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Liver Diseases in Sheep and Goats: Parallel Sonographic and Pathologic Findings

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ABSTRACT

This study was carried out to investigate the ultrasound findings in sheep and goats with hepatic disorders and its correlation with postmortem findings. Twenty-three female sheep (n=9) and goats (n=14) of 1-5 years were examined. They were refereed because of gradual loss of body condition, inappetence, anorexia, and abdominal distension. Ten clinically healthy female animals were used as a control group. The right side of the diseased and control animals were scanned by ultrasonography. None of the control animals showed any sonographic abnormality on hepatic imaging. Diseased animals were classified into 7 groups. Hepatic sonography in group 1 (gallstones) showed dilated bile ducts within the hepatic parenchyma and calculus in the gall bladder. In group 2, the cholecystitis group; the thickening of the gall bladder wall was remarkable on ultrasonography. In group number 3, stones in the bile duct, the calculus in the bile duct appeared sonographically as acoustic enhancement with a distal acoustic shadowing. In group 4 with fatty liver, hepatic imaging showed increased hepatic echogenicity (bright liver appearance) which was intense in 5 animals where blood vessels were difficult to be seen and moderate in the remaining 6. In group 5 affected with *Cysticercus tenuicolis*, hepatic sonography showed a coarse hyperechogenic pattern of the liver tissue. Unfortanately, both animals in groups 6 and 7 were not examined by sonography and only the postmortem findings were obtained. In conclusion, most of the sheep and goats examined in this study were admitted with nonspecific symptom. It is believed that without hepatic ultrasonography in diseased cases, it will be difficult to reach an antemortem diagnosis. The sonographic findings were parallel almost in all cases with postmortem findings.

Key words: Animals, Diagnostic imaging, Diseases, Pathology, Ruminant.

INTRODUCTION

In small ruminants, hepatic diseases are recorded frequently. In a three-year abattoir study carried out in Sudan, condemnation of the liver tissue was carried out due to hepatic necrosis, fascioliosis, cysticercosis, calcification, hepatic abscessation and liver fibrosis (Mohamed 2021). In another short-period abattoir study done in Ghana, the liver was condemned due to hepatic necrosis, granuloma, cystic valuation, and hepatic degeneration (Ntiamoah et al. 2021). All of these diseases were discovered incidentally at the abattoir and none of the animals suffered any symptoms previously. In a third abattoir study performed in Ethiopia on 1030 sheep and goats, 37% of the livers were excluded due to calcification, hepatitis, cirrhosis, *Cysticercus tenuicolis*, *Stelesia hepatica*, and adhesions (Bulbula and Bedada 2019).

In cattle, it was also reported that verification of liver disorders is a little bit difficult as these diseases have non-specific symptoms and additionally, laboratory methods for diagnosis as hepatocellular enzymes are not sufficient (Braun 2009). A thorough sonographic scanning of the hepatic parenchyma is important for obtaining full information about the position, size, and pattern of liver echotexture as well as the position and size of the gallbladder and bile ducts and hepatic blood vessels. It was also reported that ultrasonography in cattle is very useful for the detection of hepatic diseases. The technique can detect either diffuse or discrete lesions and biopsied or aspirated under ultrasound guidance (Braun 2009).

In large animals, ultrasound is used mainly for the evaluation of gynecological disorders. The procedure is used also for the diagnosis of several hepatic affections (Tharwat 2012a; Tharwat et al. 2012a, c, d; Abdelaal et al. 2014; Tharwat 2020). In small ruminants, sheep, and goats, ultrasonography has been used for the diagnosis of several

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medical disorders (Tharwat et al. 2012b; El-Tookhy and Tharwat 2013; Tharwat and Al-Sobayil 2017; Tharwat 2021; Sadan et al. 2023). The procedure is very useful in the verification of the disease process and determines the prognosis and treatment follow-up in the sheep and goats. However, pictures determining hepatic pathologies have not been reported in veterinary literature to our knowledge. Therefore, this research work was designed to clarify the importance of ultrasound in sheep and goats with different hepatic disorders and its correlation with postmortem findings.

