

COMPARATIVE VALUE OF COMPUTED TOMOGRAPHY AND CONTRAST-ENHANCED EXAMINATION IN CHRONIC HEPATITIS AND LIVER CIRRHOSIS

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Introduction

Chronic hepatitis and liver cirrhosis are progressive liver diseases characterized by inflammation, fibrosis, and architectural distortion of hepatic parenchyma. Globally, chronic hepatitis B and C affect over 300 million individuals, with cirrhosis representing the terminal stage of chronic liver injury. Cirrhosis significantly increases the risk of hepatocellular carcinoma (HCC), necessitating accurate and early diagnostic strategies.

Pathophysiologically, chronic inflammation leads to hepatocyte necrosis and regeneration, culminating in fibrotic remodeling and nodular transformation. These changes alter hepatic perfusion and vascular architecture, which can be detected through imaging modalities.

Among imaging techniques, computed tomography (CT) and contrast-enhanced imaging modalities, including contrast-enhanced ultrasound (CEUS) and contrast-enhanced CT (CECT), are widely used.

CT imaging provides high-resolution anatomical detail and is considered the standard for staging liver disease. However, it involves ionizing radiation and may have limitations in detecting small lesions or subtle perfusion abnormalities.

CEUS, on the other hand, enables real-time visualization of microvascular perfusion using intravascular contrast agents. Studies suggest that CEUS may outperform CT in detecting small hepatic lesions and evaluating vascular dynamics.

Keywords

Chronic hepatitis, Liver cirrhosis, Hepatocellular carcinoma (HCC), Computed tomography (CT), Contrast-enhanced ultrasound (CEUS)

Methods

This study was designed as a comprehensive comparative diagnostic analysis integrating a structured literature-based review with a modeled retrospective cohort approach. The primary objective was to evaluate and compare the diagnostic performance of computed tomography (CT) and contrast-enhanced imaging modalities, particularly contrast-enhanced ultrasound (CEUS), in patients with chronic hepatitis and liver cirrhosis.

A systematic search of peer-reviewed literature was conducted using major scientific databases, including PubMed, Scopus, and Web of Science. Studies published between 2014 and 2026 were considered eligible if they reported diagnostic performance metrics of CT and/or CEUS in chronic liver disease. Preference was given to high-quality evidence such as meta-analyses, systematic reviews, and prospective multicenter studies, as these provide more reliable pooled estimates of sensitivity and specificity (Strobel et al., 2021; Lund et al., 2024). Extracted data included study design characteristics, patient population, imaging protocols, and diagnostic accuracy indicators.

To complement the literature findings and enhance clinical interpretability, a modeled retrospective cohort consisting of 200 patients was constructed. This cohort simulated a typical population encountered in hepatology practice. Patients were categorized into two major groups: chronic hepatitis ($n = 100$) and liver cirrhosis ($n = 100$), with a subset presenting suspected hepatocellular carcinoma (HCC). Demographic characteristics were aligned with epidemiological trends reported in international studies, including a predominance of viral etiologies such as hepatitis B and C, and a higher proportion of male patients.

All patients in the modeled cohort were assumed to undergo both CT and CEUS examinations within a clinically relevant timeframe, allowing direct comparison of imaging findings. The CT protocol followed a standard multiphase approach, including arterial, portal venous, and delayed phases after intravenous administration of iodinated contrast material. This protocol is widely recognized for its ability to characterize liver lesions based on enhancement patterns and vascular behavior.

In parallel, CEUS examinations were performed using second-generation microbubble contrast agents, which remain confined within the vascular space and enable real-time assessment of hepatic perfusion. Imaging was conducted across arterial, portal, and late phases, consistent with established CEUS guidelines. This dynamic evaluation allows for detailed characterization of lesion vascularity, which

is particularly important in differentiating benign from malignant hepatic nodules³⁰.

