernia and clinical signs as well as the treatment outcome. Data were presented as *P* value. Clinical signs were recorded and scored, with calculation of clinical sum scores. Non-parametric Kruskal Wallis test was used to assess the improvement of clinical sum scores after treatment. Results with a *P* value <0.05 were considered significant.

RESULTS

Clinical findings

Out of 26 studied camels, abdominal hernia was prevalent in Wadeh camels than Mejhem, Ashaal and Asfar breeds (17 vs. 9,

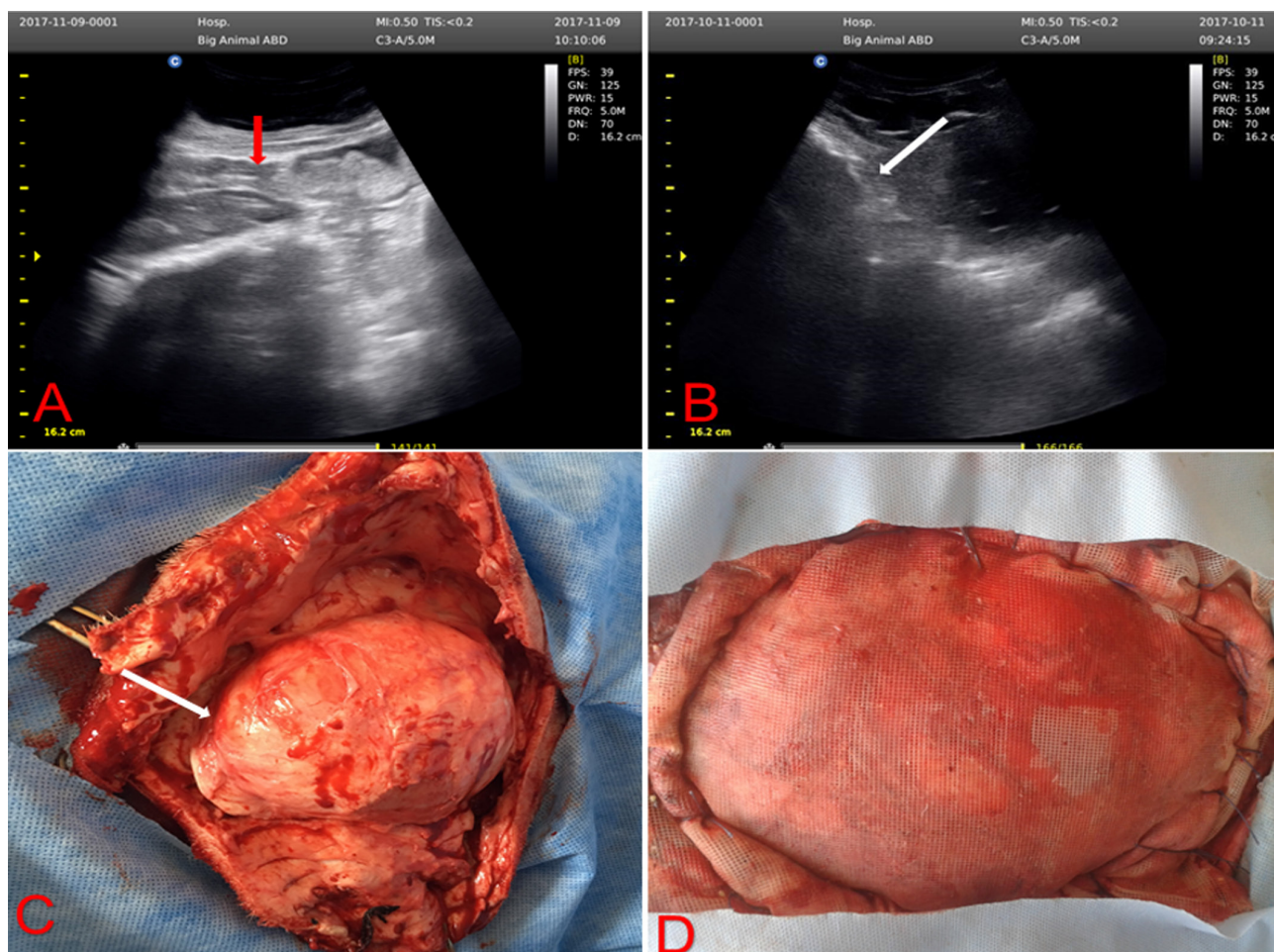


Fig. 2. Ultrasonographic view of longitudinal intestinal loop (A, arrow) and the ruminal wall (rumenocoele) (B, arrow) within the hernial sac. Separation of the internal hernial sac (arrow) from the skin and subcutaneous tissue (C). Fixation of the polypropylene mesh during repair of abdominal hernia in camels (D).

$P < 0.01$). Camels < 6 years of age exhibited more abdominal hernias than other age groups (18 vs. 8, $P < 0.01$). In addition, female camels showed a significantly higher prevalence (19 vs. 7, $P < 0.01$) of abdominal hernia compared to male camels (26.9%, $n = 7$).

According to the cause, acquired abdominal hernias were more prevalent than congenital ones (24/26 vs. 2/26, $P < 0.001$). The causes of acquired abdominal hernias were postoperative complication ($n = 14$), abdominal trauma ($n = 7$) and unknown cause ($n = 3$). Furthermore, the size of abdominal hernial ring in all investigated cases was varied from 4 to ≥ 22 cm in diameter and the swelling varied from orange size up to the football size.

Early diagnosed and treated cases of included abdominal hernia resulted in rapid recovery. Where 16 cases investigated early were recovered rapidly ($P < 0.001$). However, 1 case with duration 17–22 months was recovered with complication and another one admitted > 23 months was recurrent.

The treatment outcome of abdominal hernias was affected by the location and side of hernia. Lateral abdominal hernia recovered rapidly, where 13 cases with lateral hernia recovered rapidly ($P < 0.05$). But, only 5 cases with ventral hernia recovered rapidly. Two cases with ventrolateral has complications as postoperative slight swelling. Interestingly, 2 cases with ventral hernia showed recurrence after 3 weeks postoperatively. While, seventeen cases with left side hernia recovered rapidly than the right one ($P < 0.05$). Whereas, 2 cases with right side hernia showed recurrence and only one case recovered with complication.

