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Evaluation of ultrasonography as a diagnostic tool for hepatic hydatid cysts in sheep

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Abstract: This retrospective study was designed to evaluate the use of ultrasonography for the diagnosis of hepatic hydatid cysts. This study was conducted on 22 sheep, which were classified into 2 groups according to their liver health group (healthy liver = 13 and cystic liver = 9). Biochemically, serum concentrations of γ-glutamyl transferase, aspartate aminotransferase, total bilirubin, and globulins were significantly increased ($P < 0.01$) while albumin was lowered ($P < 0.01$) in sheep with cystic livers. Ultrasonographically, rounded, anechoic, and unilocular hydatid cysts with elliptical circumferences ranging from 6 to 10 cm were seen. The interiors of cysts contained echogenic particulate materials, septations, or fine echoes. At the 10th intercostal space (ICS), ventral margin, size, thickness, and angle of livers increased in sheep with hepatic cysts, while the diameter of portal vein decreased in sheep with liver cysts. At the 9th ICS, the circumference of the gall bladder was lowered in sheep with hepatic cysts ($P < 0.01$). The sensitivity, specificity, and positive and negative predictive values of ultrasonography for diagnosis of hepatic hydatid cysts were 80%, 100%, and 100% and 83%, respectively. In conclusion, ultrasonography alone or in combination with some biochemical parameters reflecting liver function could be helpful for the diagnosis of hepatic hydatid cysts in sheep.

Key words: Ultrasonography, liver, hydatid cysts, sheep

1. Introduction

Hydatid cysts, or cystic echinococcosis (CE), are a zoonotic parasitic infection of many mammalian species caused by the larvae of *Echinococcus granulosus*, which are found in the small intestines of dogs and other carnivores (1). Sheep, cattle, and camels are considered intermediate hosts (2). Furthermore, liver and lung cysts of *E. granulosus* are a worldwide parasitic disease (3) and it is endemic in countries where sheep grazing is carried out with the help of dogs (4).

The disease also has a wider public health importance. Humans are accidental intermediate hosts (5). Sheep and goats appear to be the most important reservoir for human hydatidosis because of the widespread practices of home slaughtering, feeding of the diseased offal to the definitive host (the dog) (6), and the high percentage of fertile cysts found in small ruminants (7). Sheep as intermediate hosts are infected by the ingestion of parasite eggs, which reach the liver via the portal system to form hydatid cysts (7). The liver is involved in up to 75% of cases but no part of the body is spared (8,9).

Cystic liver disease has an economic impact in countries where livestock industry is an important segment of the agricultural sector and where livestock production is based mainly on an extensive grazing system (10). Significant losses are of particular significance in countries with low economic output where sheep production is of particular importance (11), as they include losses of meat and milk production; fleece values from infected sheep may also be affected (12). CE in farm animals also causes considerable economic problems due to the loss of edible livers (13).

With the advent of ultrasonography, many organs and tissues can be scanned and examined for the presence of many diseases. There are no reliable methods for the routine diagnosis of liver cysts in living animals, but in rare cases cysts have been identified by ultrasonography, alone or in conjunction with serum antibody detection (5). Previous studies (12,14) suggested the use of ultrasonography for the diagnosis of CE, but they lacked detailed information about the ultrasonographic features and alterations of sheep livers with hydatid cysts. Therefore, this study was planned to gain information about the ultrasonographic findings of sheep livers with CE, and also to assess the use of ultrasonography for diagnosis of such a disease.

2. Materials and methods

2.1. Animals, history, and physical examination

In this study, a total of 22 Baladi sheep (aged 3 to 6 years) of both sexes were admitted to the Veterinary

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Teaching Hospital at Assiut University, Egypt, from April 2011 to March 2013 because of weight loss, diarrhea, or pregnancy. The case histories of infected sheep revealed grazing on pastures near areas known to have stray dogs or flock control with the help of dogs. This information was obtained from the owners using a questionnaire that was prepared for this study. Based on clear hepatic ultrasonographic findings, all animals were classified into 1 of 2 groups: those with hepatic cysts (n = 9) and without liver cysts (healthy liver, n = 13). All animals were subjected to physical examination as described previously (15). This included their general behavior and condition; auscultation of the heart, lungs, rumen, and intestines; and measurement of heart rate, respiratory rate, and rectal temperature. Animals with other disease conditions were excluded from the study.