MATERIALS AND METHODS

Ethical Approval, Animals, History and Clinical Examination

Animal Welfare and Care and Organization of the Scientific Research Deanship of Qassim University, Kingdom of Saudi Arabia approved the study design. Twenty-three female sheep (n=9) and goats (n=14) of 1-5 years were examined at the Veterinary Hospital of the University of Qassim, Saudi Arabia between 2018 and 2023. They were refereed because of gradual loss of body condition, inappetence, anorexia, and abdominal distension. The period of the illness ranged from 3 to 60 days. Ten clinically healthy female animals (5 sheep and 5 goats) were used as a control group. Just after admission, all animals received a full physical examination including rectal temperature, pulse and respiratory rates, mucus membranes, and cardiopulmonary and digestive systems. Special attention was paid to the liver parenchyma, gall bladder, bile ducts, and hepatic blood vessels.

Ultrasonographic and Pathologic Examinations

On the right side of the abdomen and thorax, the hair and wool from goats and sheep, respectively were clipped and skin shaved. Sonographic imaging of the urinary system was carried out using a 7.5 sector MHz transducer (SonoScape, Sonoscape Medical Corp., China). This was followed by the application of transmission gel to the probe and then hepatic sonography was started beginning at the right flank and extending forward to the 5th intercostal space. Each space was scanned from dorsal to ventral with the probe parallel to the ribs. The liver parenchymal echotexture, gall bladder, extrahepatic and intrahepatic bile ducts, and hepatic veins including portal veins, hepatic veins, and caudal vena cava were imaged (Braun and Steininger 2011; Braun et al. 2013). Postmortem examination was carried out on 15 animals (9 goats and 6 sheep). The thoracic and abdominal cavities were examined in detail. Special attention was given to the liver and biliary system.

RESULTS

None of the control animals showed any sonographic abnormality on hepatic imaging. Seven categories for sheep and goats affected with liver diseases are displayed in Table 1. The first category was gallstones; it was detected in sheep. It was admitted with a history of weakness in spite of good nutrition for a month. On clinical examination, icteric conjunctival mucus membranes were found. Hepatic sonography showed dilated bile ducts within the hepatic parenchyma and a calculus in the gall bladder. At necropsy, the gall bladder wall was thickened, the common bile duct was dilated and a white friable mass obstructed its lumen (Fig. 1). In the second category, the cholecystitis (inflammation of the gall bladder) group; it was discovered in 3 animals (1 sheep and 2 goats). The owners' complaints included progressive loss of body condition for 25 days. Icteric mucus membranes were detected on initial examination. Thickening of the gall bladder wall was remarkable on ultrasonography. Postmortem examination showed a distended gall bladder (Fig. 2).

Table 1: Classification of sheep and goats with liver diseases (n=23)

	Category	Number (species)
1	Gallstones	1 (sheep)
2	Cholecystitis	3 (1 sheep, 2 goats)
3	Choledocholithiasis	1 (sheep)
4	Fatty liver	11 (3 sheep and 8 goats)
5	*Cysticercus tenuicolis*	2 (sheep)
6	Liver abscesses	3 (2 sheep, 1 goat)
7	Cholangitis	2 (goats)
Total		23 (9 sheep, 14 goats)

In group 3 that suffered from stones in the bile duct and one sheep was affected. The animal was referred because of inappetence for a week. The calculus in the bile duct appeared sonographically as acoustic enhancement with distal acoustic shadowing. The calculus was detected at postmortem examination (Fig. 3). The largest category was group 4, the fatty liver one. It comprised 11 animals (3 sheep and 8 goats). All animals were admitted 3 to 7 days before expected parturition with a history of isolation, decreased appetite, and recumbency that was sternal in 7 and lateral in 2 animals. All animals were diagnosed with pregnancy toxemia. Hepatic imaging showed increased hepatic echogenicity (bright liver appearance) which was intense in 5 animals where blood vessels were difficult to be seen and moderate in the remaining 6 animals. At postmortem examination, hepatomegaly was found in all necropsied cases (Fig. 4).

