

Original Article

The Efficacy of Ultrasonographic Diagnosis in Assessing Causes of Ascites in Dogs

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ABSTRACT

Background: Ascites refers to the accumulation of fluids in the abdomen, leading to abdominal enlargement and complications of the peritoneal cavity.

Objectives: This study aimed to evaluate the diagnostic efficacy of ultrasonography in identifying the causes of ascites in hybrid dog breeds.

Methods: The current retrospective cross-sectional study involved 21 dogs of hybrid breeds (12 males and 9 females) with an Mean±SD age of 6.70±0.49 years and a Mean±SD weight of 24.37±3.65 kg. In a radiology ward, a radiologist examined the dogs by conducting an abdominal cavity ultrasound to diagnose and report the cause of ascites. Notably, the radiologist knew nothing about the history, clinical symptoms, and laboratory findings regarding the dogs. After the definitive cause of ascites was determined, the result was compared with the ultrasonographic diagnosis, calculating its sensitivity, specificity, and accuracy.

Results: Liver diseases, renal conditions, and malignancies were identified as the most common causes of ascites. Based on the results, ultrasonographic diagnosis revealed the following specifications: 97.8% specificity, 91.1% sensitivity, 94.4% accuracy, 97.8% positive predictive value, and 91.1% negative predictive value.

Conclusion: In general, the research results indicate that ultrasonography can serve as a primary tool for diagnosing the early stages of ascites. In a few cases where diagnosis of the underlying cause proves challenging, this method helps reach a subsequent diagnosis, except in cases involving liver and renal complications. Also, ultrasonographic diagnosis gets around invasive techniques such as sampling and laparoscopy, reducing the hospitalization period, hospital costs, and patient stress and also facilitating the medical process.

Keywords: Ascites, Dogs, Sensitivity, Specificity, Ultrasonography

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Introduction

Ascites refers to the accumulation of fluids in the abdomen, mainly presenting with abdominal enlargement, shortness of breath, and peritoneal cavity complications (Adam et al., 2022). Chronic liver diseases such as cirrhosis, kidney complications, cardiovascular disorders, and improper nutrition are the primary causes of ascites in canines (Schmiedt et al., 2001; Badi et al., 2022). Although the exact mechanism of ascites is unknown, most theories point to portal hypertension (increased pressure in the liver blood flow) as the main culprit.

Usually, ascites is classified into 2 types: Transudate and exudate, based on the protein content in ascites fluid. Another classification method compares the amount of albumin in the ascites fluid with that in the blood serum. Elevated portal blood pressure and reduced blood albumin concentration might result in a pressure gradient, leading to abdominal ascites (Mazzaferro & Edwards, 2020; Ribeiro, 2020).

Animals with ascites may encounter challenges in eating, drinking, and mobility. Also, with the accumulation of fluid around the lungs, breathing becomes difficult. Other complications of ascites may include discomfort and pain in the abdominal area, infection, hernia, accumulation of fluid in the chest, and hepatorenal syndrome (Kyles et al., 2001). Some other causes of ascites comprise increased blood pressure gradients, congestive heart failure, and chronic kidney diseases that cause general fluid retention in the body (Ward et al., 2019).

In some cases, vascular obstruction of the liver portal increases blood pressure in this system (Zwingenberger et al., 2014). This obstruction in the hepatic portal vessels may be due to pressures on these vessels from the outside, such as tumors or enlarged masses, or from internal, such as thrombosis or various embolisms (Mays & Phillips, 2021). Ascites may also be seen after some neoplasia. This type of ascites can be caused by gastrointestinal, lungs, breasts, genitalia, and lymphatic system neoplasia (O'Neill, 2020; Elpiner, 2020). Ascites caused by pancreatic diseases may be seen in animals with subacute or chronic pancreatitis. Pancreatic ascites can also be caused by acute pancreatitis as well as pancreas trauma (Törner et al., 2020).

The diagnostic assessment of an animal with ascites may include a complete blood count, biochemical evaluation, abdominal paracentesis, biochemical and cytolog-

ical analyses of the resultant fluids, radiography, biopsy, and organ function tests. A thorough physical examination invariably precedes further diagnostic tools (Rossmeisl, 2003).