2.2. Hematological and biochemical analyses

Two blood samples were collected by puncture of the jugular vein, the first with heparin and the second without anticoagulant. Blood gas analysis and a complete blood count including hematocrit, hemoglobin, erythrocyte count, and total leukocyte count were carried out on the first sample (16). After centrifugation of the second blood sample, serum samples were collected and then frozen at –20 °C for 1 week; subsequently, an analysis of biochemical parameters was carried out. With the serum samples, commercial test kits were used to determine the concentrations of total proteins, albumin, blood urea nitrogen, creatinine, and total bilirubin. The activities of aspartate aminotransferase (AST) and γ-glutamyl transpeptidase (GGT) were also measured in serum samples. The biochemical analyses of the selected parameters were spectrophotometrically conducted according to the standard protocol of the suppliers.

2.3. Ultrasonographic examination

Ultrasound examination was carried out while the animals were standing using a real-time B-mode scanner with 3.5-, 5.0-, and 8.0-MHz linear and convex transducers (Veterinary Ultrasound Scanner System, Scanner Aqulla Pro Vet Model, Esoate Europe BV, the Netherlands). In preparation for ultrasonography, the right thorax and abdomen were clipped and shaved, and a coupling gel was applied. Ultrasonographic examination of the liver was performed on the right side of the abdomen in the 12th to 7th intercostal spaces (ICSs). In each ICS, the dimensions of the liver and, if visible, the location and diameter of the caudal vena cava and portal vein, were determined. In addition, the angle of the liver and the location and circumference of the gall bladder were also determined (17), and the number, size, and location of the cysts were noted.

2.4. Statistical analysis

Data are presented as mean ± SE and the analysis was conducted using SPSS 16.0. Hematological, biochemical, blood gas, and acid–base data, as well as ultrasonographic findings, were compared using Student's t-test. Differences between parameters were tested for significance at probability levels of $P < 0.05$, $P < 0.01$, and $P < 0.001$. A contingency 2 × 2 table was created to compute the sensitivity, specificity, and positive and negative predictive values using ultrasonography as a diagnostic tool for incidence of hepatic CE. The formulas below were used to calculate the sensitivity, specificity, and positive and negative predictive values (18):

Sensitivity = 100 [true positive/true positive + false negative],

Specificity = 100 [true negative/true negative + false positive],

Positive predictive value = 100 [true positive/test positive],

Negative predictive value = 100 [true negative/test negative].

3. Results

3.1. Clinical, hematological, and biochemical findings

Case histories of diseased sheep revealed grazing on pastures near areas with stray dogs or flock control with the help of dogs. This information was obtained from the owners after a questionnaire was prepared for this study. Table 1 summarizes the main clinical findings in sheep with cystic and healthy livers. Sheep with cystic livers experienced inappetence with frequent diarrhea and constipation. Two cases had roughness of wool and a shaggy appearance.

With regard to the hematological findings, insignificant differences were found in the sheep in the 2 liver health groups. Biochemically, compared to the control animals, increased serum levels of globulins ($P < 0.01$), total bilirubin ($P < 0.01$), AST ($P < 0.001$), and GGT ($P < 0.01$) were obtained in diseased sheep, while serum levels of albumin and albumin/globulin ratios were lower in sheep with cystic livers ($P < 0.01$). The other serum parameters did not differ significantly between sheep with hepatic cysts and healthy ones (Table 2).

3.2. Ultrasonographic findings

The livers of all animals were examined from the 12th to the 7th ICSs (Figure 1). In 1 healthy sheep, the 12th ICS was too narrow; therefore, ultrasonographic examination was not possible at this location. Table 3 shows the ultrasonographic findings from the livers in the 2 health groups. At the 10th ICS, ventral margin, size, thickness, and the angle of liver were higher in sheep with liver cysts than in healthy ones ($P < 0.01$). Out of 9 cases with hepatic cysts, 3 cases showed cysts at the right lobe of liver near the portal vein, with increased echogenicity of its wall and narrowing of its diameter (Figure 2); 2 cases exhibited cysts near the angle of the liver at the 10th ICS (Figure 3).

Table 1. Clinical findings in sheep with 2 liver health groups (n = 22).

Liver health group	Clinical observations	Temperature (°C)	Respiration (breaths/min)	Heart rate (beats/min)	Ruminal contractions
Cystic liver (n = 9)	Depression, inappetence, weight loss, poor condition, and frequent diarrhea and constipation	39.3 ± 0.04	24 ± 0.3	86 ± 2.3	2.0 ± 0.17
Healthy liver (n = 13)	Good condition; most of the ewes were at an early stage of pregnancy	39.4 ± 0.06	25 ± 0.5	87 ± 2.1	2.2 ± 0.12

Table 2. Hematological and biochemical findings of sheep with 2 liver health groups (n = 22).

