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Ultrasonographic assessment of liver and spleen in Jamunapari goats

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Twenty normal, healthy, adult Jamunapari goats were subjected to ultrasonographic imaging of the liver and spleen along with their associated structure and vasculature. Doppler ultrasonography of the portal vein and caudal vena cava was also done. The liver was visible in the 7th through 12th intercostal space (ICS) on the right thorax. The parenchyma was homogenously echogenic. The measurements of the distance of dorsal visible margin (DVM) and the ventral visible margin (VVM) of liver from the dorsal mid-line were recorded. The mean±SE value of visible size of liver was greatest at 9th ICS (11.23±0.12 cm) and smallest at 12th ICS (7.50±0.11 cm). The thickness of liver was greatest (5.76±0.11 cm) at 11th ICS and least (4.79±0.04 cm) at 12th ICS. The gallbladder was visible through 10th ICS on the right side of thorax and appeared in various shapes such as spherical, oval, or pear-shaped. The portal vein appeared as an anechoic structure, having hyperechoic wall. The caudal vena cava (CVC) appeared as a triangular anechoic structure, deeper and medial to portal vein. The mean±SE value of circumference of the CVC was 5.45±0.16 cm. The mean velocity in the CVC and the portal vein were 25.92±2.7 cm/s and 34.15±4.4 cm/s, respectively. The spleen was visible from 9th through 12th ICS in the left side of thorax, running caudo-dorsally to cranio-ventrally with a uniformly echogenic parenchyma. The distance of the DVM of spleen from the dorsal midline was largest in 9th ICS (11.93±0.36 cm) and smallest in 12th ICS (6.26±0.23 cm). The distance of VVM of spleen from the dorsal midline was largest in 9th ICS (17.66±0.03 cm) and smallest in 12th ICS (5.17±0.15 cm). The size of spleen was greatest in 10th ICS (7.26±0.09 cm) and least in 12th ICS (5.17±0.15 cm). These sonographic measurements of liver, gall bladder, portal vein, caudal vena cava, and spleen may serve as reference values and be helpful in faster detection of many hepatic and splenic ailments.

***Key words**: Jamunapari goats, Liver, Spleen, Ultrasonography*

Ultrasonography has become a reliable and non-invasive way to find liver illness in a variety of animals. It can be used to diagnose conditions like fasciolasis, hepatic neoplasia, hepatic congestion, bile duct mineralization, and disorders of the main vasculature (Braun, 1990; Braun, 1996; Streeter and Step, 2007). Ultrasonography is a practical, easy-to-use, and non-invasive technique for assessing a goat's spleen. When diagnosing splenic lesions in healthy goats, the size and appearance of the spleen serve as reference values (Braun and Steininger, 2010). Doppler sonography makes it possible to quickly see the portal vein and verify the patency of the hepatic venous and arterial vessels (Killi, 1999). The morphology and echogenecity of the liver are revealed by ultrasonography, which also proves to be a helpful technique in measuring the weight of the liver (Belotta et *al.*, 2018). The majority of sonographic abnormalities related to liver disorders, which can be identified by ultrasonography, are characterized by tissue echogenicity (hypoechoic, isoechoic, hyperechoic), as well as distribution (diffuse, focal, multifocal). In addition to surface shape or contour changes and the existence of acoustic enhancement or acoustic shadowing, the size and form of the liver, gall bladder, hepatic vasculature, and hepatic duct, if visible, may also be assessed (Lamb, 1995; Selcer et *al.*, 1995). Ultrasonography has been well documented and was frequently utilized to assess the spleen in dogs (Nyland *et al.*, 2002), horses (Reef, 1998), and cattle (Sicher, 1995; Braun and Sicher, 2006). The objective of the present study was to perform ultrasonographic assessment of liver and spleen in normal Jamunapari goats.

Materials and Methods

Twenty normal healthy adult female Jamunapari goats were used in the study. The physiological parameters such as temperature, respiratory rate, heart rate, and body weight were recorded before the sonographic examination. A 2-5 MHz convex transducer with the Aeroscan CD-10 ultrasound system (Konica Minolta) was used for B-mode scanning and Doppler sonography.

A large area (bound dorsally by spinous process of vertebrae, ventrally by right paramedian area, cranially by 7th rib and caudally by part caudal to last rib) on the right side of thorax of the animal was clipped and shaved. Similarly, for examination of spleen, a sufficiently large area on the left side of thorax was clipped and shaved from 9th to 12th ICS.

