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ORIGINAL RESEARCH

Clinical Study on the Combined Application of Ultrasound Probes to Improve the Diagnostic Value of Adenomyosis at the Bottom of the Gallbladder

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Objective: This study aims to assess the diagnostic efficacy of using a combination of ultrasonic probes including convex array probe, linear array probe, and intracavitary probe, for the detection of adenomyosis at the gallbladder fundus.

Methods: A total of 121 outpatients with suspected diagnosis of gallbladder adenomyosis were enrolled in this study. All patients underwent conventional ultrasound examination of gallbladder floor with convex array probe, linear array probe and intraluminal probe. The thickness, length and internal echo characteristics of the lesions were recorded in detail.

Results: The mean size of adenomyosis at the gallbladder fundus was found to be 1.177 ± 0.775 cm across the 121 individuals studied. The convex array probe successfully detected adenomyosis in 87 cases, while 34 cases returned negative results. The combined probes identified adenomyosis in 102 cases, with 19 cases yielding negative results. Both types of probes were concordantly positive in 77 cases and concordantly negative in 9 cases ($P = 0.018$).

Conclusion: The combined use of different ultrasonic scanning probes—convex array probe, linear array probe, and intracavitary probe—significantly enhances the diagnostic accuracy for adenomyosis at the gallbladder fundus, demonstrating significant clinical utility.

Keywords: adenomyosis, combined application of ultrasonic probe, convex array probe, intracavitary probe, linear array probe, gallbladder fundus

Introduction

Gallbladder adenomyosis (GA) lacks specific clinical manifestations and signs, and often has no obvious symptoms. A few patients may have abdominal pain and symptoms similar to cholecystitis and cholelithiasis. Gallbladder adenomyosis is a benign disease with a good prognosis. It needs to be differentiated from chronic gallbladder carcinoma. The incidence of gallbladder adenomyosis, also referred to as gallbladder adenomyoma, ranges from 2.8% to 5%, predominantly affecting individuals aged 40 to 60 years, with a higher prevalence among women.[1] GA is a non-inflammatory, non-neoplastic proliferative disorder characterized by the hyperplasia of glands and the muscle layer.[2] The thickened epithelium of the gallbladder wall penetrates into the muscle layer to form Rokitansky-Aschoff sinuses. Morphologically, GA can be classified into three types: localized, segmental, and diffuse. Among them, the localized type, which accounts for 80% of all cases, is the most common and typically presents as nodular growths at the gallbladder fundus. The segmental type, primarily located in the gallbladder body, forms a circular, narrow ring that divides the gallbladder cavity into the neck and the fundus. GA frequently coexists with cholecystitis, small gallstones, and cholesterol crystallization within the gallbladder.[3]

Relevant studies have confirmed that GA exhibits varying degrees of malignant degeneration, necessitating early diagnosis and timely intervention to mitigate the risk of malignant transformation.[4] However, due to its superficial location near the abdominal wall, adenomyosis at the gallbladder fundus is often overlooked because of near-field reverberation. In practice,

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ultrasound is superior to X-ray in the diagnosis of gallbladder adenomyosis, and the combined use of low-frequency and high-frequency ultrasound enhances the diagnostic accuracy of GA, demonstrating significant application value.[5]

Data and Methods

General Data

A total of 121 individuals, including 82 men and 39 women, who had been diagnosed with adenomyosis at the gallbladder fundus in the period from 2016 to 2020 were selected. Their age ranged from 28 to 86 years, with an average age of 59.32 ± 13.39 years. The study included adult patients with gallbladder and excluded patients under 18 years of age.

Methods

A convex array probe, a linear array probe, and a cavity probe were used with a color ultrasonic diagnostic instrument. The frequency of convex array probe is C6-1, frequency of linear array probe is L12-3, frequency of intracavitary probe is V15-4. Participants fasted for 8 hours prior to the examination and were positioned in supine, left decubitus, and half-seated positions. Combined probe examination method: initial scanning was conducted using the convex array probe, followed by the high-frequency linear array probe or the cavity probe. The manufacturers were five experienced doctors who received the uniform training (Associate Chief physician, more than 15 years in ultrasound diagnosis): Hong-Ying Ma, Tao Wu, Guo-Mei Yin, Ya-Hui Ma, Qing Wang. Then, the images were collected in length of centimeter.