There was an association between the anatomical location of the hernial side and the contents ($P < 0.001$). Where, most of the hernial contents were the rumen (11 cases) followed by intestine (8 cases) then omentum (7 cases). In addition, association between the location and nature of the hernia ($P < 0.05$) revealed, 13 cases with lateral hernia were reducible. But, 3 cases with ventrolateral hernia and 2 cases with ventral hernia were irreducible.

Ultrasonographic findings

Twenty-six abdominal hernias were precisely diagnosed by US. The sensitivity (96.8%) and specificity (93.1%) of US were higher in comparison to clinical examination (88.3%). Sonographic examination of the abdominal hernias in the studied camels

revealed that, rumen was herniated (rumenocoele) in 11 cases, loops of the intestines were herniated (enterocoele) in 8 cases and omentum (epiplocele) in the other 7 camels (Fig. 2A, 2B). In reducible hernias, US showed anechoic disruption of the abdominal wall at the level of the defect. Ultrasonographic appearance of the hernial sac differ according to the herniated organs; a hyperechoic line reflecting gas cap was characteristic for the rumen. However, the intestinal loops appeared in longitudinal and transverse intestinal section within the hernial sac with their peristaltic movement. While, the omentum appeared as hyperechoic structure with variable thickness. A thickened hernial sac with echogenic adhesions between the abdominal wall and hernial sac were observed in irreducible hernias. In addition, the movement of herniated structure was significantly decreased with evidence of anechoic inflammatory exudates around the intestinal loops and hernial sac.

Treatment outcomes

At 3 weeks postoperative, the clinical index score of 26 camels studied with abdominal hernias was significantly reduced in comparison with pretreated (22 vs. 4, $P<0.005$). However, only 2 cases had recurrence of the hernia had slight swelling in situ. By the 6th month post treatment, all treated camels were completely recovered. Regarding the cosmetic appearance, the abdominal wall was normal in appearance.