Ultrasound represents an accessible, affordable, and non-invasive method with no ionizing radiation risk. Since there has been no research on the specificity, sensitivity, accuracy, and positive and negative predictive value of this diagnostic method in determining the cause of ascites in dogs, we decided to conduct this study and fill the knowledge gap. The results acquired in this study serve as valuable insights for interpreting the findings and informing clinical decisions.

Materials and Methods

Study design and animal populations

In this retrospective cross-sectional study, 21 dogs of hybrid breeds, comprising 12 males and 9 females, were included. The dogs had a Mean±SD age of 6.70±0.49 years and a Mean±SD weight of 24.37±3.65 kg.

Methodology description

Every dog underwent an ultrasound of the abdominal cavity to assess the cause of ascites. Importantly, the radiologist knew nothing about the dogs' history, clinical symptoms, and laboratory findings. The cause of ascites was diagnosed definitively through various methods such as abdominal fluid paracentesis, laboratory tests, biopsy, laparoscopy, and laparotomy.

Processing and ultrasound examination

After the definitive diagnosis of the cause of ascites, the result was compared with the diagnosis based on ultrasound to evaluate the sensitivity, specificity, and accuracy of the result. These parameters were obtained from the following formulas:

$$\text{Sensitivity} = \frac{\text{True Positive}}{\text{True Positive} + \text{False Negative}}$$

$$\text{Specificity} = \frac{\text{True Negative}}{\text{True Negative} + \text{False Positive}}$$

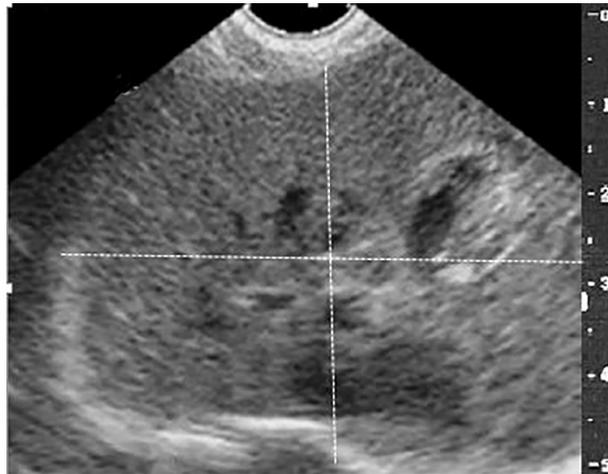


Figure 1. Sagittal sonogram of left liver lobe in an 8-year-old hybrid female dog

Non-cystic cavity lesions accompanied by an increase in parenchymal echogenicity are seen.

$$\text{Accuracy} = \frac{\text{True Positive} + \text{True Negative}}{\text{True Positive} + \text{True Negative} + \text{False Negative} + \text{False Positive}}$$

$$\text{Positive Predictive Value (PPV)} = \frac{\text{True Positive}}{\text{True Positive} + \text{False Positive}}$$

$$\text{Negative Predictive Value (NPV)} = \frac{\text{True Negative}}{\text{True Negative} + \text{False Negative}}$$

Statistical analysis

The obtained data were analyzed employing one-way ANOVA (in SPSS software, version 22) and subjecting them to Tukey’s honest significant difference (HSD) test.

All values were expressed as the Mean±SE, and P≤0.05 was used as statistical significance. All data presented are the mean of three replicates.

Results

Prevalence of ascites

According to the results, the most prevalent causes of ascites were liver diseases (29.01%), malignant diseases (15.44%), renal diseases (13.88%), and infectious diseases (13.88%). Table 1 presents the prevalence rates of the diseases.