Group 5 consisted of 2 sheep affected with *Cysticercus tenuicolis*. Animals were referred due to off-food and abdominal distension in spite of that. Intense yellow mucus membranes were observed. Sonographic examination showed a coarse hyperechogenic pattern of the liver tissue. Postmortem findings included massive serosanguineous ascetic fluid, bronzed hepatomegaly with rounded edges and severely distended gallbladder and numerous hemorrhagic tracks in the parenchyma (Fig. 5). The category number 6, liver abscesses, was composed of 2 sheep and 1 goat. Gradual loss of body weight was the main complaint. Unfortanately, both animals were referred for postmortem examination immediately after euthanasia therefore sonography was not performed. Necropsy revealed liver abscessation with enlarged gall bladders (Fig. 6). The 7th category was cholangitis (inflammation of the bile ducts). It was composed of 2 goats that were admitted for euthanasia and therefore no sonography was carried out. Postmortem examination only revealed inflammation of the extrahepatic bile duct of undetermined etiology (Fig. 7).

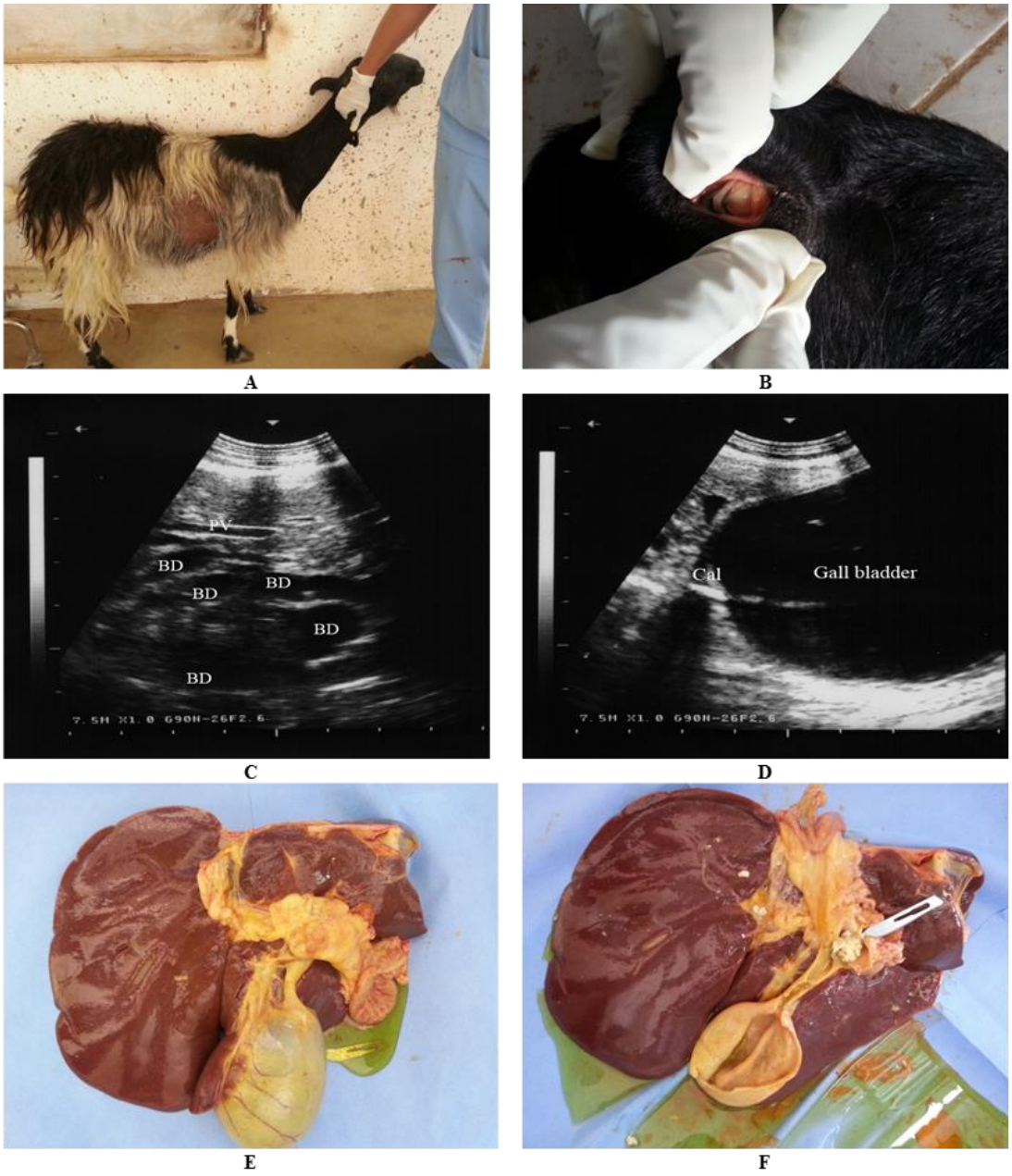


Fig. 1: Clinical, ultrasonographic and necropsy findings in a female sheep with gallstones (**A**). Icteric conjunctival mucus membranes were found (**B**). Dilated bile ducts (**C**) and a calculus in the gall bladder (**D**) were detected on hepatic sonography. Image **E** shows distended gall bladder and common bile duct. The gall bladder wall was thickened, the common bile duct was dilated, and a white friable mass obstructed its lumen (**F**).

DISCUSSION