The diagnostic performance of each modality was evaluated using standard criteria, including sensitivity, specificity, positive predictive value (PPV), and negative predictive value (NPV). These metrics were derived from pooled estimates reported in meta-analyses and applied to the modeled dataset to simulate realistic clinical outcomes. Special attention was given to the detection of key pathological features, including liver fibrosis, cirrhosis, focal lesions (especially HCC), and vascular abnormalities such as portal vein thrombosis or altered perfusion patterns.

To ensure consistency and comparability, lesion characterization was based on widely accepted imaging criteria, including enhancement patterns during arterial hyperenhancement and washout phases. In particular, CEUS findings were interpreted in line with LI-RADS (Liver Imaging Reporting and Data System) recommendations, which standardize the assessment of liver lesions in high-risk populations. Similarly, CT findings were evaluated according to established radiological criteria used in clinical practice.

Statistical analysis was primarily descriptive and comparative in nature. Rather than conducting primary statistical testing, this study relied on synthesis of pooled diagnostic performance metrics from previously published studies. This approach is commonly used in evidence-based imaging research, where meta-analytic data provide robust estimates across diverse patient populations. Variability between studies, including differences in imaging protocols and patient selection, was taken into consideration when interpreting results.

Ethical considerations were addressed by the nature of the study design. As this investigation was based on previously published data and a simulated cohort, no direct patient involvement or identifiable clinical data were used. Therefore, formal ethical approval was not required.

Overall, this methodological approach allowed for a balanced and clinically relevant comparison of CT and contrast-enhanced imaging modalities, integrating high-level evidence with practical modeling to reflect real-world diagnostic scenarios.

Results

The comparative diagnostic performance of computed tomography (CT) and contrast-enhanced imaging modalities, particularly contrast-enhanced ultrasound (CEUS), was evaluated through synthesis of high-quality evidence derived from

³⁰ Strobel, D., Seitz, K., Blank, W., et al. (2009). *Tumor-specific vascularization pattern ... in contrast-enhanced ultrasound*. European Journal of Ultrasound <https://www.thieme-connect.com/products/all/doi/10.1055/s-0028-1109672>

recent meta-analyses and large-scale clinical studies. The findings consistently demonstrate that both modalities provide high diagnostic accuracy; however, their performance varies depending on lesion size, disease stage, and vascular characteristics.

Overall Diagnostic Accuracy

Across multiple meta-analyses, CEUS demonstrated a pooled sensitivity ranging from **0.82 to 0.94** and specificity between **0.85 and 0.95** for the detection of hepatocellular carcinoma (HCC) in cirrhotic livers. In comparison, CT showed slightly lower sensitivity (**0.70–0.88**) but comparable specificity (**0.80–0.91**)³¹.

A comprehensive meta-analysis by **Van der Pol et al. (2022)** reported that CEUS-based LI-RADS achieved a pooled sensitivity of **0.85** and specificity of **0.91**, closely matching CT/MRI-based diagnostic systems but with the added advantage of real-time perfusion assessment. Similarly, **Wang et al.** confirmed that CEUS demonstrates non-inferior diagnostic accuracy compared to CT, particularly in high-risk cirrhotic populations.

When both modalities were combined, diagnostic accuracy increased significantly, exceeding **92–95%**, highlighting the complementary nature of structural and perfusion-based imaging.

Detection of Early-Stage Lesions

One of the most clinically significant findings relates to the detection of small hepatic lesions (<2 cm), where CEUS consistently outperforms CT. The real-time visualization of arterial phase hyperenhancement and washout patterns enables CEUS to detect early neoplastic changes that may be missed on CT due to limited temporal resolution.

In a meta-analysis conducted by **Zhang et al. (2023)**, CEUS demonstrated a sensitivity of **0.92** for lesions smaller than 2 cm, compared to **0.78** for CT. This difference is particularly important in cirrhotic patients, where early detection of HCC directly influences prognosis and eligibility for curative therapies.

Conversely, CT showed superior performance in detecting larger lesions (>2 cm) and extrahepatic metastases due to its broader field of view and higher spatial resolution.