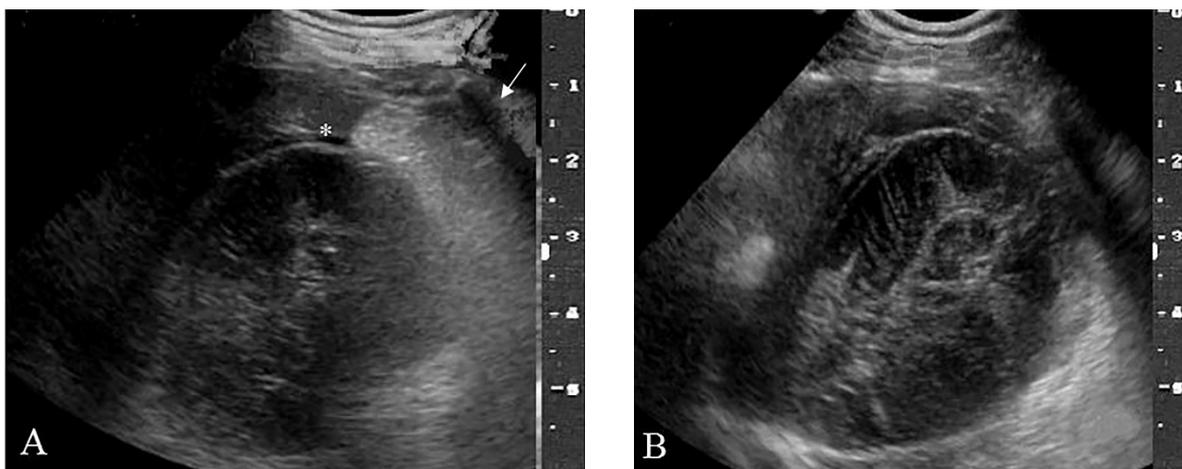


Figure 2. Transverse (A) and long-axis (B) images in a dog with a mucocele and gallbladder interior necrosis, with a biliary leakage

The mesentery (arrow) surrounds part of the gallbladder, whereas the increased echogenicity is associated with the inflamed mesentery. Additionally, a focal effusion is noted in A (asterisk).

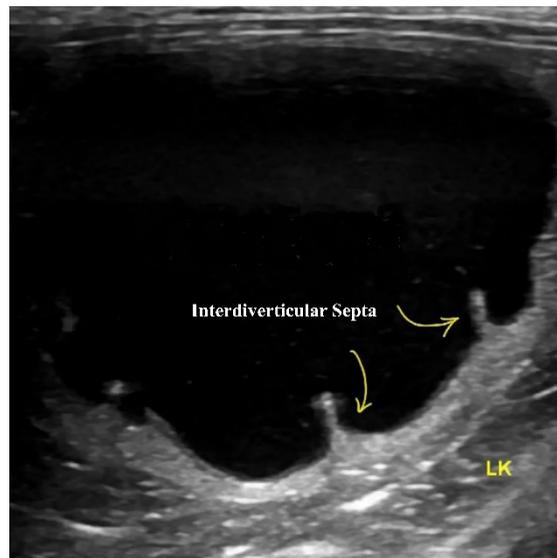


Figure 3. Hydronephrosis due to obstructive ureterolithiasis

The kidney appears as a fluid-filled cavity with peripheral hyperechoic bands consistent with interdiverticular septa.

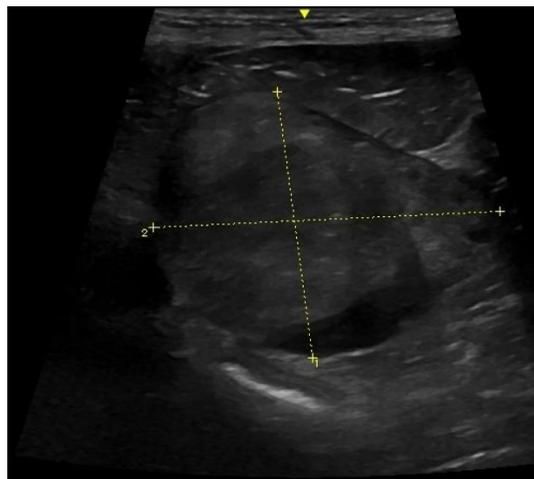


Figure 4. Hepatocellular carcinoma in a 15 years hybrid dog

Definitive diagnosis with paraclinical tests. The presence of hepatocyte clusters with varying cell sizes, nuclei, and an increased ratio of nucleus to cytoplasm and large nucleolus.