Sonographic examination was performed with the goats standing or in lateral recumbency. For liver, scanning was done from 12th ICS to 7th ICS with the transducer parallel to the ribs closest to the level of the lateral process, the transducer was gradually moved within the ICS ventrally. When the liver was

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visualised, the distance from dorsal midline up to the point where the dorsal visible margin of liver was visualised, was recorded with a measuring tape (Fig. 1). Observations about parenchymal pattern, echotexture, vasculature etc. were recorded until the ventral visible margin of the liver came into view. The distance from the dorsal midline up to the point where the ventral visible margin was visualised was noted. The extent of liver visible between the dorsal visible margin and the ventral visible margin of liver was arrived at by subtracting the distance of the ventral visible margin and the dorsal visible margin from the dorsal midline.

The thickness of the liver at each ICS was calculated by in-built sonographic calipers. The thickness of liver parenchyma over the portal vein and caudal vena cava, and the circumference of caudal vena cava were measured by in-built sonographic calipers. This procedure was followed to scan through each ICS. The ICS where the gall bladder was visualized was identified, and the echo pattern of the same was seen. The length, width, and wall thickness of the gall bladder were recorded with the in-built sonographic calipers.

For scanning the spleen, the transducer was placed on the left aspect of the abdomen from the 12th to 9th ICS, and the transducer was placed in the manner similar to that for scanning the liver. The parenchyma pattern of the spleen was observed and recorded. The distance of dorsal and ventral visible margins of the spleen from the dorsal midline of spine were measured with the help of a measuring tape in the manner similar to that observed for the liver (Fig. 2). The extent of spleen at each ICS was calculated by subtracting the dorsal visible margin distance from ventral visible margin distance. The thickness of the spleen at each ICS was calculated by in-built sonographic calipers.

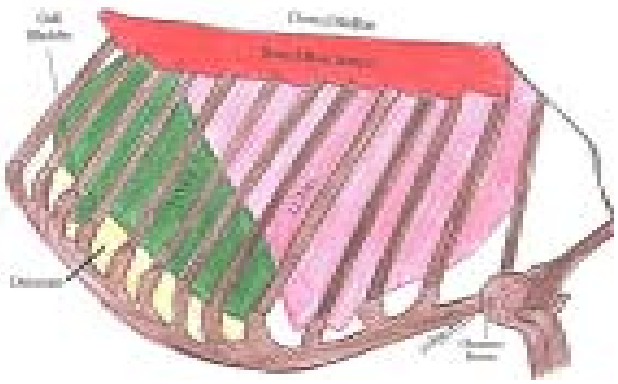

Fig. 1: Schematic diagram of the right thorax of a goat showing locations for scanning the liver.

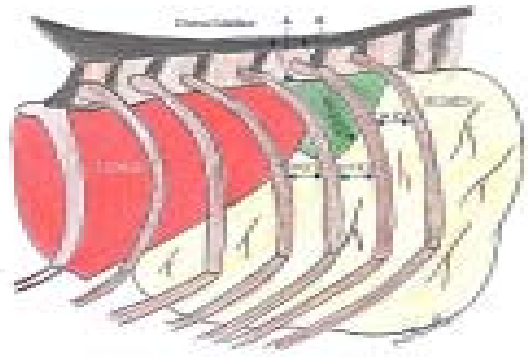

Fig. 2: Schematic diagram of the right abdomen of a goat showing locations for measurements.

During ultrasonographic scanning of portal vein and vena cava, colour Doppler and pulse wave Doppler study was performed after designating the spectral gate and the Doppler indices such as peak systolic velocity (Vp), end diastolic velocity (Vd), mean velocity (Vm), pulsatility index (PI) and resistivity index (RI) were recorded in all goats through in-built ultrasound software.

Results and Discussion

The sonographic imaging was done in a standing position after clipping and shaving of hair on the proposed site of scanning without the use of any sedative or analgesic drug. The same method of restraining has been used by Soroori *et al*. (2008), Kandeel *et al*. (2009), Braun and Steininger (2010), Braun *et al.* (2011), Braun *et al.* (2013), Balasundaram and Sivagnanam (2021) in goats, and Yamaga (1983) in domestic farm animals including goats.

The liver was scanned on the right side of the thorax from 7th to 12th ICS, where it was visible and well defined. Kandeel *et al.* (2009) and Yadav *et al.* (2021) have also scanned the liver from 7th ICS to 12th ICS in sheep and goats and Beetal goats, respectively. However, Soroori *et al.* (2008) scanned the liver in goats from 6th to 12th ICS on the right abdominal wall. Braun *et al.* (2011) could scan the liver in goats from 5th to 12th ICS, but it was more clearly defined from 7th to 10th ICS. In another study, Braun *et al.* (2013) visualised the liver from 5th to 6th ICS.