Parameters		Liver health group	
		Cystic liver (n = 9)	Healthy liver (n = 13)
Hematocrit (%)		34 ± 1.0	32 ± 0.6
Hemoglobin (g/L)		98 ± 3	100 ± 2
Erythrocytes (T/L)		9.2 ± 0.18	9.6 ± 0.24
Leukocyte count (g/L)		6.4 ± 0.17	5.9 ± 0.15
γ-Glutamyl transferase (U/L)		46 ± 3**	33 ± 2
Aspartate aminotransferase (U/L)		104 ± 4***	36 ± 1
Total bilirubin (µmol/L)		8.5 ± 0.55**	4.2 ± 0.40
Total proteins (g/L)		69 ± 1	70 ± 0.8
Albumin (g/L)		22 ± 0.5**	28 ± 0.44
Globulins (g/L)		47 ± 1.3**	42 ± 0.8
Albumin/globulin ratio		0.5 ± 0.06**	0.7 ± 0.02
Blood urea nitrogen (mmol/L)		3.9 ± 0.16	4.2 ± 0.15
Creatinine (µmol/L)		111 ± 2.0	114 ± 1.5
Venous blood gas and acid–base indices	pH	7.37 ± 0.02	7.36 ± 0.01
	HCO_3 (mmol/L)	22 ± 0.3	23 ± 0.2
	tCO_2 (mmol/L)	24 ± 0.5	25 ± 0.4
	pO_2 (mmHg)	34 ± 0.3	35 ± 0.3
	pCO_2 (mmHg)	42 ± 0.6	44 ± 0.5
	BE (mmol/L)	0.42 ± 0.04	0.40 ± 0.07

Data presented as mean ± SE, **: $P < 0.01$; ***: $P < 0.001$.

The parenchymal pattern of livers in the control sheep consisted of numerous weak echoes homogenously distributed over the entire liver (Figures 4 and 5), whereas in diseased sheep, the liver showed heterogeneous hyperechogenic parenchyma (Figures 2 and 6).

In general, liver cysts were rounded, anechoic, and unilocular in structure with typically hypoechogenic contents (Figure 6). The elliptical circumference of hepatic cysts ranged from 6.7 to 10.4 cm. The ultrasonographic appearance of liver cysts was homogeneous in 5 animals and heterogeneous in the rest of the animals. The interior of some cysts contained echogenic particulate materials (Figure 7), septations (Figure 2), or fine echoes (Figure 8). The borders of cysts were either well defined (Figure 8) or ill defined (Figure 2).

The caudal vena cava was located dorsal and medial to the portal vein. It was usually triangular on cross-sectional view (Figures 2 and 4), whereas the portal vein was round or slightly oval (Figures 3 and 4). In both health groups, the diameter of the caudal vena cava increased cranially, whereas the portal vein diameters decreased cranially ($P < 0.05$). The dorsal margin, depth, and diameter of the caudal vena cava showed insignificant differences between the 2 liver health groups ($P > 0.05$), whereas at the 10th

Figure 1. Location of the liver. The lines drawn on the sheep represent the dorsal and ventral limits of the liver from the 7th to the 12th intercostal spaces. These limits correspond to the mean positions of the dorsal and ventral limits of the liver in 13 healthy sheep.

ICS, the diameter of the portal vein was smaller in sheep with hepatic cysts than in control ones ($P < 0.01$).

The gall bladder was visualized in all sheep. Generally, the gall bladder was visible at the 9th, 10th, or both ICSs. Ultrasonographically, the gall bladder was recognized as a fluid-filled vesicle, which appeared as an oval- or pear-shaped dark area with a bright margin (Figure 4). At the 9th and 10th ICSs, dorsal margins of gall bladders were greater in sheep with hepatic cysts than in healthy sheep ($P < 0.01$), whereas at the 9th ICS the circumference of the gall bladder was smaller in the diseased group than in control animals ($P < 0.01$) (Table 4).

