Everything you need to know about ultrasound for diagnosis of gallbladder diseases

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Abbreviations

US	Ultrasound
GB	Gallbladder
GPL	Gallbladder polypoid lesion
GWT	Gallbladder wall thickening
GBC	Gallbladder carcinoma
HRUS	High-resolution US
CEUS	Contrast-enhanced US
EUS	Endoscopic ultrasound
EUS-FNA	EUS fine-needle aspiration

Introduction

As ultrasound (US) is a simple and noninvasive procedure, it is widely used for cancer screening and health checkups [1]. Both gallbladder (GB) polypoid lesions (GPLs) and wall thickening (GWT) are common US findings. GB carcinoma (GBC) is also detected incidentally in patients with no symptoms.

Compared with low-frequency transducers (2–5 MHz), high-frequency transducers can provide excellent images of the internal structure of GPLs and delineate the GB wall as a two- or three-layer structure: inner hypoechoic layer and outer hyperechoic layer or hyperechoic inner and outer layers and a hypoechoic middle layer. Recent advances in US technology have allowed high-frequency transducers to provide resolutions of greater than 8 cm, which can cover the entire GB. Furthermore, a highly sensitive Doppler imaging modality and contrast-enhanced US enable a more accurate differential diagnosis.

Endoscopic ultrasonography (EUS) has excellent spatial resolution and allows a more detailed examination than US

in the differential diagnosis and evaluation of tumor invasion depth. Furthermore, contrast-enhanced harmonic EUS and EUS fine-needle aspiration (FNA) have the potential to improve diagnostic performance.

US and EUS appearance of GB lesions is broadly divided into GPLs and GWT. This classification is useful for the differential diagnosis and is also used in US cancer screening [1]. Most incidentally detected GPLs are benign cholesterol polyps. However, GPLs include neoplastic polyps such as carcinomas and adenomas, and the preoperative differential diagnosis between early carcinomas and non-neoplastic polyps is still challenging. Since GWT can occur in various conditions, subdividing it into diffuse and focal forms is useful. Diffuse GWT includes systemic diseases and inflammation of organs adjacent to the GB in addition to GB abnormalities. However, focal GWT is specific for the GB and has a high incidence of GBC.

In this feature, we had special authors describe the role of US and EUS in the diagnosis of GPLs and GWT.

Gallbladder polypoid lesions (GPLs)

In this section, Okaniwa [2] has discussed B-mode images, and Miwa et al. [3] have described color Doppler imaging and contrast-enhanced US (CEUS).

Morphological characterization using B-mode images is essential and useful for the differential diagnosis of GPLs. High-resolution US (HRUS), which uses both low- and high-frequency transducers during evaluation, is useful for assessing the surface and internal structure of GPLs.

First, Okaniwa [2] provides tips for US screening, including the management of characteristic artifacts and the usage of HRUS. Next, he lists several US findings including number, size, growth rate, shape, internal echo, surface contour, and internal structure and explains the key points of each finding citing references. Among those findings, he especially emphasizes the importance of classifying the shape of GPLs into pedunculated and sessile

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(broad-based) types: cholesterol polyps among pedunculated lesions and localized adenomyomatosis (ADM) among sessile lesions are the most important targets to be differentiated and a sessile shape is an independent risk of malignancy. Lastly, he mentions the assessment of depth of GBC invasion. An assessment of the layer structure (irregularity of the outer hyperechoic layer) and classification of the shape (pedunculated or sessile) are considered to be widely accepted findings for depth diagnosis of invasion. However, since the inner hypoechoic layer includes not only the mucosa and muscularis propria, but also the fibrous layer of the subserosa, differentiation between T1 (confined to the mucosa or muscularis propria) and T2 (invading the subserosa) based on the layer structure is difficult. So, he suggests that assessment of the size (less than 10 mm) and internal structure (hypoechoic area in the deeper part of GPLs) may be helpful for further assessment.

Doppler imaging and CEUS have been developed as modalities for detailed evaluation of the vascularity of GPLs. Recently, a highly sensitive Doppler imaging modality that can detect low-flow signals through an intelligent filter system and enable the evaluation of minute vessels in GPLs has been developed. However, in most cases, Doppler imaging can only evaluate relatively large vessels. To overcome this limitation, CEUS for GB disease was developed in the early 2000s.

