

Deep Swellings in Sheep and Goats: Clinical, Ultrasonographic and Post-Mortem Findings

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ABSTRACT

Surgical swellings are commonly occurring in sheep and goats causing health problems and economic losses. This study was carried out to describe the findings of deep-seated lesions and assess the role of ultrasonography and post-mortem findings in the verification of these lesions in sheep and goats. Thirty-four animals (sheep, n=18; goats, n=16) were used in this investigation-based on presence of deep lesions in the abdomen and pelvis. Clinical and ultrasonographic examination of deep swellings resulted in diagnosis of abscesses (n=22; 64.70%), hydatid cysts (n=7; 20.60%), and Hematomas (n=5; 14.70%). Each lesion type could be properly differentiated by ultrasonography; the echogenicity differed based on sort, site and inclusions as well as duration of the structures. Abscesses were recognized as a structure containing homogeneously distributed contents enclosed in a thickened echogenic surrounding in the acute stage, while long-lasting lesions imaged as echogenic lesions and were demarcated with an echogenic wall. Hydatid cysts diagnosed as lesions with anechoic contents including echogenic solid septa. Hematomas occurred mostly in the abdomen. It varied when imaged based on the history of the disease, and term of the affection. Hematomas appeared as heterogeneous mass due to infiltration of blood within the tissues. Conclusively, ultrasonography is a rapid, precise, and distinctive, non-invasive diagnostic modality which proves accurate diagnosis and successive surgical decisions used for management of variant deep-seated lesions in sheep and goats.

Key words: Animals, Diagnostic Imaging, Pathology, Pathophysiology, Ruminant.

INTRODUCTION

Surgical swellings commonly occurring in sheep and goats include abscesses (Barwell 2015; Sadan, 2019), hematomas (Tsioli et al. 2013; Sadan 2019), cysts (Abu-Seida 2014; Hakim et al. 2018), hernias (Young et al. 2007; Jettennavar et al. 2010; Simse 2018), urethral diverticula (Temizsoylu 2005; Smith et al. 2006; Bokhari 2013), and neoplasms (Ahmed and Hassanein 2012; Pesato 2018), resulting in high economic losses, including decreased milk, meat, pelt, and wool production and decreasing of marketing value of the animal as a result of

bad effect on animal health, and deformity of the animal conformation (Tsioli et al. 2013; Barwell 2015).

Deep surgical swelling could be precisely diagnosed and discriminated through clinical, ultrasonographical, and post-mortem findings. However, the clinical diagnosis of deep-seated lesions by physical examination alone is sometimes difficult for the veterinarian as these lesions has comparable clinical presentation, including their site, extent, and the associated suffering. Furthermore, outcome of these lesions varies from one to other. Diagnostic ultrasound is a harmless imaging technique that allows the discrimination of these lesions, and it

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provides accurate details to differentiate them from the neighbouring tissues depending on variation in echogenic patterns (Scott 2012; Sadan 2019). Differential diagnosis of deep-seated lesions in sheep and goats is a great challenge in veterinary practice, as various forms of such lesions has sometimes identical clinical findings. Sonography can precisely diagnose and discriminate these swellings from each other allowing verification of firm and pocket-like structures. In addition, it supplies much better information which is not gained on physical and radiographical screenings (Braun 1993; Sagar 2010; Abouelnasr et al. 2016).

Despite the popularity of sheep and goats, to the authors' information, there are few reports concerning the use of US as a distinctive harmless imaging modality in the verification and comparable diagnosis of deep-seated lesions in small ruminants. This research is a continuation of our previous published work on superficial swellings in sheep and goats (Sadan 2019), and it was planned to demonstrate the presentation, ultrasonographic and post-mortem results of deeply detected lesions in sheep and goats.

MATERIALS AND METHODS

Ethical Approval

The Committee of Animal Ethics, Research of Scientific Deanship, University of Qassim, Saudi Arabia approved the experimental procedures of this study.

Animals

Thirty-four animals (sheep, n=18; goats, n=16) were examined in this study over the period of 2015–2023 at the Qassim University, University Veterinary Hospital, Kingdom of Saudi Arabia; Eighteen sheep were examined and they were of three local breeds (Nagdi, 11; Naimi, 5; Sakni, 2), of both sexes (male, 8; female, 10) aged 1-75 (mean, 35±19) months, and weight of 20 to 67 kg (mean, 38±15). They were referred for various causes including inappetence, loss of body condition, dysuria and pigmented urine. Clinical examination of all the sheep and goats were carried out as reported previously (Sadan 2019).

Ultrasonography and Post-Mortem Examination

Transcutaneous ultrasonographic examination of the abdomen and pelvis was carried out using a 2.5–5.0 MHz convex/7.5–10.0 MHz linear probes (SSD-500, Aloka, Tokyo, Japan). The examination of affected sheep and goats was carried out in the standing or downer position. The kidneys were assessed using both cross and longitudinal sections, the right kidney was scanned in the right region just caudal to the last rib at the level of the last two intercostal spaces, while in order to evaluate the left kidney, both right and left paralumbar regions were thoroughly examined Tharwat (2021a, b).

According to Tharwat (2021c), the ultrasonographic evaluation of urinary bladder was achieved by scanning of both right and left inguinal regions, while the animal was in the downer position. In some affected sheep and goats, a thorough post-mortem examination was performed, following their ultrasonographic examination.

RESULTS

Deep swellings were detected in 34 sheep and goats in this study; 22 out of them (64.70%) were diagnosed with abscesses, 7 (20.60%) with hydatid cysts, and 5 (14.70%) with hematomas. Clinically, the animals under current investigation suffered from decreased appetite, decreased body weight, dysuria and pigmented urine (Table 1; Figs. 1-8).

The pyogenic structures in sheep and goats were located at various body cavities; abdomen (n=8), and pelvic cavity (n=14), (Figs. 1-6). Post-mortem examination revealed various sizes and shapes of abscesses, the consistency of the pus varied in nature from thin to thick consistency, while the pus had yellowish to greenish color (Fig. 2C, 3D, 4C, 5D and 6A). The abscesses were diagnosed as firm circumscribed localized retroperitoneal swellings adhered to the intestine (Fig. 2B, 2C and Fig. 5), urinary bladder or compressing the urethra (Fig. 4 and Fig. 6), and almost had a solid fibrous surrounding with a little amount of pyogenic material (Fig. 4C and 5D).