3.3. Postmortem findings

In order to evaluate the reliability of ultrasonography for detection of hepatic cysts, 10 animals were slaughtered, with the owners' agreement, after ultrasonographic examination. Necropsy examination of 2 cases showed that all cysts were located in the right (Figure 9) and left lobes of the liver. These cysts were dead, as they were caseous. In 3 cases, cysts were observed near the portal area. Postmortem examination of these cysts revealed the presence of protoscolices and clear hydatid fluid, indicating viability. Postmortem examination of the rest of the slaughtered sheep (5 cases) revealed no gross hepatic lesions. One positive sheep on postmortem examination had been falsely identified as negative on ultrasonographic examination. In comparison with postmortem findings, the sensitivity, specificity, and positive and negative predictive values of ultrasonography as diagnostic tools for hepatic hydatid cysts were 80%, 100%, and 100% and 83%, respectively.

4. Discussion

Killing infected sheep at a rural breeding site begins the transmission cycle that progresses with infection of dogs and culminates in the contamination of the environment where other sheep, and occasionally humans working in contact with them, acquire the disease (19).

Although the importance of sheep in the cycle of CE has been recognized, diagnostic methods that allow in vivo identification of parasitized sheep have been poorly evaluated. Serological tests for the diagnosis of hydatid cysts in sheep have been proven unreliable (20) and of limited use (21), as these tests does not distinguish between current and previous infections, along with the

Table 3. Ultrasonographic examination of sheep liver (n = 22).

Variable	Liver health group	Intercostal space					
		12	11	10	9	8	7
Dorsal margin[1]	Cystic liver (n = 9)	6.1 ± 0.23	8.0 ± 0.17	8.4 ± 0.17	11 ± 0.17	15 ± 0.4	27 ± 0.23
	Healthy liver (n = 13)	6.0 ± 0.16	7.6 ± 0.21	8.5 ± 0.14	11 ± 0.20	16 ± 0.4	26 ± 0.24
Ventral margin[1]	Cystic liver (n = 9)	15 ± 0.23	17 ± 0.15	20 ± 0.33**	25 ± 0.4	27 ± 0.5	36 ± 0.24
	Healthy liver (n = 13)	16 ± 0.26	17 ± 0.21	18 ± 0.24	24 ± 0.3	27 ± 0.3	36 ± 0.28
Size (cm)	Cystic liver (n = 9)	8.9 ± 0.33	9 ± 0.29	11.6 ± 0.22**	14 ± 0.4	12 ± 0.4	9 ± 0.15
	Healthy liver (n = 13)	10 ± 0.34	9.4 ± 0.26	9.5 ± 0.26	13 ± 0.2	11 ± 0.5	10 ± 0.14
Thickness (cm)	Cystic liver (n = 9)	NA	7.1 ± 0.28	9.2 ± 0.09*	7.8 ± 0.27	NA	NA
	Healthy liver (n = 13)	NA	7.2 ± 0.54	8.3 ± 0.29	8.1 ± 0.21	NA	NA
Angle (°)	Cystic liver (n = 9)	NA	33 ± 1.3	38 ± 1*	34 ± 0.8	NA	NA
	Healthy liver (n = 13)	NA	34 ± 0.7	35 ± 0.9	35 ± 1.1	NA	NA

[1]Centimeters distal to the midline of the back. Values represented as mean ± SE, *: $P < 0.05$; **: $P < 0.01$, NA = not applicable.

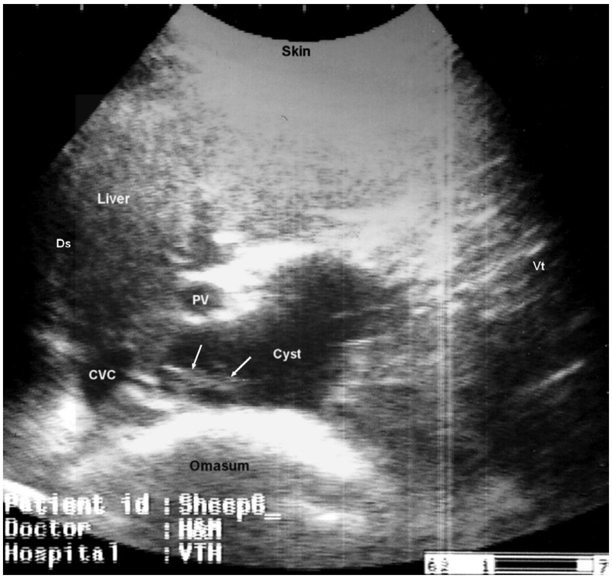

Figure 2. Ultrasonogram of the liver of a 5-year-old sheep viewed from the 9th intercostal space with a 5-MHz convex transducer showing a periportal cyst with ill- defined borders and anechoic content containing echogenic septa (white arrows). Note narrowing with hyperechogenicity of the portal vein. CVC: caudal vena cava, PV: portal vein, Ds: dorsal, Vt: ventral.