In this study, with the exception of icteric mucus membranes recorded in some sheep and goats with hepatic diseases, referral complaints consisted of general symptoms including weakness, gradual loss of body condition, inappetence, anorexia, and abdominal distension. Therefore, ultrasonography was preliminary used to scan thoracic and abdominal cavities to detect any causative agent. To the authors' knowledge, this is the first report describing sonographic findings parallel to postmortem data in the small ruminants, sheep, and goats.

Examining the sheep in the first group, gallstones were incidentally detected in a sheep with only a referral complaining of weakness. On hepatic imaging, several intrahepatic bile ducts were found to be dilated and a large calculus was detected within a distended gall bladder. The sonographic diagnosis was confirmed by necropsy examination. Mineralization of the hepatic parenchyma is usually discovered in large animals with hepatic parasitism (Kojouri et al. 2008; Tharwat 2012b). In this study, the mineralization of the gall bladder was not determined. However, the animals in this study were reared in a desert area and the water source was not of good quality. Examining the 3 animals in the second group, cholecystitis was discovered on ultrasonography as a remarkable thickening in the gall bladder wall that was confirmed at postmortem. In cattle and buffaloes with chronic hepatic fascioliasis, cholecystitis was also detected on gall bladder sonography (Tharwat 2012b; Khalphallah et al. 2018).

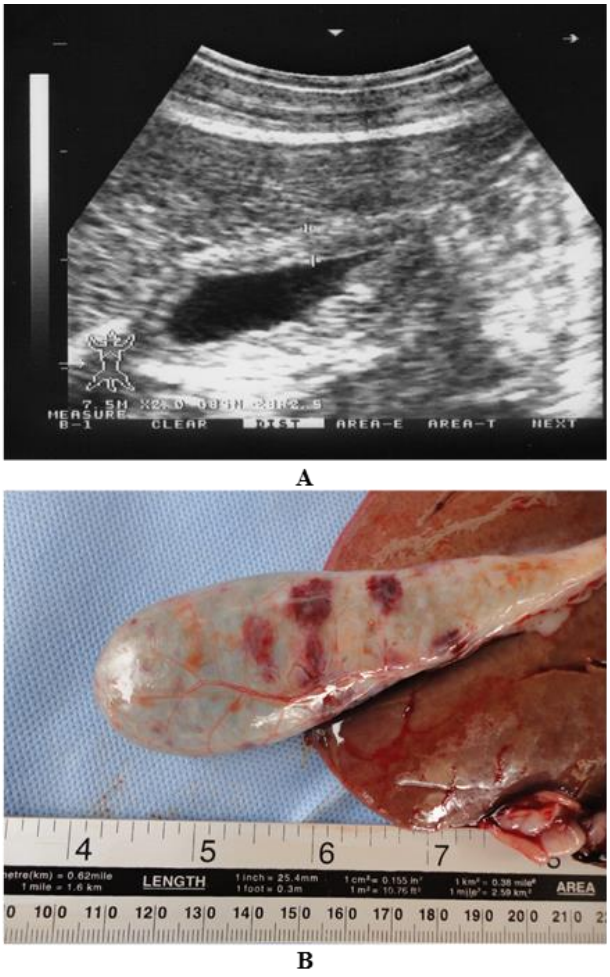


Fig. 2: Ultrasonographic and necropsy findings in a female goat with cholecystitis. Thickening of the gall bladder wall was remarkable in ultrasonography (**A**). Image **B** shows a distended gall bladder at postmortem examination.