Hydatid cysts (7; 20.60%) were diagnosed in the present study in the abdomen of sheep and goats (3; 8.82%), (4; 11.78%) respectively due to parasitic infestation caused by the larval stage of *Echinococcus granulosus* (Table 1), the hydatid cysts had various sizes and number. A clear fluid was obtained upon exploration of the hydatid cysts. Different numbers of cysts range from 2-5 were recorded in the abdomen adhered to the intestine and liver (Fig. 7C and D).

Hematomas were reported in sheep (3; 8.82%) and goats (2; 5.88%); (Table 1) and they mostly occurring as a result of blunt trauma. In general, they were discriminated in the abdomen and pelvis of affected sheep and goats in this study, and they appeared as ovoid or round circumscribed localized fluctuating swellings characterized by small or large size (Fig. 8). Pure bloody content and hemerosous fluid were detected by ultrasound guided needle aspiration of recent hematomas (Fig. 8D) and organized hematomas respectively.

Ultrasonographic Findings

In this study, deep lesions in the sheep and goats were ultrasonographically classified into recent or old, and acute or chronic depending on stage of the inflammatory process and time elapsed after occurrences up to the presentation to the clinic. Various factors affecting the echogenicity of deep swellings in examined sheep and goats were found in this investigation including, type of

Table 1: Number and incidence of the deep surgical swellings in sheep (n=18) and goats (n=16)

Category	Total Number	%	Sheep	%	Goats	%
Hematomas	5	14.70	3	8.82	2	5.88
Abscesses	22	64.70	12	35.29	10	29.41
Hydatid cysts	7	20.60	3	8.82	4	11.78
Total	34	100	18	52.94	16	47.06



Fig. 1: Pelvic abscess in a goat. The animal was admitted with a history of anorexia and weight loss one month after parturition (a). Transrectal ultrasonography detected a well-circumscribed, encapsulated abscess dorsal to the urinary bladder (b) yielding a purulent material on aspiration on ultrasound-guided aspiration.

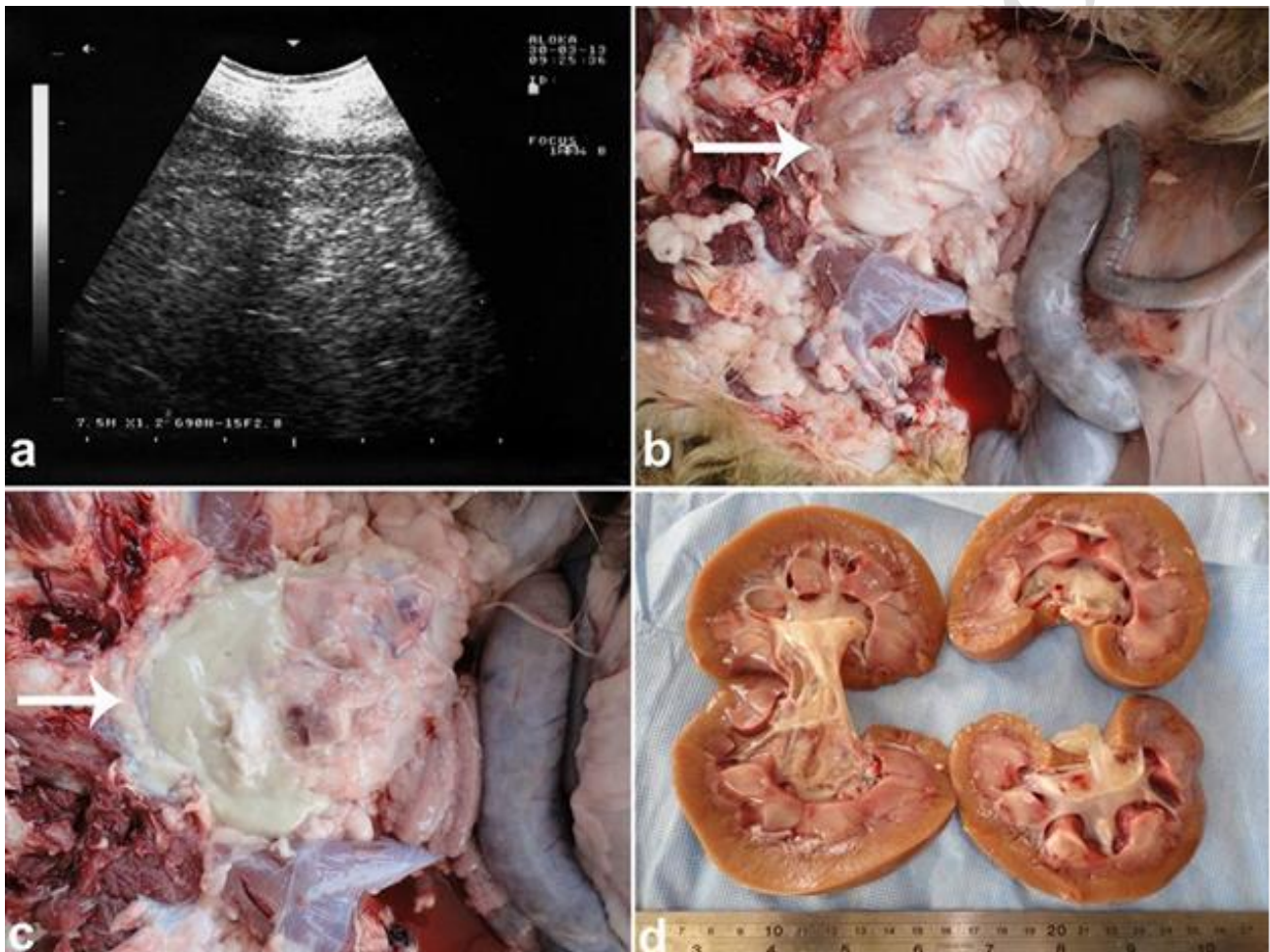


Fig. 2: Abdominal abscess in a sheep with progressive body weight loss. Ultrasonographic examination revealed a capsulated hyperechoic material (a) which was confirmed post-mortem (b). The puncture of the lesion yields a pyogenic material (c). Other necropsy findings demonstrated bilateral dilatation of the renal pelvis (d).

such swellings, the nature of their content, time elapsed after occurrence of the swelling up to the presentation to the clinic, and their location in the body cavities. The number of reported deep swellings were higher in the abdomen (n=20; 58.82%) than in the pelvic cavity (n=14; 41.18%).