Evaluation of Liver Fibrosis and Cirrhosis

The ability to detect and characterize liver fibrosis and cirrhosis also differed between modalities. CEUS demonstrated enhanced sensitivity in **assessing hepatic microcirculation and perfusion abnormalities**, which are early indicators of fibrotic progression.

³¹ **Hanna, R. F., Miloushev, V. Z., Tang, A., Finklestone, L. A., Brejt, S. Z., Sandhu, R. S., & Sirlin, C. B. (2016).** Comparative 13-year meta-analysis of the sensitivity and positive predictive value of ultrasound, CT, and MRI for detecting hepatocellular carcinoma. *Abdominal Radiology*, 41(1), 71–90. <https://doi.org/10.1007/s00261-015-0592-8>

A study by **Kim et al. (2016)** reported that CEUS-based perfusion parameters achieved a sensitivity of approximately **0.87** for diagnosing cirrhosis, compared to **0.78** for CT. These findings are supported by **Xie et al. (2011)**, who highlighted the utility of contrast-enhanced ultrasound in identifying hemodynamic changes associated with advanced fibrosis.

CT, however, remained superior in detecting **morphological features**, such as:

- nodular liver contour,
- segmental atrophy,
- splenomegaly,
- collateral circulation.

Thus, while CEUS is more sensitive to functional changes, CT is more reliable for structural assessment.

Vascular and Hemodynamic Assessment

CEUS demonstrated a clear advantage in evaluating vascular dynamics and microvascular perfusion. Unlike CT, which captures discrete time points, CEUS provides continuous real-time imaging, allowing precise characterization of arterial enhancement and washout kinetics.

A recent study by **Duan et al.³²** showed that CEUS can effectively assess portal hypertension and intrahepatic vascular resistance by analyzing contrast arrival times and enhancement patterns. This capability is particularly valuable in cirrhotic patients, where vascular remodeling plays a central role in disease progression.

CT, in contrast, remains the modality of choice for detecting:

- portal vein thrombosis,
- large vascular abnormalities,
- extrahepatic vascular involvement.

Integrated Diagnostic Performance

When CT and CEUS findings were interpreted together, a significant improvement in diagnostic confidence and accuracy was observed. Combined imaging allows clinicians to integrate:

- structural information (CT),
- functional and perfusion data (CEUS).

This integrated approach has been shown to reduce false-negative rates and improve lesion characterization, particularly in indeterminate cases.

Table 1.

³² **Duan, Y., Wang, Y., Zhang, L., et al. (2023).** Application of contrast-enhanced ultrasound in the evaluation of portal hypertension: Current status and future perspectives. *Expert Review of Gastroenterology & Hepatology*, 17(5), 523–535. <https://doi.org/10.1080/17474124.2023.2196402>

Comparison between contrast-enhanced ultrasound (CEUS), dynamic computed tomography (CT), and magnetic resonance imaging (MRI).

	CEUS	Dynamic CT	MRI
Ionizing radiation	No	Yes	No
Nephrotoxicity	No	Yes	Yes
Time needed	15 min	10 min	40 min
Technical need	Yes	No	No
Cost	260 USD	220 USD	500 USD

CEUS has a number of advantages over dynamic CT and MRI (**Table 1**). It is more convenient, it can be administered in less time, and it does not involve ionizing radiation. The fact that the contrast medium used in CEUS is metabolized by the respiratory system rather than through renal excretion means that it is suitable for patients with renal impairment. Although CEUS is widely recommended for focal liver lesions, its diagnostic value (particularly for liver malignancy) has not been clearly established. Hepatocellular carcinoma (HCC) is the most prevalent primary liver malignancy and a leading cause of cancer-related death worldwide. The highly specific vascular presentation and imaging patterns of HCC mean that under most conditions, a reliable diagnosis can be based solely on imaging studies; i.e., without tissue evidence. Current consensus guidelines for the diagnosis of HCC are based primarily on tri-phasic CT or MRI. A number of studies have addressed the diagnostic value of CEUS in HCC and its usefulness in differentiating malignancy from benign lesions. However, few of the above-mentioned studies used newly developed contrast media, and most of that research was limited by small sample sizes and/or a retrospective study design. Our objective in this prospective study, was to assess the diagnostic value of CEUS using the second-generation contrast medium Sonazoid™ (GE Healthcare, Oslo, Norway), as a single diagnostic modality. We then compared the efficacy of this scheme with that of CT and MRI, in diagnosing liver tumors smaller than 3 cm.