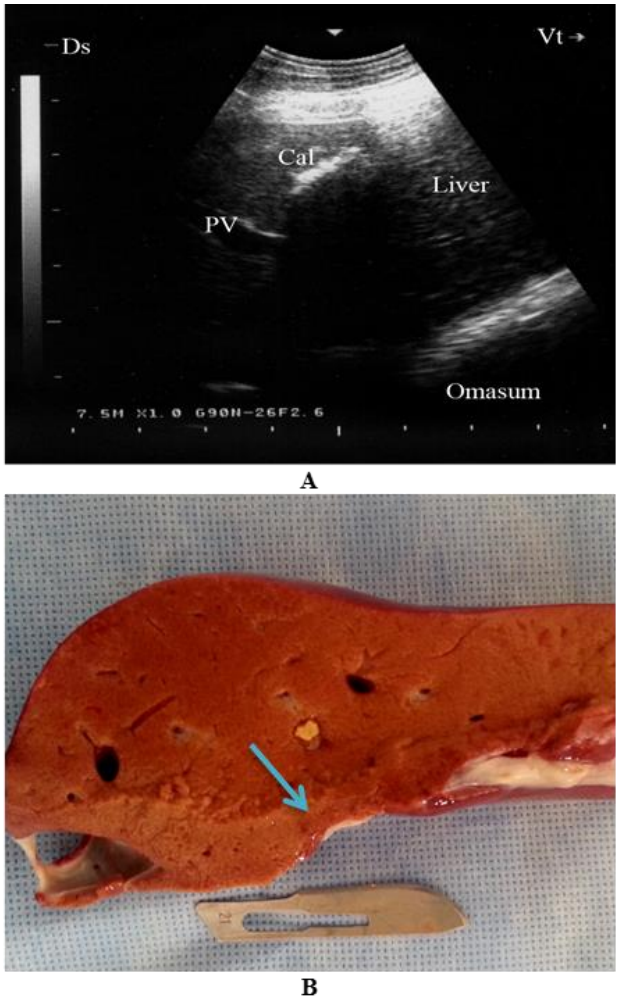
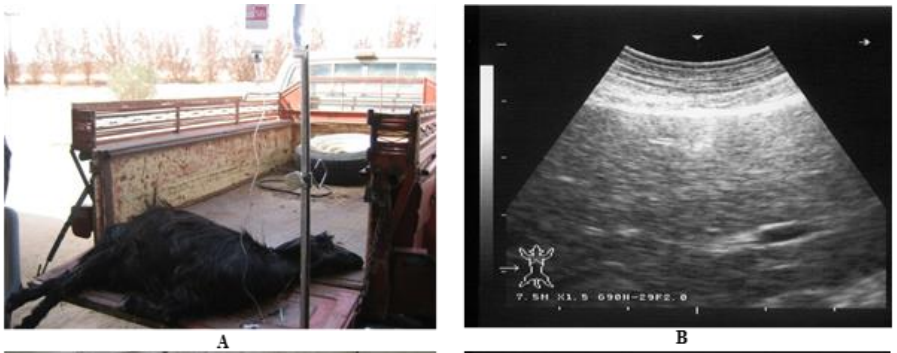


Fig. 3: Ultrasonographic and necropsy findings in a female goat with bile ducts stones. The calculus in the bile duct appeared sonographically as acoustic enhancement with a distal acoustic shadowing (**A**). Image **B** shows the calculus at postmortem examination. Cal, calculus; PV, portal vein; Ds, dorsal; Vt, ventral.