In this study, the echogenicity of abscesses contents varied depending on the stage of the inflammatory process (recent or old), and they were diagnosed as anechoic to hyperechoic structures separated from the neighbouring organs by a well thickened hyperechoic demarcating capsule. In the acute phase, lesions contents were recognized

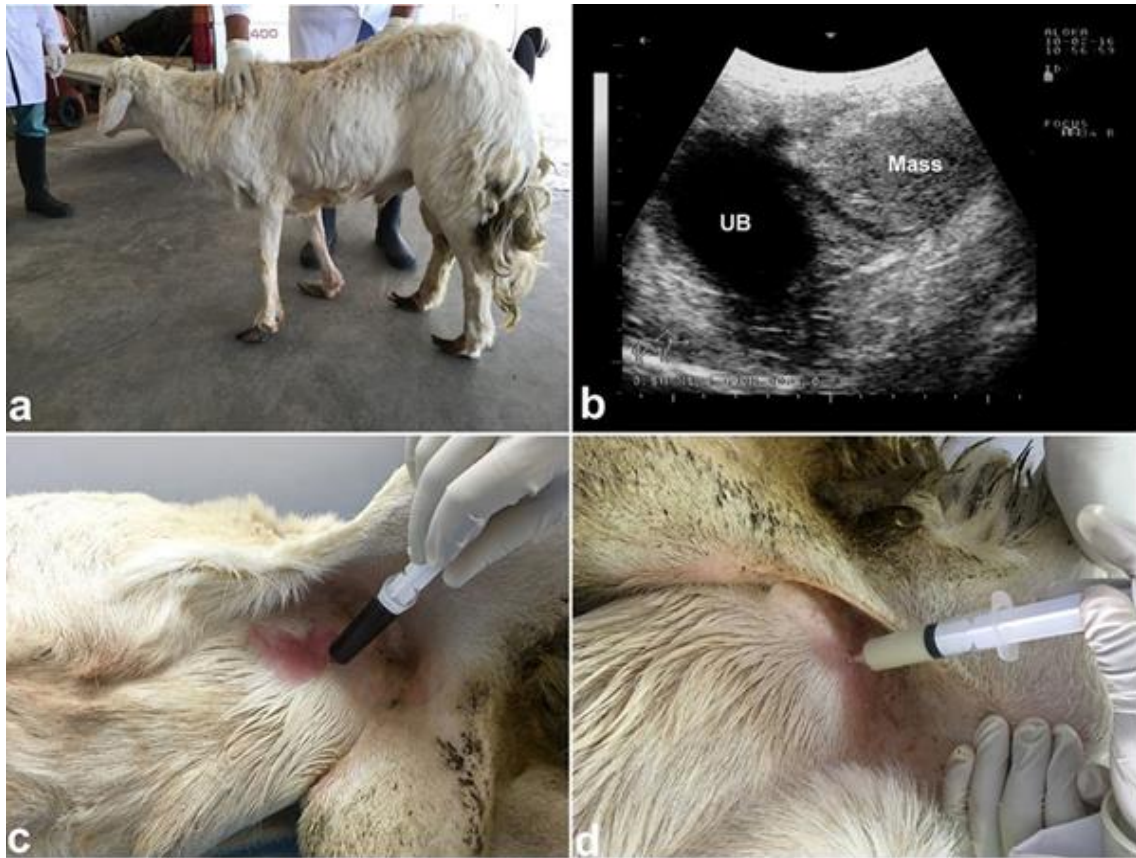


Fig. 3: A ram with decreased body weight due to pelvic abscessation (a). Ultrasonographically, the abscess (mass) (b) was adhered to the urinary bladder (UB), the contents were hyperechoic, and the urinary bladder was distended and contained sediments. The urinary bladder contained deep red urine (c). Abscess confirmation was confirmed through ultrasound-guided aspiration of pyogenic material (d).