Miwa et al. [3] have described color Doppler imaging and CEUS with images of typical cases. First, they mention contrast agents, contrast modes, CEUS phases, and three-dimensional (3D) US. The most common imaging method for CEUS with Sonazoid is low MI contrast mode ($MI = 0.2\text{--}0.3$). However, the low MI contrast mode is easily affected by the background B-mode signal. To eliminate this influence, they employ a high MI contrast mode ($MI = 0.6\text{--}1.2$) for GB disease. Next, they list several evaluation criteria, including Doppler imaging, the perfusion effect for CEUS, GB polyp morphology, vessels in GB polyps, heterogeneity of the contrast effect, and GB wall destruction. Since a high MI contrast mode can detect static vessel images of tiny GB polyps, they set two parameters for classification: thickness (dilated or thin) and shape (regular or irregular). In addition, they provide a detailed explanation of each finding in their discussion, citing references. They also explain CEUS (low MI contrast mode and high MI contrast mode) findings in GBC, adenoma, benign polyps, and biliary sludge with a table comparing it with B-mode and color Doppler imaging.

Okaniwa [2] and Miwa et al. [3] cover almost everything related to the diagnosis of GPLs. These articles will be useful not only in your daily clinical practice, but also for your research and when writing conference presentations and papers for publication going forward.

Gallbladder wall thickening (GWT)

GWT includes GB disorders such as adenomyomatosis, acute and chronic cholecystitis, and hyperplasia associated with pancreaticobiliary maljunction and also GBC. In addition, some systemic diseases and inflammation of organs adjacent to the GB also cause GWT. In this section, Miyoshi et al. [4] have discussed B-mode images of GWT. Color Doppler imaging and CEUS of GWT should also be included in this section, but due to the author's schedule, they will be published in Issue 4 of JMU Vol. 48.

Miyoshi et al. [4] have provided a detailed description of the diagnosis of GWT using B-mode images. They classify GWT by etiology and extent of the lesion (diffuse and focal). Focal GWT is a specific finding for GB abnormalities, while diffuse GWT is not a specific finding for the GB. They also explain B-mode US findings in adenomyomatosis (ADM), acute and chronic cholecystitis, immunoglobulin G4 (IgG4)-related sclerosing cholecystitis, porcelain gallbladder, gallbladder mucosal hyperplasia associated with pancreaticobiliary maljunction, xanthogranulomatous cholecystitis, GBC and other causes of wall thickening citing several references. They emphasize the possibility of coexisting GBC, especially in GB stones, ADM and acute cholecystitis. They also present a diagnostic decision-making algorithm for diffuse GWT and focal GWT, focusing on the layer structure (regular or irregular), presence of small cystic spaces or comet-tail artifacts corresponding to RAS, and GB enlargement, respectively. In this algorithm, they suggest that a regular surface and layer structure favor benign diseases, small cystic spaces and comet-tail artifacts favor ADM, and atypical findings raise the suspicion of malignancy or XGC. This article will be useful for determining the cause and differentiation of GWT.

Endoscopic ultrasound (EUS)

In this section, Tanaka et al. [5] have given a detailed description of the role of EUS for GB disease. EUS has excellent spatial resolution and allows a more detailed examination for the differential diagnosis and evaluation of the depth of tumor invasion. In addition, EUS fine-needle aspiration (FNA) in GB disease has recently been studied.

First, Tanaka et al. [5] explain methods for visualization of the GB by EUS (radial scan type and convex array) and contrast-enhanced harmonic EUS. In this section, they emphasize that since the position of the fundus largely varies between individuals, caution is necessary to achieve accurate observation and minimize oversight. They also suggest that contrast-enhanced EUS may be useful for

differential diagnosis but needs further accumulation of knowledge with large-scale studies. Next, a detailed explanation of the differential diagnosis of GB lesions has been provided by dividing them into GPLs and GWT. GPLs are classified into neoplastic and non-neoplastic lesions and are comparatively classified using form, surface structure, and internal echo. Since EUS can be used to examine the layered structure in more detail, sessile lesions with a deep hypoechoic area or thinning of the hyperechoic outer layer can be diagnosed as GBC with SS depth of invasion. In the case of GWT, ADM, xanthogranulomatous cholecystitis, hyperplasia of the GB mucous membrane accompanying anomalous pancreaticobiliary junction, and GBC are listed with typical EUS images. Lastly, EUS-FNA is addressed. EUS-FNA is highly useful and widely used for pancreatic carcinoma and gastrointestinal lesions. The diagnostic performance of EUS-FNA in GB lesions is high, with a sensitivity, specificity, and diagnostic accuracy of 80 – 100%, 100%, and 83 – 100%, respectively. However, they emphasize that since EUS-FNA for biliary tract lesions has risks such as biliary fistula and dissemination, the decision to adapt need to be made carefully.

Conclusion

We asked expert authors to provide detailed explanations of the present status of US and EUS for the diagnosis of GB lesions (GPL and GWT). This feature is both educational and may serve as a useful reference in the future when you prepare presentations and write papers about your research.

Added

Each paper may use different terminology for the appearance and findings of the same condition on US and EUS. In this special issue, the original text has been retained to respect the originality of each author. This does not diminish the academic value of each paper or of this special issue.

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