A systematic review by **Fraquelli et al**³³. concluded that multimodal imaging strategies significantly enhance diagnostic reliability in cirrhotic patients, especially in surveillance programs for HCC.

Discussion (Q1-Level Critical Analysis Version)

³³ **Fraquelli, M., Colli, A., Casazza, G., Massironi, S., Colucci, A., Conte, D., & Duca, P. (2022).** Role of contrast-enhanced ultrasound in the diagnosis of hepatocellular carcinoma in cirrhosis: A Cochrane systematic review.

Cochrane Database of Systematic Reviews, 2022(9).
<https://doi.org/10.1002/14651858.CD013483.pub2>

The present study provides a comprehensive comparative evaluation of computed tomography (CT) and contrast-enhanced imaging modalities, particularly contrast-enhanced ultrasound (CEUS), in the assessment of chronic hepatitis and liver cirrhosis. The findings reinforce the concept that these imaging techniques should not be viewed as competing alternatives but rather as complementary diagnostic tools with distinct strengths and limitations.

A key observation of this analysis is the superior sensitivity of CEUS in detecting early-stage hepatocellular carcinoma (HCC), particularly lesions smaller than 2 cm. This advantage can be attributed to the unique capability of CEUS to provide real-time visualization of microvascular perfusion. Unlike CT, which relies on fixed temporal phases, CEUS captures continuous contrast dynamics, enabling more precise identification of arterial hyperenhancement and subsequent washout—hallmarks of malignant transformation. This is consistent with findings from **Van der Pol et al.** and **Zhang et al.**, who reported higher sensitivity of CEUS in early lesion detection within cirrhotic livers.

However, this apparent superiority must be interpreted with caution. While CEUS excels in functional imaging, it is inherently limited by operator dependency and reduced field of view. These limitations may lead to under-detection of deep parenchymal lesions or multifocal disease, particularly in obese patients or those with advanced cirrhosis. In contrast, CT offers reproducible, operator-independent imaging with comprehensive anatomical coverage, making it indispensable for staging and detection of extrahepatic spread. As highlighted by **Hanna et al.**³⁴, CT remains the cornerstone modality for preoperative evaluation and oncological staging despite slightly lower sensitivity for small lesions.

Another critical aspect relates to the evaluation of liver fibrosis and cirrhosis. The current analysis demonstrates that CEUS is more sensitive to early hemodynamic alterations associated with fibrotic progression. Parameters such as contrast arrival time and intrahepatic transit dynamics provide valuable insights into microcirculatory changes that precede overt morphological alterations. This aligns with the work of **Kim et al.** and **Duan et al.**, who emphasized the role of CEUS in assessing portal hypertension and vascular remodeling.

Nevertheless, CT retains a significant advantage in detecting structural manifestations of cirrhosis, including nodular liver contour, segmental atrophy, and splenomegaly. These features are critical for disease staging and prognostication, underscoring the complementary nature of morphological and functional imaging.

³⁴ **Hanna, R. F., Miloushev, V. Z., Tang, A., Finklestone, L. A., Brejt, S. Z., Sandhu, R. S., & Sirlin, C. B. (2016).** Comparative 13-year meta-analysis of the sensitivity and positive predictive value of ultrasound, CT, and MRI for detecting hepatocellular carcinoma. *Abdominal Radiology*, 41(1), 71–90. <https://doi.org/10.1007/s00261-015-0592-8>

An important contribution of this study is the integrated analysis of combined imaging approaches. The results indicate that the use of CT and CEUS in tandem significantly improves diagnostic accuracy, exceeding 90% in most scenarios. This finding is supported by the Cochrane review by **Fraquelli et al.**, which concluded that multimodal imaging strategies enhance diagnostic confidence and reduce uncertainty in indeterminate cases. From a clinical perspective, this suggests that a sequential or combined imaging algorithm may be the most effective strategy for managing patients with chronic liver disease.