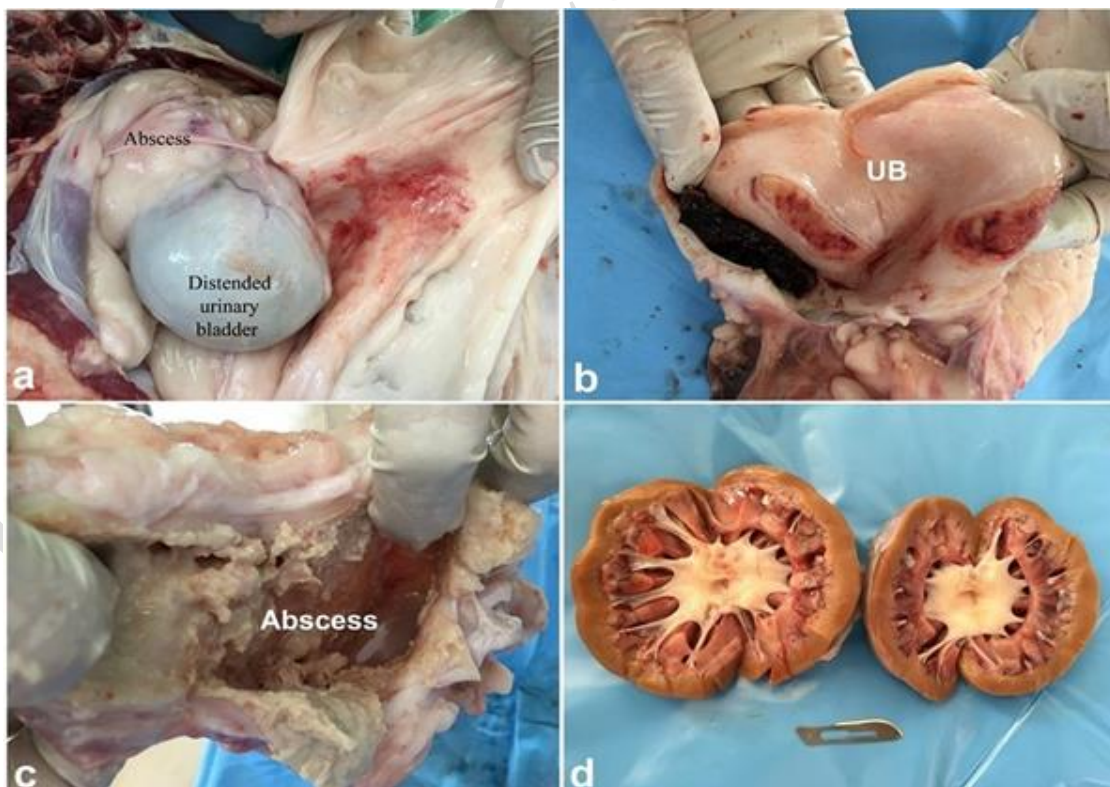


Fig. 4: Post-mortem findings in a ram with pelvic abscessation. The distended urinary bladder was adhered to a retroperitoneal abscess (a). A large blood clot within the bladder with ulceration of the bladder wall was detected (b). Image (c) shows cavitation of the abscess. Bilateral dilatation of the renal pelvis was also found (d).

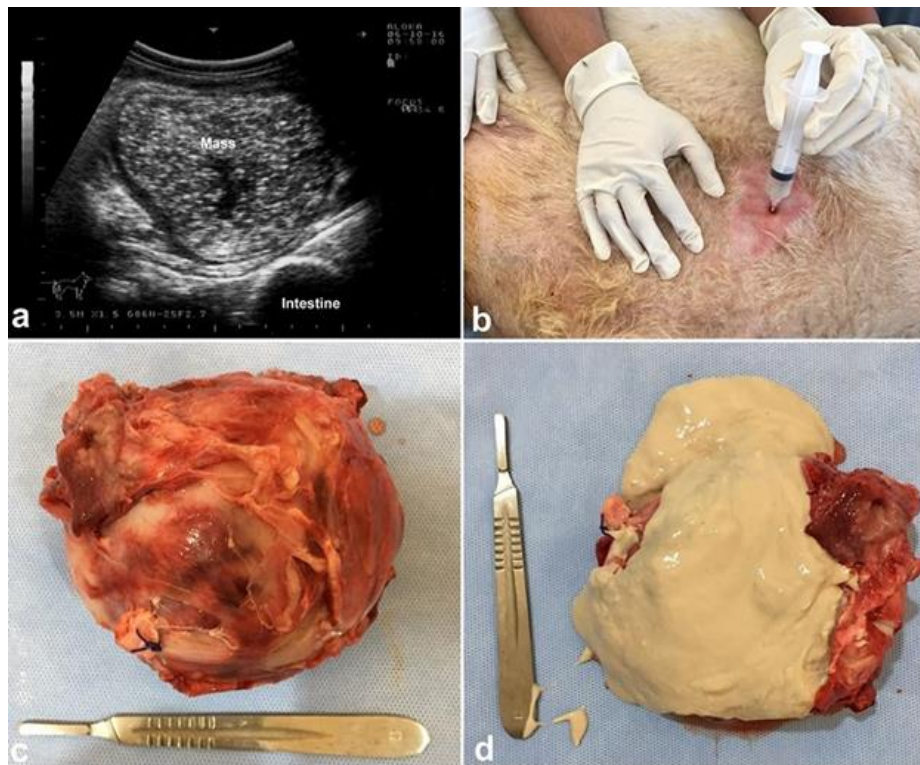


Fig. 5: Abdominal abscess in a ram. The ram was admitted with a history of progressive weight loss for the 4 weeks. Routine abdominal ultrasonography detected a capsulated retroperitoneal mass just in front of the umbilicus with hyperechogenic texture (a) where thick pus material was aspirated under ultrasound-guidance (b). Removal of the mass with its capsule was carried out surgically (c). Image (d) showed a thick pyogenic material after puncture of the abscess.