Sensitivity and accuracy

The sensitivity and accuracy of ultrasound were observed as follows: 100% and 99% in liver diseases, 90.4% and 98.7% for malignant diseases, 100% and 100% for renal and cardiovascular diseases, and 64% and 100% for infectious diseases, respectively. For liver diseases, sensitivity was 100%, specificity 99%, positive predictive value (PPV) 97.7%, and Negative Predictive Value (NPV) 100% (Figures 1 and 2). In kidney disease, all 5 parameters, including sensitivity, specificity, accuracy, PPV, and NPV were 100%. An increase or decrease in kidney size (acute or chronic disease process) and in-

creased parenchymal echo were characteristic symptoms of kidney disease, and no misdiagnosis was observed in any case (Figure 3).

In heart failure, all five parameters were determined as 100%. In infectious disease, sensitivity was 64%, specificity 100%, accuracy 95.09%, PPV 100%, and NPV 94.6%; the diagnosis was based on secondary symptoms of ascites.

For bleeding cases, all five parameters were 100%; the diagnosis relied on identifying the free intraperitoneal

Table 1. Distribution of patients according to the etiology of ascites

Diseases	No. (%)		
	Female (n=9)	Male (n=12)	Total (n=21)
Liver disease	3(33.33)	3(24.70)	6(29.01)
Malignant disease	2(22.23)	1(8.66)	3(15.4)
Kidney disease	1(11.11)	2(16.66)	3(13.88)
Infectious disease	1(11.11)	2(16.66)	3(13.88)
Heart failure	1(11.11)	-	1(11.11)
Bleeding	-	1(8.33)	1(8.33)
Malabsorption disease	1(11.11)	1(8.33)	2(9.72)
Ileus	-	1(8.33)	1(8.33)
Collagen Vascular	-	1(8.33)	1(8.33)
Total	9(100)	12(100)	21(100)

*Significantly at the level of P<0.05

fluid and the presence of small echogenic and floating particles in the peritoneal fluid.

We could not detect the cause of ascites due to malabsorption with ultrasound, so the sensitivity was reported as 0. In malignant diseases, sensitivity was 90.4%, accuracy 97.05%, PPV 95%, and NPV 97.5% (Figure 4). In intestinal obstruction, the diagnosis was made possible

by the severe expansion of loops containing intestinal fluid, so all five parameters were 100% (Tables 2 and 3).

Discussion

According to the results, ultrasound possesses high sensitivity, accuracy, specificity, PPV, and NPV in diagnosing ascites etiology. Examining 17 hybrid dogs, Kull et al. (2001) reported the cause of ascites as a liver

Table 2. Determination of sensitivity, specificity, accuracy, PPV, and NPV in the etiology of ascites in male and female dogs

Diseases	%									
	Sensitivity		Specificity		Accuracy		PPV		NPV	
	Female	Male	Female	Male	Female	Male	Female	Male	Female	Male
Liver disease	100	100	97.9	98.7	98.7	99.3	94.9	95.1	96.9	98.1
Malignant disease	89.7	91.1	98.1	98.7	97.2	97.8	100	100	100	100
Kidney disease	100	100	100	100	100	100	100	100	100	100
Infectious disease	61	67	100	100	95.1	96.7	100	100	94.1	95.1
Heart failure	100	100	100	100	100	100	100	100	100	100
Bleeding	100	100	100	100	100	100	100	100	100	100
Malabsorption disease	-	-	100	100	98.7	99.3	-	-	100	100
Ileus	100	100	100	100	100	100	100	100	100	100
Collagen vascular	-	-	100	100	98.6	99.4	-	-	98.8	99.2

Table 3. Determination of sensitivity, specificity, accuracy, PPV, and NPV in the etiology of ascites in total

Diseases	%				
	Sensitivity	Specificity	Accuracy	NPV	PPV
Liver disease	100	98.3	99	97.5	95
Malignant disease	90.4	98.7	97.05	100	100
Renal disease	100	100	100	100	100
Infectious disease	64	100	95.09	94.6	100
Heart failure	100	100	100	100	100
Bleeding	100	100	100	100	100
Malabsorption disease	-	100	99	100	-
Ileus	100	100	100	100	100
Collagen Vascular	-	100	99	99	-
Total	91.1	97.8	94.4	91.1	97.8

*Statistically significant ($P < 0.05$).

disease with estimated values of the NPV and PPV at 94.1% and 97.3%, respectively. Nyland and Park (1983) calculated PPV and NPV at 95.4% and 93.4%, respectively, in dogs with ascites, a finding consistent with this study's results. However, they only analyzed the ascites in liver and renal failure cases, whereas our research addressed all cases of ascites.