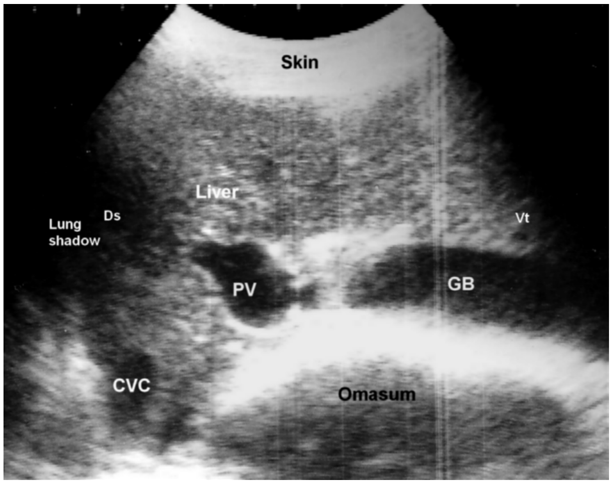

Figure 3. Ultrasonogram of the liver of a 4-year-old sheep viewed from the 10th intercostal space with a 5.0-MHz convex transducer showing the anechoic content of a hepatic cyst near the liver angle with increased echogenicity of liver parenchyma. A: abdominal wall, D: diaphragmatic surface, PV: portal vein, Ds: dorsal, Vt: ventral.

fact that cross-reactivity between *Echinococcus* and *Taenia* species may occur (21). Such information is currently obtained from postmortem examination and only at an abattoir during veterinary meat inspections. Thus, the only available data are incomplete and only refer to institutional slaughtering (22). As listed in Table 1, there are no specific signs indicating infection of sheep with cystic hepatic disease. Additional diagnostic techniques are often helpful for the evaluation of liver function through estimation of liver enzymes, total bilirubin, total proteins, and albumin (23). In diseased sheep, the significantly increased activities of AST and GGT could be attributed to leakage of these enzymes from hepatocytes

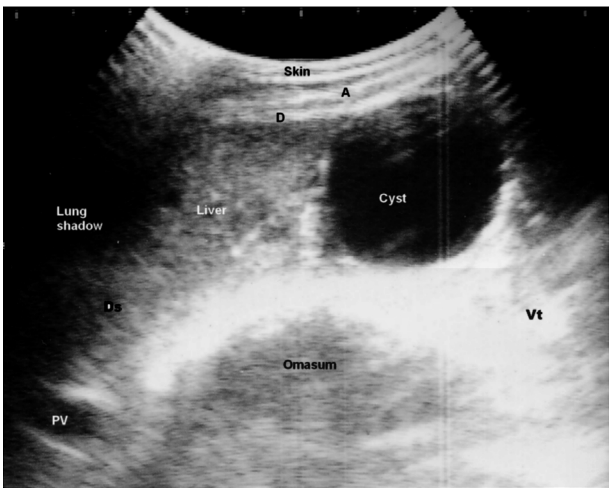

Figure 4. Ultrasonogram of the liver of a 5-year-old sheep viewed from the 9th intercostal space with a 5-MHz convex transducer showing grayish echogenicity of parenchyma in a healthy liver and noncompressed portal vein (compare with Figure 2). CVC: caudal vena cava, PV: portal vein, GB: gall bladder, Ds: dorsal, Vt: ventral.

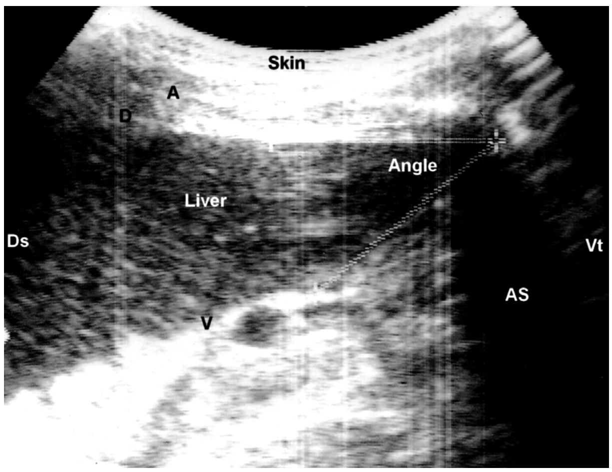

Figure 5. Ultrasonogram of the liver of a 5-year-old sheep viewed from the 10th intercostal space with a 3.5-MHz convex transducer showing the angle of a healthy liver (40°) and numerous homogeneous weak echoes (gray in color). A: abdominal wall, D: diaphragmatic surface of liver, AS: acoustic shadowing, V: visceral surface of liver, Ds: dorsal, Vt: ventral.