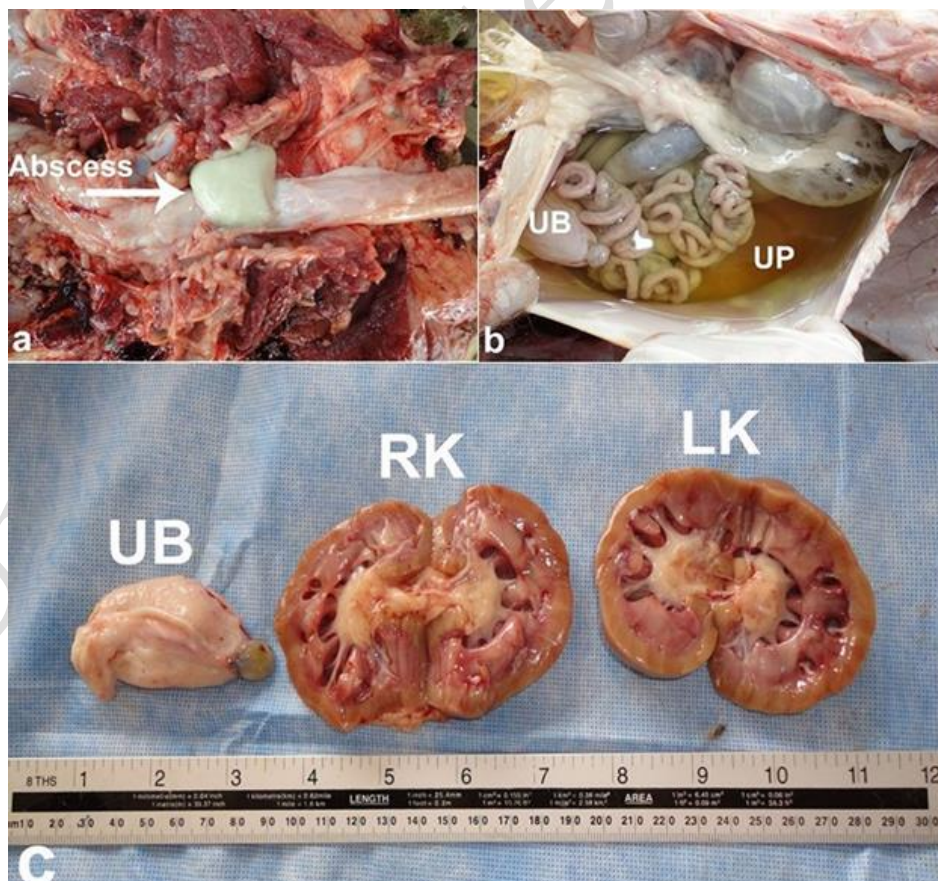


Fig. 6: Post-mortem findings in a 2-month-old female lamb with ruptured urinary bladder. Image (a) shows pelvic abscess compressing the urethra. Image (b) shows uroperitoneum (UP) with floating viscera and collapsed urinary bladder (UB). Image (c) hydronephrosis of the right and left kidneys (RK and LK) with perforated and collapsed urinary bladder (UB).

as homogeneous and echogenic region enclosed by a thick echogenic well demarcated wall (Fig. 1B), whereas abscesses in chronic stage were appeared as hyperechoic structures separated from the surrounding tissues by a hyperechoic wall (Fig. 2A and 3B). The brightness of the abscess contents elevated by time as mineral deposition increases (Fig. 5A).

Hydatid cysts were particularly occurring at the abdomen (n=7). They were diagnosed as lesions with anechoic contents including echogenic solid septa (Fig. 7A and B).

Hematomas mostly occurred in the abdomen (Fig. 8A) of sheep and goats. Hematomas varied by ultrasound according to the history and interval of affection. It had hypoechoic to anechoic contents in recent cases, whereas organized hematomas were diagnosed as heterogeneous mass (Fig. 8B) containing thick septa; this may be contributed to gradual formation of fibrinous septa inside the lumen of the hematoma. Diagnosis was proved by needle aspiration of the bloody content under guided ultrasonography (Fig. 8C and 8D).

DISCUSSION

Early precise diagnosis of deep swellings is necessary to achieve effective treatment that, will assure the affected sheep and goats regain normal function and better health.

This type of swellings is widespread with a worldwide allocation. It is reported in recent research as main cause for surgery in sheep and goats (Omidi et al. 2011; Barwell 2015; Pesato et al. 2018; Hakim et al. 2018; Sadan 2019). However, few published articles have documented the application of ultrasonography in precise diagnosis and discrimination of deep seated lesions in sheep and goats. Therefore, this research work is a continuation of our previous work on superficial swellings in sheep and goats (Sadan 2019).

Discrimination of deeply seated lesions in sheep and goats by means of history of the case and clinical findings alone is mostly indecisive. This could be attributed to the deep seating position of these swelling, therefore, the utility of additional diagnostic imaging tool as ultrasound is necessary to emphasize the initial diagnosis and to speed the subsequent decision for invasive intervention of those lesions in these animals. In the recent researches, ultrasonography and exploratory puncture under guided ultrasonography have been efficiently used to diagnose and to differentiate the thoracic, abdominal, hepatic and urinary diseases and disorders in farm animals (Tharwat and Oikawa 2007; Tharwat and Al-Sobayil 2017; Cribb and Arroyo 2018; Tharwat et al. 2018c; Tharwat 2019; El-Shafae et al. 2020; Tharwat 2020; Khalphallah et al. 2021; Tharwat 2021a; Tharwat 2021b; Tharwat 2021d).