In the third group with biliary stones, a large calculus was found in the bile duct and images as acoustic enhancement with a distal acoustic shadowing. Sonographic examination was confirmed at postmortem examination. In cattle and buffaloes with chronic hepatic fascioliosis, mineralization of the bile ducts was also detected on hepatic sonography as intense echoes accompanied by a distal acoustic shadowing (Katsoulos et al. 2011; Tharwat 2012b; El Damaty et al. 2018). The nature of desert rearing in animals in this study and the source of drinking water may be contributing causes.

The discovered fatty infiltration of the liver in the fourth group was expected to some extent as all animals in this group were diagnosed initially to have pregnancy toxemia based on history and parturition expected timing. Similar findings in cattle and buffaloes affected with fatty liver were reported (Tharwat 2012a; Patel et al. 2022). In the later report, hepatic parenchyma was not visible in 14 out of the 26 animals with fatty liver. In the present study, in 5 out of the 11 diseased animals with fatty liver, the hepatic parenchyma was intense hyperechoic and the hepatic blood vessels could not be imaged. The syndrome of hepatic lipidosis is usually detected in dairy cows during the periparturient or transition period due to negative energy balance (Tharwat et al. 2012c, d; Aleri et al. 2016; Tsuchiya et al. 2020). In this report, the disease was also detected in animal few days of the expected parturition time as reported (Tharwat et al. 2012e).

Hepatic sonography examination of the 2 sheep with *Cysticercus tenuicolis* in group 5 revealed a course and enlarged hepatic parenchyma. The diagnosis was confirmed at postmortem. *Cysticercus tenuicollis* represents the second most common cause of traumatic hepatitis in sheep, second to liver fluke (Cullen and Stalker 2016; Kilinc et al. 2019; Mohammed 2020; Abbas et al. 2021). Severe traumatic liver damage was evident as numerous tracks were filled with blood cells. Similar results were reported by Bamorovat et al. (2014) and Radfar et al. (2014). Ovine visceral metacestodiasis caused by *Cysticercus tenuicollis* has been repeatedly recorded from wild and domesticated ovine, caprine, bovine, porcine, and camelid species (Chege et al. 2016). The adult tapeworm of such larva is the canine tapeworm *Taenia hydatigena*. Ova are passed with dog feces on the pasture and may get ingested by an intermediate host like the sheep in this study. The released oncospheres from eggs penetrate the intestine and pass through the portal vein to various tissues, especially the liver, omentum, mesentery, and peritoneum. Migration through the former results in hemorrhagic tracks and thereafter when succeeds in



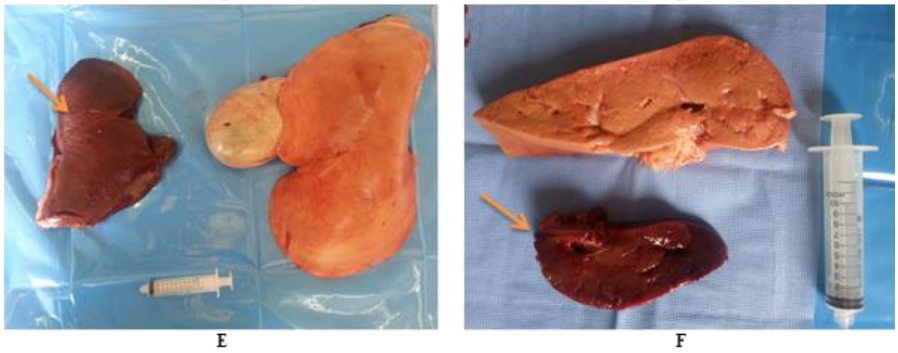


Fig. 4: Clinical, ultrasonographic and necropsy findings in goats with fatty liver due to pregnancy toxemia (**A, C**). Opposite sonographic images for both cases (**B**, **D**, respectively) show increased hepatic echogenicity (bright liver). Image **E** shows enlarged liver in a sheep with fatty liver compared to healthy liver (arrow). Image **F** shows cut section in the same liver in image **E** compared to healthy organ (arrow).

Fig. 5: Sonographic and pathologic findings in a sheep with acute hepatic cysticercosis. Sonographic examination showed a coarse hyperechogenic pattern of the liver tissue (**A**). Postmortem findings included massive serosanguineous ascetic fluid (**B**), bronzed hepatomegaly with rounded edges and severely distended gallbladder (**C**) and numerous hemorrhagic tracks in the parenchyma (**D**).

making a way into the liver surface, the larva develops a thin-walled fluid-filled bladder, otherwise degenerate and calcified or, occasionally, predispose to the black disease (Blazek et al. 1985).