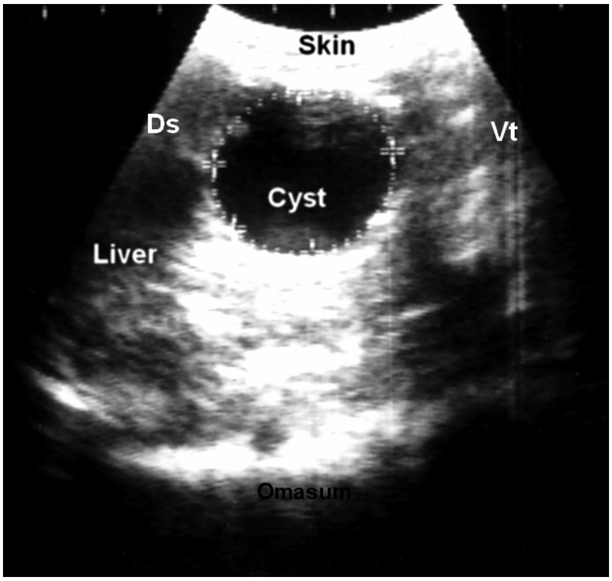

Figure 6. Ultrasonogram of the liver of a 3-year-old sheep viewed from the 9th intercostal space with a 3.5-MHz convex transducer showing the anechoic content of liver cyst (ellipse circumference = 9.49 cm) and the increased echogenicity of liver parenchyma. Ds: dorsal, Vt: ventral.

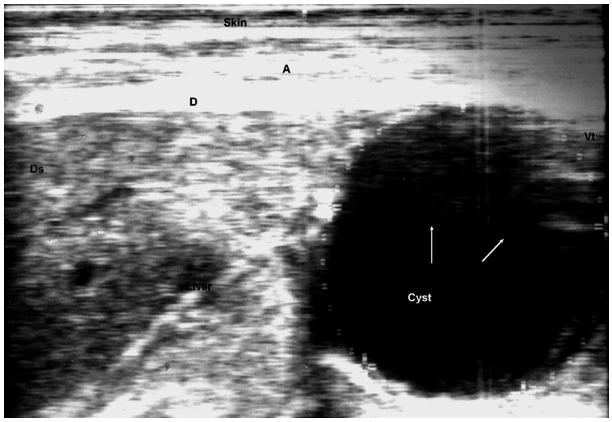

Figure 8. Ultrasonogram of the liver of a 6-year-old sheep viewed from the 10th intercostal space with an 8-MHz linear transducer showing a cyst (ellipse circumference = 10.05 cm) with well-defined borders and fine echogenic contents representing hydatid sand (white arrows). A: abdominal wall, D: diaphragmatic surface, Ds: dorsal, Vt: ventral.

as a result of pressure damage caused by hydatid cysts on the liver tissue, whereas increased serum levels of total bilirubin, decreased albumin, and lowered albumin globulin ratios might be due to impaired liver function. Previously, Barnes et al. (24) stated that hydatid cysts grow progressively and increase in size and weight, producing pressure atrophy of the parasitized organ, displacement of adjacent tissues, and functional alterations of varying degrees. Furthermore, growing hepatic cysts may interfere with the bile flow, causing cholestasis.