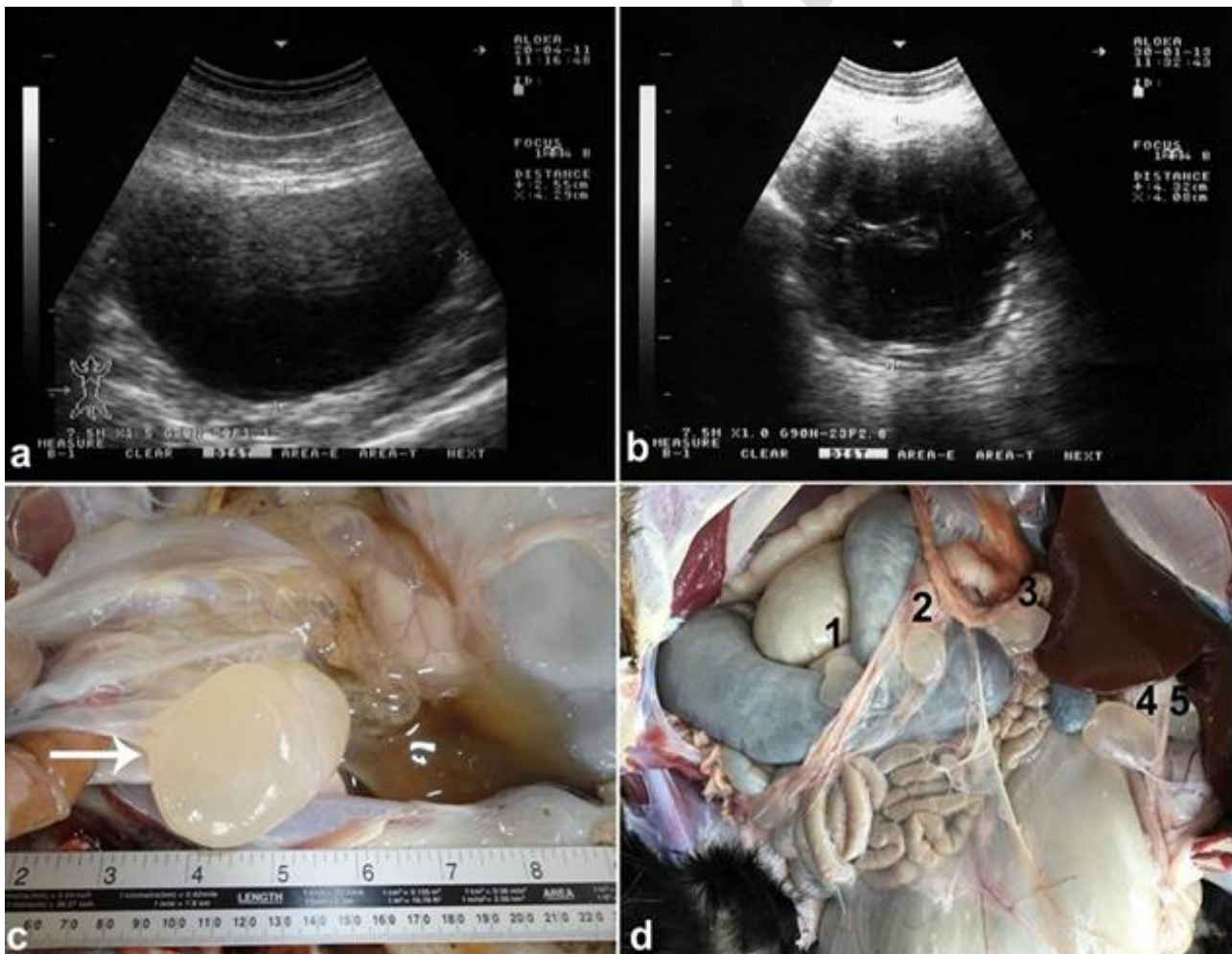


Fig. 7: Abdominal hydatid cysts in a goat. Images (a & b) showed 2 hydatid cysts of different sizes. Image (c) showed a large cyst at post-mortem examination while image (d) showed 5 hydatid cysts of various sizes.

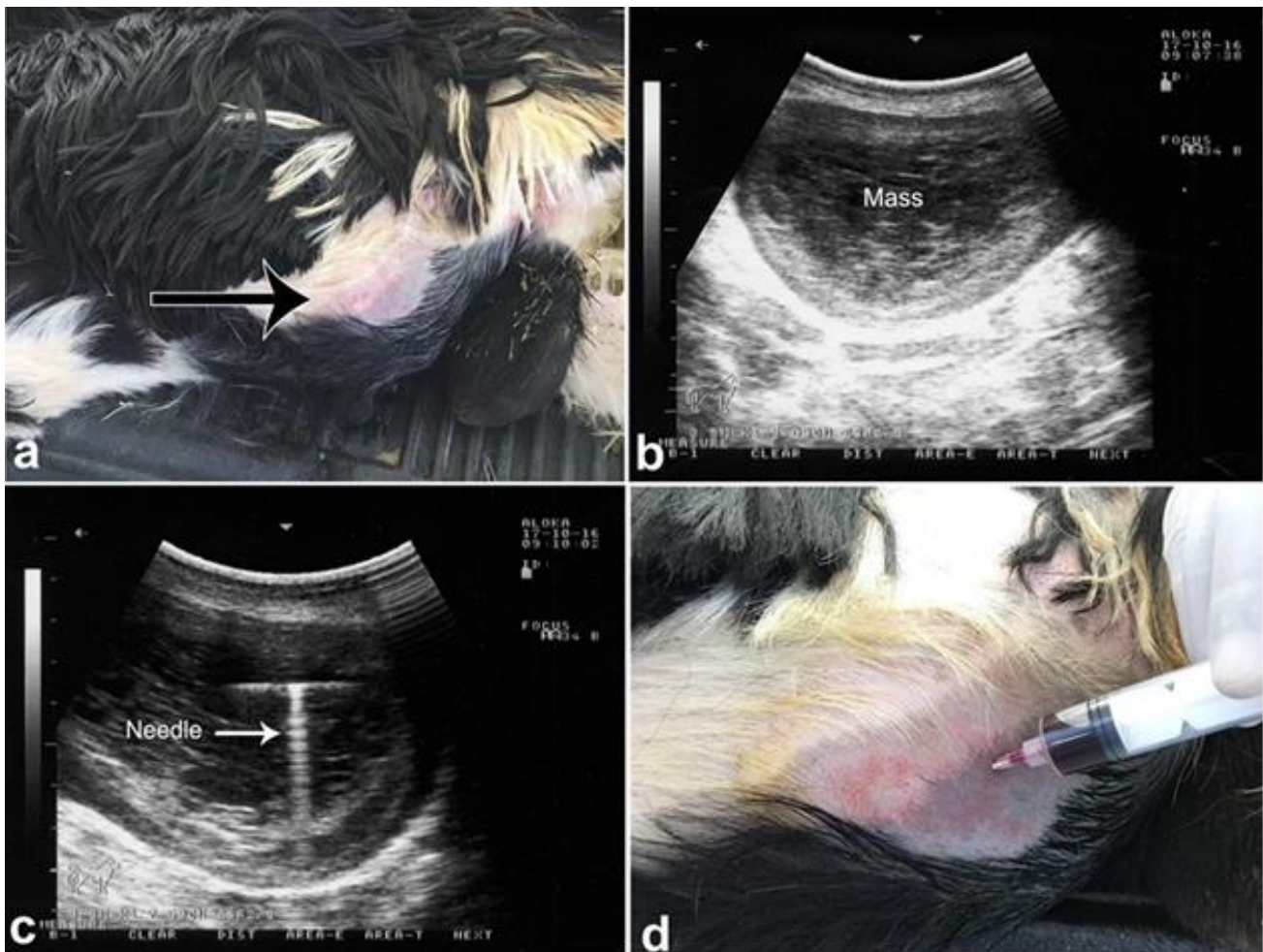


Fig. 8: Inappetence in a ram due to abdominal hematoma (black arrow, **a**). Sonographic examination of the lesion revealed a heterogeneous mass content (**b**). Image (**c**) shows ultrasound-guided puncture of the lesion where the needle appeared as a sharp bright line on the screen where a bloody material was obtained (**d**).