Leduce et al. (2008) explored the causes of ascites due to liver, kidney, and heart diseases and concluded that ultrasound could quickly identify the causes. They introduced ultrasonography as a suitable technique. The present study diagnosed cases of liver disease with a sensitivity of 100%, specificity of 99%, PPV of 97.7%, and NPV of 100%. There was only one mistake related to the malabsorption disease, which was wrongly diagnosed as cirrhosis. In other cases, cirrhosis was diagnosed easily with ultrasound symptoms such as decreased liver size, especially in the right lobe, lateralization of the gallbladder, parenchymal echo change, an irregularity of the liver margin, and the presence of degenerative nodules, facilitating accurate diagnosis of cirrhosis.

In renal disease cases, the reported sensitivity, specificity, accuracy, PPV, and NPV were all 100%, particularly evident by the increase or decrease in the kidney size (depending on the acute or chronic conditions of the disease). The increased parenchymal echo was the most common symptom. Furthermore, there were no errors in any cases.

Heart diseases were considered in cases where the diameter of the lower inferior vein increased. Therefore, through an intercostal or subcostal examination, the heart was evaluated with respect to the pulse strength and size. Remarkably, all five parameters (sensitivity, specificity, accuracy, PPV, and NPV) were determined to be 100%. As observed in three cases of liver, kidney, and heart disease, ultrasonography accurately diagnosed the causes of ascites.

In infectious diseases, the sensitivity, specificity, accuracy, PPV, and NPV of the ultrasound were reported to be 64%, 100%, 95.09%, 100%, and 94.6%, respectively. In these cases, the diagnosis was based on the subsidiary signs of ascites, which will be discussed shortly. However, if these symptoms are undetected, it will be impossible to diagnose the infectious ascites through ultrasonography without clinical and laboratory symptoms. According to the observations, the percentage of cases with subsidiary symptoms was equivalent to the sensitivity percentage. This finding emphasizes the role of subsidiary symptoms in identifying microbial peritonitis.

In bleeding cases, all 5 parameters were reported at 100%, and the diagnosis was mainly based on identifying intraperitoneal fluids and fine echogenic particles floating in the peritoneal fluid. No lesions were observed in any organs.

In cases of malabsorption, ultrasonography failed to diagnose the cause of ascites. There are no standards in ultrasonography for this purpose. Therefore, the “sensitivity” analysis is 0 for malabsorption diagnosis.

In cases of intestinal obstruction, diagnosis with ultrasonography might be difficult. Although sensitivity and PPV were reported as 0 in this study, the presence of polyserositis (pericardial effusion, pleural effusion, and ascites) and the presence of parenchymal kidney disease in some cases might indicate collagen-vascular disease.

In addressing the accuracy of false negative cases, specificity was reported at 100% in this disease, whereas accuracy and NPV were reported at 99% and 99%, respectively. However, only a few patients were studied for intestinal obstruction, collagen vascular disease, bleeding, and malabsorption.

In malignant diseases, sensitivity, accuracy, PPV, and NPV were reported at 90.4%, 97.05%, 95%, and 97.5%, respectively. The diagnosis was possible by observing the hypochoic nodules, target lesions, or mixed lesions in the liver, pseudo-kidney adenopathy, and sometimes observation of a mass in the affected organ that would cause the organ parenchyma to change size and echo.

In our study, there were only two misdiagnoses: A case of metastasis with mistakenly reported lymphoma and a malignancy of the ovary. These two cases were diagnosed without determining their origins. Thus, in two cases, the possibility of malignant complications was determined; however, it was impossible to detect the origin. Therefore, the sensitivity of ultrasonography to detect malignancy as the etiology of ascites was reported 100% regardless of its origin. Nevertheless, sensitivity was reduced to 90.4% regarding the malignancy origin in this study.