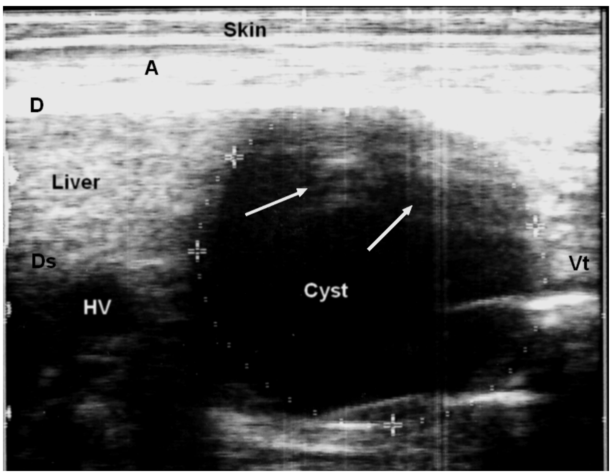

Figure 7. Ultrasonogram of the liver of a 4-year-old sheep viewed from the 9th intercostal space with an 8-MHz linear transducer showing a cyst (ellipse circumference = 10.05 cm) with ill-defined borders and echogenic particulate contents (white arrows). A: abdominal wall, D: diaphragmatic surface, HV: hepatic vein, Ds: dorsal, Vt: ventral.

In ruminants, liver function tests are not specific for diagnosis of liver diseases. Metabolic disorders lead to diffuse changes in the liver, whereas abscesses, cysts, and tumors usually induce focal changes (25). Hepatic function tests are generally unable to distinguish these diseases (23). In contrast to liver function tests, ultrasonography is a quick, noninvasive, and well-tolerated technique for the diagnosis of cystic hepatic disease in the field (12,14).

In the present study, in both healthy and diseased sheep, livers were examined via ultrasonography from the 12th to the 7th ICSs, except in 1 healthy sheep where ultrasonographic examination was not possible as the 12th ICS was too narrow. In sheep with hepatic cysts, increased echogenicity of the liver may be due to changes in the nature of the liver tissue, which may increase the attenuation of the ultrasound beams. This postulation was supported previously by Szebeni et al. (26), who found that the average attenuations of ultrasound beams in bright livers and normal livers were 1.21 ± 0.06 dB/cm per MHz and 0.68 ± 0.03 dB/cm per MHz, respectively. In comparison with the control sheep, there was a significant increase of the ventral margin of the liver in diseased sheep at the 10th ICS, though it is difficult to generalize this finding as, previously, Braun and Hausammann (17) tabulated the ventral margin at the 10th ICS of healthy sheep as ranging from 20.7 to 39.5 cm.

At the 10th ICS, the significant increase of liver size, thickness, and angle in sheep with hepatic cysts might be due to hydatid cyst growth. In a previous study, Barnes et

Table 4. Ultrasonographic findings of caudal vena cava, portal vein, and gall bladder of sheep in 2 liver health groups (n = 22).

Variable	Liver health group	Intercostal space			
		12	11	10	9
Caudal vena cava Dorsal margin[1]	Cystic liver (n = 9)	8.6 ± 0.63	11.4 ± 0.63	13.8 ± 0.66	16.0 ± 0.62
	Healthy liver (n = 13)	7.6 ± 0.68	10.3 ± 0.56	12.7 ± 0.54	16.2 ± 0.53
Depth (cm)	Cystic liver (n = 9)	5.1 ± 0.28	5.4 ± 0.17	5.4 ± 0.13	6.1 ± 0.19
	Healthy liver (n = 13)	5.2 ± 0.24	5.1 ± 0.27	6.1 ± 0.29	6.6 ± 0.24
Diameter (cm)	Cystic liver (n = 9)	1.4 ± 0.06	1.5 ± 0.08	1.7 ± 0.10	1.7 ± 0.05
	Healthy liver (n = 13)	1.5 ± 0.04	1.6 ± 0.04	1.8 ± 0.03	1.8 ± 0.03
Portal vein					
Dorsal margin[1]	Cystic liver (n = 9)	11 ± 0.8	13.3 ± 0.74	13.7 ± 0.87	16.7 ± 0.51
	Healthy liver (n = 13)	12 ± 0.7	12.8 ± 0.65	14.5 ± 0.59	17.2 ± 0.69
Depth (cm)	Cystic liver (n = 9)	3.7 ± 0.21	3.7 ± 0.15	4.0 ± 0.17	3.8 ± 0.14
	Healthy liver (n = 13)	4.5 ± 0.32	4.1 ± 0.13	4.1 ± 0.16	3.9 ± 0.14
Diameter (cm)	Cystic liver (n = 9)	1.8 ± 0.09	1.8 ± 0.12	1.2 ± 0.06**	1.2 ± 0.05
	Healthy liver (n = 13)	1.9 ± 0.04	1.7 ± 0.05	1.5 ± 0.03	1.2 ± 0.02
Gall bladder					
Dorsal margin[1]	Cystic liver (n = 9)	NA	NA	16 ± 0.58**	27 ± 0.35**
	Healthy liver (n = 13)	NA	NA	12 ± 0.13	23 ± 0.28
Circumference (cm)	Cystic liver (n = 9)	NA	NA	12 ± 1.0	11 ± 1.1**
	Healthy liver (n = 13)	NA	NA	13 ± 0.9	16 ± 0.3