Ultrasound is an imaging methodology for tender tissue structures; it could be used as a safe, rapid, simple, distinctive, non-invasive imaging tool for detection and comparable diagnosis of variant deep-seated lesions in sheep and goats under the field conditions with animal comfort, especially when clinical examinations are imprecise and indecisive. Additionally, US describes the features of swelling contents and facilitates accurate needle aspiration of these contents that, probably helps veterinarians to precisely discriminate between these surgical disorders. In this research, deep swellings were ultrasonographically differed according to the form, site, period, and nature of the inclusions. This was in accordance with other published findings in farm animals (Streeter et al. 2007; Hashefi 2009; Tharwat et al 2018a, b; Sadan 2019).

The abscesses and hematomas are deceptively similar invasive disturbances frequently occurring in sheep and goats, these swelling commonly caused by trauma. Because of their resemblance to clinical examinations, the diagnosis of deep swelling is a great challenge in veterinary practice. Hydatid cyst is a parasitic manifestation occurs because of presence of the larval stage of *Echinococcus granulosus*. Hydatid cysts were recorded in the intestine and liver due to these parasitic infestations. Discrimination of hydatid cysts from other

soft cystic structures is considered a great challenge for veterinary practitioners. Therefore, the utility of ultrasonography in assessment of hydatid cysts is considered a rapid accurate modality for their diagnosis and differential diagnosis. The results of the present study were in accordance with those reported previously (Zhang 2003; Kofler 2009).

The echogenicity of deep swellings differed based on the duration and the kind of the inclusions. In examined sheep and goats, in the acute phase, abscess lesions were diagnosed as homogeneous echogenic regions enclosed by a thick highly echogenic demarcating surrounding, whereas abscesses in chronic stage were appeared as hyperechoic structures separated from the surrounding tissues by an echogenic wall, while hematomas had hypoechoic to anechoic contents in recent cases due to permeation of blood to the tissues, whereas organized hematomas were diagnosed as heterogeneous mass containing thick septa; this may be contributed to gradual formation of fibrinous septa. These results were like those reported by Sadan (2019).

In this study, hydatid cysts and hematomas were mostly similar. The case history of an old non-sharp injury in case of hematoma could be used in precise discrimination between them. On the other hand, the lumen of hydatid cysts was characterized by presence of

solid and highly echogenic septa than found in hematoma. These findings are in accordance with those already reported (Hashefi 2009; Sadan 2019). It can be concluded that, ultrasound is considered as a distinctive, simple, rapid, diagnostic technique used for the detection, confirmation, and successive invasive planning for treatment of different surgical deeply seated lesions in sheep and goats.

Conflict of Interest

The authors declare that there is no conflict of interest.

Authors Contribution

Sadan M. and Tharwat M. designed the study, carried out the practical and laboratory work, Sadan M. wrote the manuscript draft. All authors revised and approved the manuscript.

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REFERENCES

- Abouelnasr K, EL-Shafaey E, Mosbah E and EL-Khodery S, 2016. Utility of ultrasonography for diagnosis of superficial swellings in buffalo (*Bubalus bubalis*). The Journal of Veterinary Medical Science 78: 1303–1309. <https://doi.org/10.1292/jvms.15-0629>
- Abu-Seida AM, 2014. Radiographical examination and treatment of wattle cyst in goats and sheep. Global Veterinary 12: 862–864. <https://doi.org/10.5829/idosi.gv.2014.12.06.8493>
- Ahmed AF and Hassanein KM, 2012. Ovine and caprine cutaneous and ocular neoplasms. Small Ruminant Research 106: 189–200. <https://doi.org/10.1016/j.smallrumres.2012.03.007>
- Barwell R, Jeff E, Bruce W and Navneet KD, 2015. Foot abscess in sheep: Evaluation of risk factors and management options. Preventive Veterinary Medicine 122: 325–331. <https://doi.org/10.1016/j.prevetmed.2015.10.017>
- Bokhari SG, 2013. Hypospadias and urethral diverticulum in two goat kids: A case report. Journal of Animal and Plant Sciences 23: 675–677. <http://thejaps.org.pk/docs/v-23-2/51.pdf>
- Braun U, 1993. Ultrasonographic examination of the left kidney, the urinary bladder, and the urethra in cows. Zentralbl Veterinarmed A 40: 1–9. <https://doi.org/10.1111/j.1439-0442.1993.tb00594.x>
- Cribb NC and Arroyo LG, 2018. Techniques and accuracy of abdominal ultrasound in gastrointestinal diseases of horses and foals. Veterinary Clinics of North America: Equine Practice 34: 25–38. <https://doi.org/10.1016/j.cveq.2017.11.001>
- El-Shafaey ES, Sadan M and Refaai W, 2020. Superficial swellings in camels (*Camelus dromedarius*): Clinical and ultrasonographic findings. The Journal of Veterinary Medical Science 7; 82(9):1346-1353. <https://doi.org/10.1292/jvms.20-0163>
- Hakim A, Mujeeb RF, Abdul Qayoom M, Mudasar BG, Raja A and Hilal MK, 2018. Ultrasonography: An affordable diagnostic tool for precisely locating Coenurosis cyst in sheep and goats. Small Ruminant Research 169:19–23. <https://doi.org/10.1016/j.smallrumres.2018.10.002>
- Hashefi M, 2009. Ultrasound in the diagnosis of non-inflammatory musculoskeletal conditions. Annals of the New York Academy of Sciences 1154: 171–203. <https://doi.org/10.1111/j.1749-6632.2009.04391.x>
- Jettennavar PS, Kalmath GP and Anilkumar MC, 2010. Ventral abdominal hernia in a goat. Veterinary World 3: 93.
- Khalphallah A, Elsayed HK, Elmeligy E, Bayomi SA, Hamed MA, Salman D, Abu-Seida AM and Mousa SA, 2021. Differential diagnosis of bovine intestinal diseases and their sequelae regarding ultrasonography and other diagnostic tools. Veterinary World 14: 1537-1547. <http://www.veterinaryworld.org/Vol.14/June-2021/17.html>
- Kofler J, 2009. Ultrasonography as a diagnostic aid in bovine musculoskeletal disorders. Veterinary Clinics of North America: Food Animal Practice 25: 687–731. <https://doi.org/10.1016/j.cvfa.2009.07.011>
- Omidi A, Sara M and Abolghasem N, 2011. Hypospadias, diverticulum, and agenesis in the penile shaft of a goat kid (*Capra hircus*). Comparative Clinical Pathology 20: 417–419. <https://doi.org/10.1007/s00580-010-1143-x>
- Pesato ME, Boyle AG, Fecteau ME, Hamberg A and Smith BI, 2018. Gastrointestinal spindle cell tumor of the rumen with metastasis to the liver in a goat. Journal of Veterinary Diagnostic Investigation 30: 451–454. <https://doi.org/10.1177/1040638718759732>
- Sadan M, 2019. Superficial swellings in sheep (*Ovis aries*) and goats (*Capra hircus*): Clinical and ultrasonographic findings. The Journal of Veterinary Medical Science 18: 81(9):1326-1333. <https://doi.org/10.1292/jvms.19-0209>
- Sagar PV, Harish D and Babu PP, 2010. Ventral hernia in an Ongole cow: a case report. Veterinary World 3: 90–91.
- Scott PR, 2012. Applications of diagnostic ultrasonography in small ruminant reproductive management. Animal Reproduction Science 130: 184–186. <https://doi.org/10.1016/j.anireprosci.2012.01.013>
- Simse A, Yaman T, Icen H and Kochan A, 2018. Diaphragmatic hernia in a sheep - a case report. Veterinarski Arhiv 88: 271–277. <http://vetarhiv.vcf.unizg.hr/papers/2018-88-2-10.pdf>
- Smith KC, Brown PA and Parkinson TJ, 2006. Hypospadias in rams. Veterinary Record. 158:789–795. <https://doi.org/10.1136/vr.158.23.789>
- Streeter RN and Step DL, 2007. Diagnostic ultrasonography in ruminants. Veterinary Clinics of North America: Food Animal Practice 23: 541–574. <https://doi.org/10.1016/j.cvfa.2007.07.008>
- Temizsoy MD, 2005. Penile urethral diverticulum in a kid. Ankara Universitesi Veteriner Fakultesi Dergisi 52: 185–187.
- Tharwat M and Oikawa S, 2007. Ultrasonographic characteristics of abdominal and thoracic abscesses in cattle and buffaloes. Journal of Veterinary Medicine A 54: 512–517. <https://doi.org/10.1111/j.1439-0442.2007.00989.x>
- Tharwat M and Al-Sobayil F, 2017. Diagnostic ultrasonography in goats with contagious caprine pleuropneumonia caused by *Mycoplasma capricolum* subsp. *Capripneumoniae*. BMC Veterinary Research 13: 263. <https://doi.org/10.1186/s12917-017-1167-4>
- Tharwat, M, Sadan M, El-Shafaey E, Al-Hawas A and Saeed EMA, 2018a. Unilateral nephrectomy in a female dromedary camel with pyelonephritis caused by *Staphylococcus lugdunensis*. Pakistan Veterinary Journal 38: 116-118. <https://doi.org/10.29261/pakvetj/2018.024>
- Tharwat M, Sadan M, El-shafaey E, El-hassan SE and Al-hawas A, 2018b. Bilateral renal abscessation and chronic active pyelonephritis in a male camel (*Camelus dromedarius*) caused by *Escherichia coli*. The Journal of Veterinary