Diagnostic Criteria for GA

The diagnostic criteria via ultrasound for GA[3] included the following characteristic manifestations:

1. Localized thickening of the gallbladder wall.
2. Presence of a small anechoic area within the cystic wall.
3. Identification of individuals with a strong echo and the “comet tail” sign.

GA is a benign, acquired lesion characterized by epithelial, mucosal, and muscular (smooth muscle) hypertrophy. The GB wall has an overall thickened appearance. The pathological pictures are interpreted by professional senior pathologists (doctor, associate chief physician).

Statistical Analysis

Data were processed using SPSS 20.0 software, employing Student’s *t*-test and Chi-square test. $P < 0.05$ indicated a statistically significant difference.

Results

The age distribution of the 121 participants is presented in Table 1, Figure 1A and B. The average age was 59.21 ±13.475 years, with the oldest being 88. Among the 121 participants, 112 exhibited thickening of the bottom wall of the gallbladder, with thickness measurements ranging from 0.3 to 1.7 cm and an average thickness of about 0.78 ±

Table 1 Age Distribution of 121 Patients (Years)

	Parameter	Value
AGE	Mean value	59.21
	Median age	58.00
	Variance	181.566
	Standard deviation	13.475
	Minimum	28
	Maximum	88

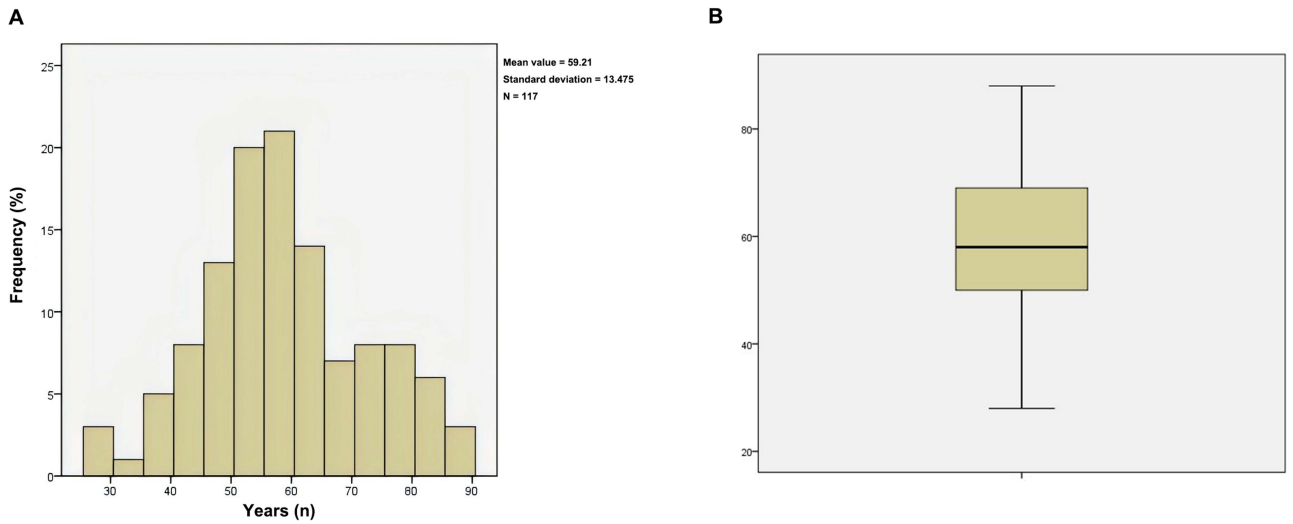

Figure 1 The age distribution of the 121 participants. (**A**) Histogram of age distribution of 121 participants. The vertical axis represents frequency (%); the horizontal axis represents years (n); (**B**) Box plot of age distribution of 121 participants.

0.32 cm. The range of gallbladder wall thickening was between 0.5 cm and 4.1 cm, with an average of 1.47 ± 0.57 cm. There were 98 cases of fine anechoic cyst wall and 82 cases with strong echo and the "comet tail" sign. The size distribution of cystic adenomyosis in these 121 participants is shown in Table 2, Figure 2A and B.