DISCUSSION

Abdominal hernias are common affections of the abdomen with a worldwide incidence about 4–5% [13, 17, 20]. They represent one of the frequent reasons for surgical interference in camels. However, available literature about hernias in camel and its incidence are limited. Thus, the present study was designed to evaluate the clinical findings and treatment outcomes of abdominal hernias using polypropylene mesh in repair of such affection in dromedary camels.

Breed difference in the occurrence of abdominal hernia in camels was evident in our study and the highest prevalence was observed in Wadeh camels than other studied breeds (17 vs. 9, $P<0.01$). This could be attributed to the highest number of the Wadeh breed among other camel breeds in Saudi Arabia in relation to its productive and tribal values [1, 28].

In this study, camels <6 years of age exhibited more abdominal hernias than other age groups (18 vs. 8, $P<0.01$). This result is consistent with the data reported in the previous studies [4, 28]. This correlation likely is simply a consequence of the incidence of sexual maturity for camel in which males subjected for mounting fighting and females for stress of pregnancy and delivery.

Gender had an effect on the incidence of abdominal hernias in camels. The result of the present study demonstrates that, female camels had a significantly higher prevalence (19 vs. 7, $P<0.01$) of abdominal hernia compared to male camels (26.9%, $n=7$). This may be due to that the females are weaker and subjected to biting by excited males, in addition to caesareans section as salvage of dystocia. This finding was in accordance with Purohit *et al.* [26] and Masakazu [21]. In contrary, Herrmann *et al.* [14], Salim *et al.* [29] and Hassen *et al.* [13] reported that, gender has no effect on the incidence of hernia in domestic animals as it was a mechanical injury in origin. Moreover, it might be due to the high rate of slaughtering of male animals and keeping females for further reproduction purposes.

Mechanical trauma contributes the highest percentage of the total causes of abdominal hernia on the majority of domestic animals [13, 34]. Our results revealed that, acquired abdominal hernias were more prevalent than congenital ones (24/26 vs. 2/26, $P<0.001$). The causes of acquired abdominal hernias were postoperative complication ($n=14$), abdominal trauma ($n=7$) and unknown cause ($n=3$) for both male and female camels. Similar findings were reported by Kawcak and Stashak [16] and Al-Sobayil and Ahmed [4].

The abdominal wall is the most active wall in camel which can be subjected to different forms of hernia at different locations [10, 28]. In this study, the treatment outcome of abdominal hernias was affected by the location and side of hernia. Lateral abdominal hernia recovered rapidly, where 13 cases with lateral hernia recovered rapidly ($P<0.05$). But only 5 cases with ventral hernia recovered rapidly. Two cases with ventrolateral has complications as postoperative slight swelling. Interestingly, 2 cases with ventral hernia showed recurrence after 3 weeks postoperatively. While, seventeen cases with left side hernia recovered rapidly than the right one ($P<0.05$). Whereas, 2 cases with right side hernia showed recurrence and only one case recovered with complication.

The high incidence of abdominal hernia could be attributed to the weakness of the abdominal muscles following the extensive left caudal flank incision for caesarean section and rumenotomy in the camel by general practitioner veterinarian [26, 28]. Regarding the rapid healing of lateral hernia in comparison to ventrolateral and ventral hernias, this could be a result of the possibility of breakdown of the body wall closure, increased likelihood of evisceration and the higher chance of ventral site contact with foreign body objects in ventral laparotomy compared to lateral site [15, 22].

The size of abdominal hernial ring in the present study varied from 4 to ≥ 22 cm in diameter. Though, this may be because of unawareness of Bedouins who tend to bring their animals to the hospital at the advanced stage of the disease. Hernia size varies depending on the extent of the abdominal defect and the amount of abdominal contents within it [17]. The type of herniated organs is more related to the anatomical proximity of the organ to the hernia site. Since the rumen is anatomically occupying most of the left side of the abdomen than the intestine which is commonly found in the right abdomen. Where, most of the hernial contents were the rumen (11 cases) followed by intestine (8 cases) then omentum (7 cases). In addition, there was an association between the location and nature of the hernia ($P<0.05$) revealed, 13 cases with lateral hernia were reducible. But, 3 cases with ventrolateral hernia and 2 cases with ventral hernia were irreducible. These findings were in agreement with Gahlot *et al.* [10] and Ramadan and Abdin-Bey [28].