- Medical Science 80: 778–783. <https://doi.org/10.1292/jvms.17-0484>
- Tharwat M, El-Shafaey E, Sadan M, Ali A, Al-Sobayil F and Al-Hawas A, 2018c. Omaso-abomasal adenocarcinoma in a female Arabian camel (*Camelus dromedarius*). Journal of Applied Animal Research 46: 1268–1271. <https://doi.org/10.1080/09712119.2018.1495644>.
- Tharwat M, 2019. Multiple splenic abscessations in a camel: case report. Journal of Camel Practice and Research 26: 273-276. <https://doi.org/10.5958/2277-8934.2019.00044.4>
- Tharwat M, 2020. Ultrasonography of the liver in healthy and diseased camels (*Camelus dromedaries*). The Journal of Veterinary Medical Science 82: 399-407. <https://doi.org/10.1292/jvms.19-0690>
- Tharwat M, 2021a. Obstructive urolithiasis in dromedary camels: clinical, ultrasonographic and postmortem findings. Journal of Camel Practice and Research 28: 85-93. <https://doi.org/10.5958/2277-8934.2021.00013.8>
- Tharwat M, 2021b. Ultrasonography of the thorax in healthy and diseased camels (*Camelus dromedaries*) – a mini-review. Journal of Camel Practice and Research 28: 313-318. <https://doi.org/10.5958/2277-8934.2021.00048.5>
- Tharwat M, 2021c. Clinical, ultrasonographic and post-mortem findings in sheep and goats with different urinary tract disorders. Veterinary World 14: 1879-1887. <https://doi.org/10.14202/vetworld.2021.1879-1887>
- Tharwat M, 2021d. Alterations in acid-base balance, blood gases and hemato-biochemical profiles of whole blood and thoracic fluid in goats with contagious caprine pleuropneumonia. Veterinary World 14: 1874-1878. <https://doi.org/10.14202/vetworld.2021.1874-1878>
- Tsioli V, Farmaki R, Papastefanou A, Galatos AD, Marinou M, Tontis D, Mavrogianni VS, Doukas D, Saridomichelakis MN and Fthenakis GC, 2013. A case of bilateral auricular haematoma in a ewe-lamb with sarcoptic mange. Small Ruminant Research 110: 145–149. <https://doi.org/10.1016/j.smallrumres.2012.11.023>
- Young J, Gilbert AI and Graham MF, 2007. The use of ultrasound in the diagnosis of abdominal wall hernias. Hernia 11: 347–351. <https://doi.org/10.1007/s10029-007-0227-2>
- Zhang W, Li J and McManus DP, 2003. Concepts in immunology and diagnosis of hydatid disease. Clinical Microbiology Reviews 16: (1) 18–36. <https://doi.org/10.1128/CMR.16.1.18-36.2003>