Among the 121 participants, the convex array probe detected GA in 87 cases, with 34 cases yielding negative results. The combined probe detected GA in 102 cases, with 19 cases showing negative results. Among them, 77 cases were positive using both methods, and 9 cases were negative. Additionally, 10 cases were positive using the convex array probe but negative using the combined probe, while 25 cases were positive using the combined probe but negative using the convex probe (see Table 3 and Figure 3A–C), with $P = 0.018$. Furthermore, 22 cases of GA were diagnosed by ultrasound and were confirmed to be GA by pathology, demonstrating the accuracy and reliability of the ultrasonic diagnostic criteria for GA. Pathological images revealed low-power views of GA with hyperplasia of gallbladder glands, accompanied by mucosal epithelium invading the muscular layer and forming Rokitansky-Aschoff sinuses (RAS) (HE staining ×10). Additionally, benign hyperplasia and an expansion gland with flat mucosa and no dysplasia were observed (HE staining ×40).

In this study, among the participants with GA, 22 cases had cholesterol crystallization in the gallbladder wall, 22 cases had gallstones, 24 cases had gallbladder polyps, and 3 cases had combined cholecystitis. Additionally, there were 6 cases with both gallbladder polyps and cholesterol crystals, 2 cases with cholecystolithiasis and cholesterol crystals, and 3 cases with both gallstones and cholecystitis. There was 1 case each of gallbladder enlargement, gallstone with cholesterol crystal and gallbladder inflammation, and gallstone with cholesterol crystal and gallbladder polyp.

Table 2 Size Distribution of Gallbladder Adenomyomatosis in 121 Patients (Cm)

Parameter	Value
Mean value	1.177
Median size	1.020
Variance	0.775
Standard deviation	0.601
Minimum	0.120
Maximum	3.780

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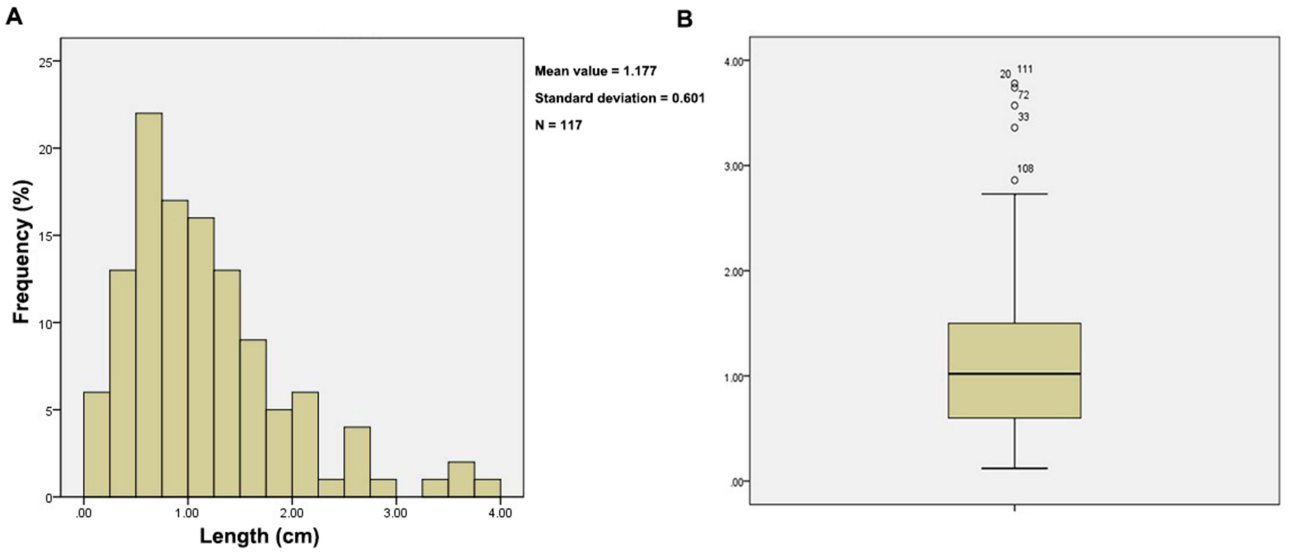

Figure 2 The size distribution of cystic adenomyosis in these 121 participants. (**A**) Histogram of length distribution in 121 participants with gallbladder adenomyomatosis. The vertical axis represents frequency (%); the horizontal axis represents length (cm); (**B**) Box plot of length distribution in 121 participants with gallbladder adenomyomatosis.