In this study, the echotexture of the liver parenchyma consisted of many tiny echoes homogenously distributed throughout the liver (Fig. 3). The same findings were reported by Braun *et al.* (2013), Soroori *et al*. (2008), Yadav *et al.* (2021). When the transducer was placed caudal to the 13th rib, the echogenicities of the liver and kidney could be compared. The liver appeared to be slightly more hyperechoic as compared to the kidney, as also reported by Soroori *et al.* (2008) in goats. El-Khodery et *al.* (2011) have reported that the liver parenchyma appeared diffusely hyperechoic in hyperlipidosis of the liver in Zaraibi goats.

The distances of the dorsal and ventral visible margins from the dorsal midline were largest (20.23±0.18 cm and 30.42±0.32 cm) in 7th ICS, and were least (7.07±0.06 cm and 14.57±0.04 cm) in 12th ICS (Table 1). In a study, Braun *et al.* (2013) have reported that both dorsal visible margin and ventral margin

Table 1: Mean±SE values (cm) of distance from the dorsal midline to the site of visibility of the dorsal and ventral visible margins of liver and size of the visible part of liver of liver at various ICS in 20 Jamunapari goats

Sl. No.	ICS	Dorsal Visible Margin	Ventral Visible Margin	Size
1.	7th	20.23 ± 0.18	30.42 ± 0.32	10.19 ± 0.13
2.	8th	15.26 ± 0.14	25.85 ± 0.67	10.58 ± 0.5
3.	9th	11.99 ± 0.31	23.22 ± 0.18	11.23 ± 0.12
4.	10th	9.15 ± 0.03	18.82 ± 0.11	9.67 ± 0.14
5.	11th	7.96 ± 0.15	16.61 ± 0.18	8.65 ± 0.17
6.	12th	7.07 ± 0.06	14.57 ± 0.04	7.50 ± 0.11

distances were largest in 5th ICS and smallest in 12th ICS. The expanse of liver was largest (11.23±0.12 cm) in 9th ICS. Soroori *et al.* (2008) reported that the visible expanse of liver was largest in 10th ICS, and Braun *et al.* (2013) reported that the largest extent of liver was seen in 7th and 8th ICS. The thickness of the liver was greatest (5.76±0.11 cm) at 11th ICS and smallest (3.61±0.17 cm) at 7th ICS (Table 2). Braun *et al.* (2013) have reported that the liver thickness was greatest in 10th ICS.

Table 2: Mean±SE values (cm) of sonographic measurements of thickness of liver at various ICS in 20 Jamunapari goats.

Sl. No.	ICS	Thickness
1.	7th	3.61 ± 0.17
2.	8th	5.0 ± 0.14
3.	9th	5.61 ± 0.09
4.	10th	5.74 ± 0.21
5.	11th	5.76 ± 0.11
6.	12th	4.79 ± 0.04

Fig. 3: B-mode ultrasonogram showing liver parenchyma having an interface with lung on dorsal side and omasum on ventral side by a thin echogenic line.

The portal vein was visible as an anechoic structure, having hyperechogenic walls from 7th to 10th ICS. Classic stellate ramifications of the portal vein were visible, extending into the liver parenchyma. It had an oval or circular shape when viewed in cross section, and was present ventral to the caudal vena cava (Fig. 4). Similar findings were reported by Kandeel *et al.* (2009), and Braun and Steininger (2013), however, Soroori et *al.* (2008) have reported that the visibility of the portal vein was not clear in 6th and 7th ICS.

Fig. 4: B-mode ultrasonogram of liver showing triangular non-echogenic caudal vena cava (CVC) and portal vein (PV).

The thickness of liver over the portal vein in the present study was 2.49±0.08 cm; however, Soroori *et al*. (2008) have reported it to be in the range of 2.12±0.29 to 2.81±0.19 cm. The thickness of liver over the caudal vena cava in this study was 3.12±0.2 cm; whereas Soroori *et al*. (2008) in their study have reported it as 2.97±0.7 cm. Braun and Hausammann (1992) have suggested while scanning alpine sheep that an increase in liver size may be suspected when the liver extends >25 cm into first ICS or is >8.5 cm thick. They have further suggested that when the diameter of the caudal vena cava in 10th ICS is > 2.7 cm and the diameter of the portal vein is > 2.0 cm, dilatation from congestion may be suspected.

For the portal vein, the mean±SE values for Doppler indices, namely peak systolic velocity (Vp) was 44.29±6.0 cm/s, end diastolic velocity (Vd) was 28.47±3.5 cm/s and mean velocity (Vm) was 34.15±4.4 cm/s. The pulsatility index (PI) was 0.38±0.03 while the resistivity index (RI) was 0.3±0.02.