[1]Centimeters distal to the midline of the back. Values presented as mean ± SE, **: $P < 0.01$, NA = not applicable.

al. (24) found increased size and weight of liver as a result of growth of hydatid larvae. Braun and Hausammann (17) concluded that increased liver size in sheep could be suspected when the liver thickness in a single ICS was >8.5 cm. Ultrasonographically, hepatic cysts were rounded or oval with well- or ill-defined borders. Generally, the contents of hepatic cysts were anechoic, although the interior of some cysts contained either echogenic particulate materials, which may correspond to hydatidic gallstones' fine echoes and may represent the hydatid sand, or septations, which may produce a daughter cyst. These findings are in agreement with those of Von Sinner (27), who described the hepatic cysts as completely or partially calcified. Furthermore, Taylor et al. (28) found that growth of hydatid cysts was progressive with the arising of septae and budding of numerous daughter cysts.

In the current study, the significant decrease of the portal vein diameter at the 10th ICS could be attributed to the compression caused by hepatic cysts, as out of 9 cases with hepatic cysts, 3 cases showed cysts near the portal vein (Figure 2). In a previous study, Cebra et al. (29) described dilatation and stricture of intrahepatic vessels in cattle with hepatic lipidosis. In diseased sheep, the increased dorsal margin of the gall bladder at both the 10th and 9th ICSs might be due to displacement of the gall bladder and the pressure caused by liver cysts. In this work, although the circumference of the gall bladder was significantly decreased in sheep with liver cysts at the 9th ICS, it is difficult to conclude that the size was lowered; this is because the circumference of the gall bladder changes daily as described previously (20). Ultrasonography can be used in the diagnosis of hepatic CE because it allows for identification of the affected organ as well as the topographic relationship of the cysts.

In this study, the presence of one sheep as a false negative caused a lowering of the sensitivity of the ultrasounds. This could be attributed to the cysts in this sheep being located in the left lobe of the liver, an area not accessible to ultrasound detection (12). The results in the present study showed higher sensitivity of ultrasound for diagnosis of CE than previous results (sensitivity = 57.36%) obtained by Sage et al. (14). Such a difference may be due to variations in the number of animals that were false negatives. In the current study, furthermore, as a result of owners' disagreements over the slaughtering of the rest of the infected animals (4 sheep) for economic and zootechnic reasons, they were treated with oral oxfendazole (Synthatec, 22.5% solution) at 30 mg kg^{-1} day^{-1} (30). Unfortunately, these animals were discharged from the hospital and we did not have the opportunity to follow them for evaluation of treatment.

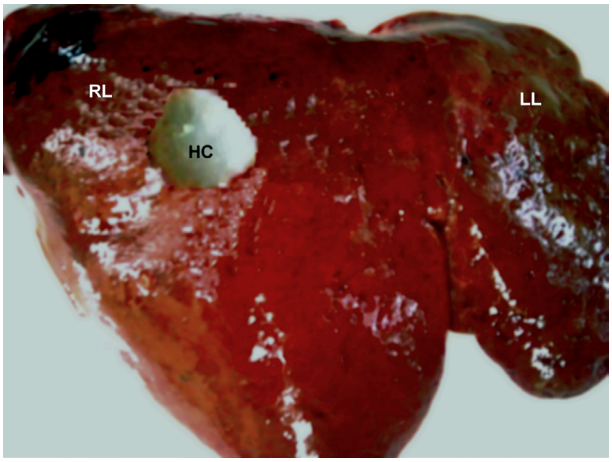

Figure 9. A hydatid cyst located near the right lobe of a sheep liver at postmortem examination. HC: hydatid cyst, LL: left lobe, RL: right lobe.

In conclusion, although this study was conducted on a limited number of animals, the data obtained may contain some illuminating results signifying that hydatid cysts cause some alterations in the liver features that could be easily recognized by ultrasound. In addition, ultrasonography is a sensitive method for diagnosis of hepatic CE; therefore, as an objective noninvasive practical tool, ultrasonography alone or in combination with testing of biochemical parameters reflecting liver function could be helpful for the diagnosis of CE of the liver in sheep.

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