Early diagnosed and treated cases of included abdominal hernia resulted in rapid recovery. Where 16 cases investigated early

were recovered rapidly ($P < 0.001$). However, 1 case with duration 17–22 months was recovered with complication and another one admitted >23 months was recurrent. Therefore, the collaboration system between the clinical index scores and US used in this study provides a proper simple and rapid tool for subjective assessment and clinical decision making of abdominal hernia in camel. These findings were in coinciding with Abouelnasr *et al.* [2] and El-Shafaey *et al.* [8].

US is a valuable diagnostic and prognostic imaging tool for evaluation of camels with variant swelling [31]. Our results demonstrate the highest specificity for ultrasonographic evaluation of hernia was 100% in comparison to clinical evaluation (69.2%). This could be explained by feasibility of ultrasonography to provides accurate preoperative details regarding the extent, size, contents, and nature of different forms of abdominal hernias in dromedary camels especially in cases of intestinal and ruminal herniation. Similar findings were reported by Young *et al.* [36] and Abouelnasr *et al.* [2].

Polypropylene meshes is one of the most widely used prosthetic materials for reconstruction of abdominal wall hernias specially in large-sized than 3 cm in diameter [18, 23, 35]. It allows for a tension free repair, that significantly decreases the hernia recurrence rate in comparison to the primary suture repair [3, 7, 9]. Thus, the polypropylene mesh was our maneuver of choice to treat such cases; aims to improve the effectiveness of hernioplasties and to reduce recurrences with a relatively affordable cost. To the best of author knowledge, this is the first study using prosthetic hernioplasty in treatment of abdominal wall defect in camel.

The economic aspect of ordinary herniorrhaphy using commercial sutures with the risk of recurrence gives opportunity for the polypropylene mesh as a feasible technique for hernia repair in camels. The choice of a polypropylene mesh is also favored by the knit structure of the mesh itself. This characteristic is desirable in closing large abdominal hernias in horses and cattle, as it results in fewer wrinkles, especially when the hernial sac is lacking and only subcutaneous tissue and skin cover the mesh [23, 32]. Our results revealed viability of polypropylene mesh to repair abdominal hernia in camels with time saving, excellent structural resistance and high success rate. Moreover, it was easy to handle and available with low cost. In all operated camels the surgical wounds healed by primary intention, except, 2 cases had slight swelling in situ and 2 camels showed recurrence of the hernia 3 weeks following surgery. The recurred hernia which also treated by polypropylene mesh with good outcome. These findings were in accordance with numerous reports document successful use of polypropylene mesh for repair of abdominal hernias in large animals [18, 33, 35].

Implantation of a mesh using an on-lay technique is the most popular commonly used technique for hernioplasty of abdominal wall defect. This technique induces equal distribution of stress over the mesh and thus decreased tendency of the suture material to harbor infection and played a critical role in reducing the rate of hernia recurrence [23, 33]. Therefore, using of on-lay technique for repair of abdominal hernia in the present study induce adequate healing with minimal complications and gave better outcome making it to be declared the standard of care of abdominal hernias in camels.

The limitation of this study should be presented. Firstly, the sample size of studied camels was small, which does not allow obtaining concrete conclusion. Secondly, the evaluation of mesh as surgical intervention was presented alone. Comparative randomized clinical study with other prosthetic and biological materials for repair of the abdominal wall defect are warranted to get precise conclusion about the clinical relevance of mesh in camels.

In conclusion, this is the first evaluation of polypropylene mesh in repair of abdominal wall defect in dromedary camels after applying association between clinical findings and treatment outcomes of hernia in camels. Thus, our results recommend the use of the polypropylene mesh as a viable and consistent alternative effective treatment for abdominal hernias in camels. Moreover, the clinical index scores and US provide a precise paradigm for diagnosis and preoperative planning for abdominal hernias in dromedary camels.

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