Unfortunately, diseased sheep and goats in both groups 6 and 7 were not examined by ultrasonography and only postmortem examination was carried out. Those groups were liver abscessation and inflammation of the bile ducts,

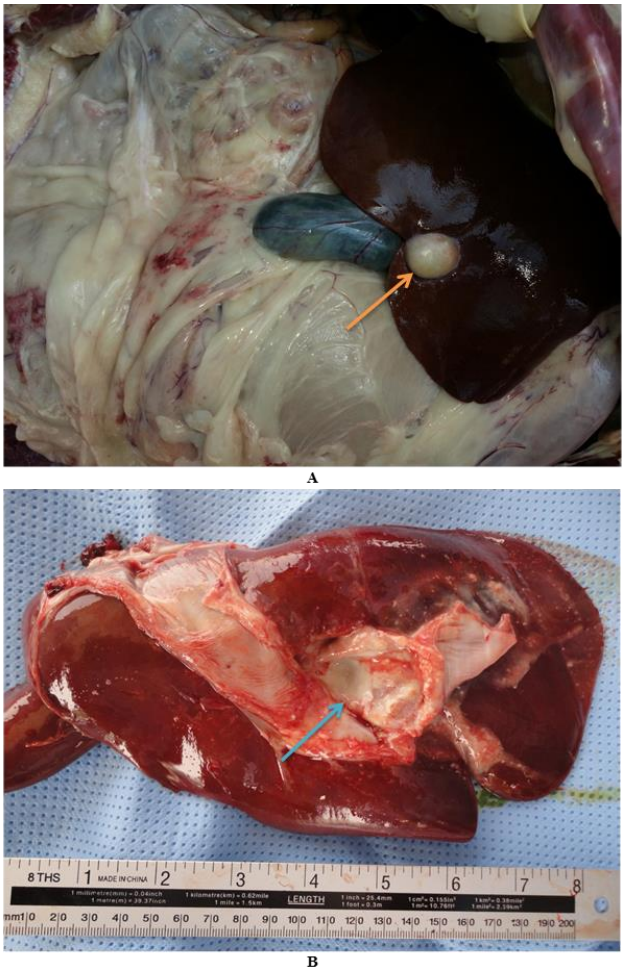


Fig. 6: Hepatic abscessation in a sheep (**A,** arrow) and a goat (**B,** arrow-open abscess) liver detected at postmortem examination. In both cases, the gall bladder was enlarged.

Fig. 7: Cholangitis, an inflammation of the common bile duct in a goat.

respectively. Abscesses may form in the livers of sheep and goats either by hematological spread or by local invasion from the rumen. Such abscesses may be caused by a variety of organisms (Abdelaal et al. 2014; Amachawadi and Nagaraja 2022). In sheep and goats, the most common organism causing liver abscessation is *Fusobacterium necrophorum*. Clinically, the animals will be sick with pyrexia and jaundice may be a feature. Diagnosis may be helped by raised liver enzymes, liver biopsy, and trans-abdominal ultrasonography. Obviously, aggressive antibiotic treatment is required, but it is unlikely to be successful (Tehrani et al. 2012). Inclusion of antacids or buffers such as sodium bicarbonate in the ration is also indicated to reduce the risk of ruminal acidosis which could lead to liver abscesses (Tehrani et al. 2012).

Conclusion

Most of the sheep and goats examined in this study were admitted with nonspecific symptoms. It is believed that without hepatic ultrasonography in diseased cases, it will be difficult to reach an antemortem diagnosis. The sonographic findings were parallel almost in all cases with postmortem findings. It is recommended therefore to routinely scan the thorax and abdomen in sheep and goats referred with general presentations.

Author's Contribution

Mohamed Tharwat: Planned and designed the study, carried out the practical work and participated in drafting the manuscript. Abdulla Al-Hawas: Shared in designing the study, and practical work. Both authors read, revised and approved the final manuscript.

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