Discussion

GA is a common clinical condition, yet it is not obvious and lacks distinct clinical specificity, making preoperative diagnosis challenging. It is often detected by laboratory tests or physical examinations for other conditions. Epidemiological investigation shows that ultrasound has a high positive rate among various imaging examinations and is frequently utilized in clinical practice. However, the average detection rate remains below 50%, indicating a significant likelihood of missed and false detections.[6] Many scholars have reported coexisting cases of GA and gallbladder cancer.[7–9] In 1990, Aldridge officially proposed that GA may be a precancerous lesion, primarily due to the presence of a mucocytogenesis area in the hyperplastic mucosa, indicating the possibility of a precancerous lesion.[8] Domestic and foreign scholars have also reported cases of localized GA with malignant degeneration.[10,11]

The shallow location of the gallbladder fundus, in close proximity to the abdominal wall, poses challenges for the detection of adenomyosis at the gallbladder fundus. Factors such as the low frequency of conventional convex array probes, the thickness of the abdominal wall, and the inability of some individuals to tolerate ultrasound examination contribute to the likelihood of missed diagnoses when solely relying on convex array probes or when the imaging of the gallbladder fundus is overlooked by the sonographer. Enhancing the detection rate of GA is therefore a critical objective.

To improve detection, sonographers should adjust the ultrasonic detection depth to a shallow level (approximately 6 to 8 cm) to better visualize the gallbladder bottom wall. Utilizing the "zoom" function to enlarge the image can aid in observing the gallbladder wall's thickness, the extent of the lesion, internal echoes, and strong dot echoes. When there is strong suspicion of thickening at the gallbladder's fundus and the convex array probe provides unclear images, the linear array probe or the intracavitary probe should be employed. The optimal depth for both the linear array and intracavitary

Table 3 Results of Two Ultrasonic Testing Methods for Gallbladder Adenomyomatosis

Items		Combined Probe			Test Statistic	P
		Positive	Negative	n		
Convex Array Probe	Positive	77	10	87	5.600	0.018
	Negative	25	9	34		
	n	102	19	121		

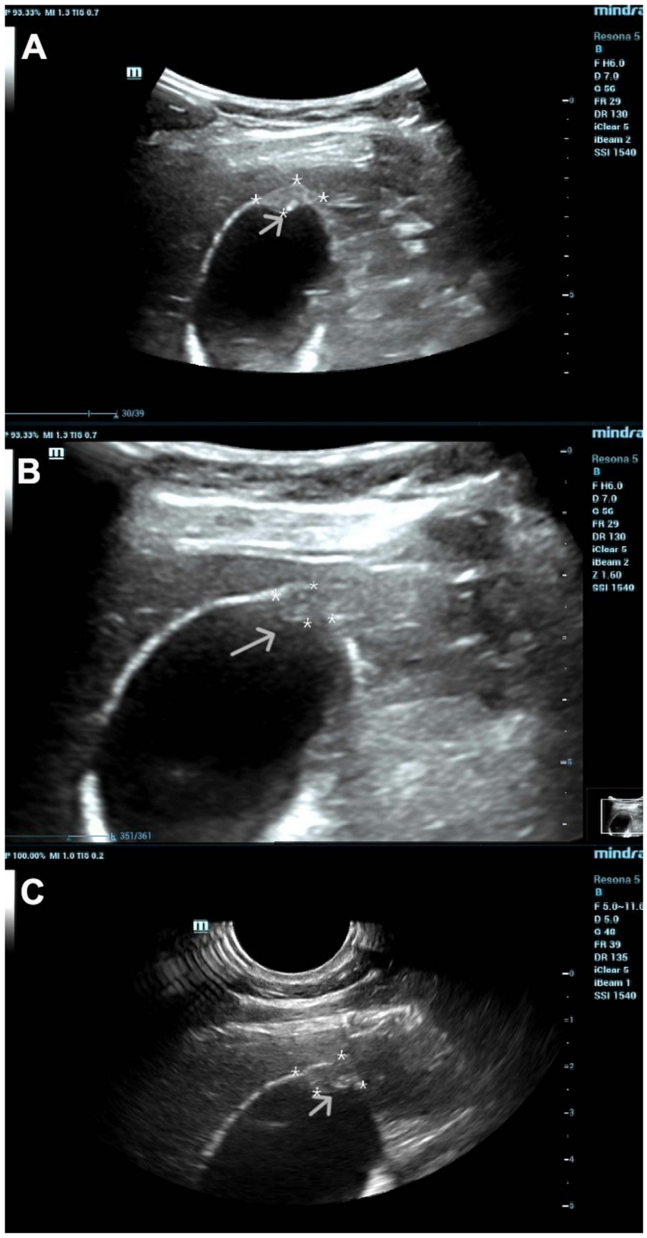

Figure 3 Diagnostic results of different probes. (**A**) Lesions at the gallbladder fundus visualized using a convex array probe. (**B**) Lesions at the gallbladder fundus visualized using a high-frequency probe. (**C**) Lesions at the gallbladder fundus visualized using an intracavitary probe.
Notes: The arrow shows the location of the adenomyosis at gallbladder fundus and the asterisk means the boundary.