The caudal vena cava (CVC) was visualized as a triangular anechoic structure, and it was present medially to the portal vein at a greater depth. It was seen well in at least one of the ICSs from 8th to 12th. The wall was less echogenic than the portal vein. Similar findings of CVC have been reported by Yamaga *et al.* (1983), Soroor et *al.* (2008), Kandeel *et al.* (2009), Braun *et al.* (2011), and Braun *et al.* (2013) in healthy goats;

and the CVC was well visualised in 11th or 12th ICS with the visibility of 75%. For CVC, the mean±SE values for Doppler indices namely peak systolic velocity (Vp), end diastolic velocity (Vd), mean velocity (Vm), pulsatile index (PI) and resistivity index (RI) in all goats were 27.99±5.12, 20.95±4.9, 25.92±2.7, 0.51±0.01, 0.38±0.09, respectively.

The gallbladder was spherical, oval, or pear-shaped, and depending on the quantity of bile, it occasionally expanded past the liver's ventral edge. There was always an echoic wall surrounding the hypoechoic content (Fig. 5). It was seen in 10th ICS on the right side in all goats. Yamaga *et al.* (1983) reported having seen it in 9th and 10th ICS; Kandeel *et al.* (2009) visualized it in the last 2 to 3 ICSs. Braun and Steininger (2011) have reported great variation in the width and length of the gall bladder and even non-visibility of the gall bladder in goats due to its physiological emptying during feeding and rumination.

Fig. 5: B-mode ultrasonogram showing gall bladder as an oval structure along with its cystic duct (red line).

The spleen was always visible on the left side of the thorax between 9th and 12th ICS. All of the spleen could be visualized on the left dorsolateral aspect of the abdomen. The texture of the spleen's parenchyma was homogenously echogenic. In the parenchyma, the splenic vessels were visible as round to oval hypoechoic structures in cross section and as elongated hypoechoic structures in longitudinal section (Fig. 6). Balasundaram and Sivagnanam (2021), Braun and Steininger (2010), Braun *et al.* (2013) and Yamaga *et al*. (1983) have also reported similar findings. In goats, the spleen is limited to the dorsolateral region of the costal part of the left abdominal wall. Because of its location, the caprine spleen is not predisposed to diseases caused by penetrating reticular foreign bodies as in cattle (Braun, 2003).

The distance of the dorsal visible margin of the spleen from the dorsal midline was largest (11.93±0.36 cm) in 9th ICS and smallest (6.26±0.23 cm) in 12th ICS.

Fig. 6: B-mode ultrasonogram of the spleen with a clearly distinct interface with the lung and rumen by a thin echogenic line.

The distance of the ventral visible margin of the spleen from the dorsal midline was largest (17.66±0.03 cm) in 9th ICS and smallest (11.71±0.45 cm) in 12th ICS (Table 3). The same findings were reported by Balasundaram and Sivagnanam (2021). Braun and Steininger (2010) concluded that the distance of the dorsal visible margin of the spleen from the dorsal midline was largest in 8h ICS and smallest caudal to the last rib. The thickness of the spleen was greatest (6.5±0.19 cm) at 10th ICS and least (4.0±0.17 cm) at 12th ICS. The size of the spleen in this study was largest (7.26±0.09 cm) in 10th ICS, whereas it was least (5.17±0.15 cm) in 12th ICS, while Braun and Steininger (2010) reported in their study that the size was largest in 11th ICS.

Table 3: Mean±SE values of distances of dorsal and ventral visible margins from the dorsal midline and the thickness of spleen in 20 Jamunapari goats.

Inter-costal Space	Dorsal Visible Margin (cm)	Ventral Visible Margin (cm)	Size (cm) (cm)	Thickness
9th	11.93±0.36	17.66±0.03	5.73±0.39	4.4±0.24
10th	10.03±0.03	17.29±0.06	7.26±0.09	6.5±0.19
11th	7.94±0.34	14.91±0.26	6.975±0.07	6.4±0.16
12th	6.26±0.23	11.71±0.45	5.17±0.15	4.0±0.17

To conclude, ultrasound is a very useful, non-invasive imaging technique for visualization of the liver, its vasculature, and spleen in standing position without any discomfort in goats and the use of any anaesthetic or sedative agent. The liver can easily be scanned from 7th to 12th ICS on the right side of the thorax, whereas the spleen can be scanned from 9th to 12th ICS on the left side of the thorax. The sonographic measurements of liver, gall bladder, portal vein, caudal vena cava, and spleen may serve as reference values and be helpful in faster detection of many hepatic and splenic ailments.

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