Conclusion

Overall, ultrasonography effectively detected the etiology of ascites with a sensitivity of 91.1%, accuracy of 97.8%, PPV of 97.7%, and NPV of 91.1%. Ultrasonography is now used as a complementary method following other interventions, which are primarily invasive. The results of this study also indicate that ultrasonography can be employed as the primary tool for diagnosing early-stage ascites. In a few cases where it was impossible to determine the underlying cause, this method helped reach the subsequent diagnosis, except for cases involving liver and renal complications. However, it circumvents the need for invasive methods such as sampling

and laparoscopy. In addition to facilitating the medical process, the ultrasound technique also reduces the hospitalization period, hospital costs, and patient stress.

Ethical Considerations

Compliance with ethical guidelines

All the study's protocols were approved by the Ethics Committee of the [Faculty of Medical Sciences, Urmia Branch, Islamic Azad University](#) (Code: IR.IAU.UR-MIA.REC.1400.034).

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Authors' contributions

All authors equally contributed to preparing this article.

Conflict of interest

The authors declared no conflict of interest.

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مطالعه پژوهشی

نقش تشخیصی اولتراسونوگرافی در ارزیابی علل وقوع آسیت در سگ‌ها

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چکیده



زمینه مطالعه: آسیت به‌عنوان تجمع مایعات در شکم شناخته می‌شود. مهم‌ترین علائم آن بزرگ‌شدگی شکم و عوارض حفره صفاقی می‌باشد.

هدف: هدف از این مطالعه بررسی نقش تشخیصی اولتراسونوگرافی در ارزیابی علل وقوع آسیت در سگ‌ها می‌باشد.

روش کار: در این مطالعه مقطعی گذشته‌نگر، ۲۱ قلاده سگ از نژادهای مختلف شامل ۱۲ سگ نر و ۹ سگ ماده با میانگین سنی $6/70 \pm 0/49$ سال و میانگین وزنی $24/37 \pm 3/65$ کیلوگرم مورد ارزیابی قرار گرفتند. هریک از این سگ‌ها که به بخش رادیولوژی ارجاع می‌شدند توسط رادیولوژیست تحت اولتراسونوگرافی کامل از محوطه شکمی قرار می‌گرفتند و بدین ترتیب تشخیص علت آسیت گزارش می‌شد. البته رادیولوژیست هیچ اطلاعی از تاریخچه، نشانه‌های کلینیکی و یافته‌های آزمایشگاهی نداشت. بعد از اینکه تشخیص قطعی علت آسیت مشخص می‌شد با تشخیص اولتراسونوگرافی مقایسه و حساسیت، ویژگی و دقت آن بررسی می‌شد.

نتایج: بیشترین علت بروز آسیت ناشی از بیماری‌های کبدی، کلیوی و بدخیمی‌ها بود. ویژگی کلی در تعیین علت بروز آسیت $97/8$ درصد، حساسیت $91/1$ درصد، دقت $94/4$ درصد، ارزش پیش‌بینی مثبت $97/8$ درصد و ارزش پیش‌بینی منفی $91/1$ درصد بود.

نتیجه‌گیری نهایی: براساس این مطالعه، سونوگرافی می‌تواند به‌عنوان ابزار اصلی در تشخیص مراحل اولیه آسیت استفاده شود. در مواردی که نمی‌توانیم علت اصلی را تشخیص دهیم، این روش به استثنای عوارض کبدی و کلیوی، در تشخیص بعدی کمک می‌کند. ضمن آن که از روش‌های تهاجمی مثل نمونه‌برداری، لاپاروسکوپی و غیره جلوگیری می‌کند و بدین ترتیب باعث کاهش دوره درمان، کاهش استرس بیمار و تسهیل کار دامپزشک معالج می‌شود.

کلیدواژه‌ها: آسیت، سگ‌ها، حساسیت، ویژگی، اولتراسونوگرافی

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