probes should be within 5 cm. Employing a multi-probe scanning approach can significantly enhance the detection rate of adenomyosis at the bottom of the gallbladder and reduce the likelihood of missed diagnosis.

In this study, the detection rate of GA was 71.9% using the convex array probe, 84.3% with the linear array and intracavity probes, and 92.5% using the combined method. This combined approach markedly improved the detection rate. Despite this, there were nine cases of missed diagnoses identified during surgical follow-up, highlighting that even thorough investigations with combined scanning methods may not achieve perfect diagnostic accuracy.

Fortunately, no malignant lesions of adenomyosis at the gallbladder fundus were identified in the participants undergoing surgery, which confirmed the reliability and accuracy of the ultrasonic diagnosis of GA. GA is often linked with cholecystitis, cholesterol crystals in the gallbladder wall, and gallstones. Reports suggest that the carcinogenesis of

GA is frequently driven by gallstones, which are a significant risk factor for gallbladder cancer.[12] Some domestic scholars have proposed that the malignancy of GA may also be associated with the prolonged stimulation of gallstones.[13] It has also been reported that up to 60% of individuals with adenomyosis also have gallstones,[14] and about 33% have gallbladder polyps.[15]

In this study, among the participants with GA, 22 had cholesterol crystallization in the gallbladder wall, 22 had gallstones, 24 had gallbladder polyps, and 3 had combined cholecystitis. Additionally, there were 6 cases with both gallbladder polyps and cholesterol crystals, 2 cases with cholecystolithiasis and cholesterol crystals, and 3 cases with both gallstones and cholecystitis. There was 1 case each of gallbladder enlargement, gallstone with cholesterol crystal and gallbladder inflammation, and gallstone with cholesterol crystal and gallbladder polyp.

Given these findings, it is essential in routine ultrasound practice to pay close attention to individuals with gallstones, polyps, cholesterol crystals, and cholecystitis. The combined application of various ultrasonic probes should be emphasized to prevent missed diagnoses of adenomyosis at the gallbladder fundus.

The detection rate of adenomyosis following cholecystectomy ranges from 1% to 9%, with a higher prevalence among women aged 50 to 60 years.[16,17] In the present study, adenomyosis at the gallbladder fundus was not detected in 9 participants when using the linear array probe and intracavitary probe. The primary factors contributing to these missed diagnoses included obesity, significant interference from intestinal gas, intolerance to the ultrasonic probe scan, and the presence of small lesions with unclear image display at the gallbladder fundus. Among the 121 cases examined in this study, 82 were men and 39 were women, which differs from previously reported literature and may be attributed to the limited sample size. Future research should focus on continuous follow-up and expanding the sample size to gather more comprehensive data. The age of the participants ranged from 28 to 86 years, with a mean age of 59.32 ± 13.39 years, aligning with findings in the literature. Therefore, in future practice, careful attention should be paid to the gallbladder fundus in women aged 50 to 60 years who present with gallbladder-related issues. The use of multiple probes and thorough, detailed scanning can improve the ultrasound diagnosis of GA.

Conclusion

Relying exclusively on the abdominal convex array probe can result in missed diagnoses of GA, particularly at the fundus. However, the combined application of the abdominal convex array probe, linear array probe, and intracavity probe significantly enhances diagnostic accuracy. This multimodal approach demonstrates substantial clinical value and is recommended for broader application in clinical practice.

Abbreviation

GA, gallbladder adenomyosis.

Data Sharing Statement

The datasets used and/or analyzed during the current study are available from the corresponding author upon reasonable request.

Ethics Approval and Consent to Participate

This study was conducted with approval from the Ethics Committee of Aerospace Center Hospital. This study was conducted in accordance with the declaration of Helsinki. Consent was not required and waived by the ethics committee because it's a retrospectively study and data analysis was conducted for the article only with good confidentiality.

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Disclosure

The authors declare that they have no competing interests.

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