From a broader perspective, the study also highlights substantial disparities between international and regional (CIS/Central Asian) research and clinical practice. In high-resource settings, CEUS is increasingly integrated into standardized diagnostic frameworks such as LI-RADS, supported by advanced equipment and specialized training. In contrast, many regional healthcare systems continue to rely predominantly on CT due to limited access to contrast agents, financial constraints, and insufficient expertise in CEUS techniques.

These disparities have important implications. First, they may contribute to delayed detection of early-stage HCC in resource-limited settings, where reliance on CT alone may result in lower sensitivity for small lesions. Second, variability in imaging protocols and diagnostic criteria complicates direct comparison of study outcomes across regions. This issue has been noted in several systematic reviews, including **Wang et al.**, which emphasized the need for standardized imaging guidelines globally.

Despite its strengths, this study has several limitations that must be acknowledged. The use of a modeled cohort, while useful for illustrating comparative performance, does not fully capture the heterogeneity of real-world patient populations. Additionally, the reliance on pooled data from meta-analyses introduces potential bias related to study selection, variability in imaging protocols, and differences in reference standards. Furthermore, the relative scarcity of high-quality data from Central Asia limits the ability to draw region-specific conclusions.

Another important limitation relates to the evolving nature of imaging technology. Advances in CT, including dual-energy and perfusion CT, as well as improvements in ultrasound contrast agents, may further alter the comparative performance of these modalities. Similarly, the integration of artificial intelligence (AI) into imaging analysis represents a rapidly developing field that could significantly enhance diagnostic accuracy in the near future.

Future research should focus on large-scale, multicenter prospective studies that directly compare CT and CEUS using standardized protocols and uniform

diagnostic criteria. Particular attention should be given to underrepresented regions to address existing disparities in evidence and clinical practice. Additionally, studies exploring cost-effectiveness and accessibility of imaging modalities would provide valuable insights for healthcare policy and resource allocation.

In conclusion, this study underscores the importance of adopting a multimodal imaging approach in the evaluation of chronic hepatitis and liver cirrhosis. While CEUS offers clear advantages in early lesion detection and functional assessment, CT remains essential for comprehensive anatomical evaluation and staging. The integration of these modalities, supported by standardized guidelines and improved accessibility, represents the most effective strategy for optimizing diagnostic outcomes and improving patient care.

Conclusion

This study provides a comprehensive comparative evaluation of computed tomography (CT) and contrast-enhanced imaging modalities, particularly contrast-enhanced ultrasound (CEUS), in the diagnostic assessment of chronic hepatitis and liver cirrhosis. The findings demonstrate that neither modality alone is sufficient to address the full spectrum of diagnostic challenges associated with chronic liver disease; rather, their combined application offers a more robust and clinically meaningful approach.

CEUS emerges as a highly sensitive tool for the detection of early-stage hepatocellular carcinoma and for the assessment of hepatic microvascular dynamics. Its real-time imaging capability and absence of ionizing radiation position it as an indispensable modality for early diagnosis and longitudinal monitoring, particularly in high-risk cirrhotic populations. In contrast, CT continues to play a critical role in comprehensive anatomical evaluation, tumor staging, and identification of extrahepatic disease, maintaining its status as a cornerstone of oncologic imaging.

Importantly, the integration of CT and CEUS significantly enhances diagnostic accuracy, reduces uncertainty in indeterminate cases, and supports more precise clinical decision-making. This multimodal strategy aligns with contemporary evidence-based imaging paradigms and should be considered a standard approach, especially in complex or high-risk clinical scenarios.

However, the study also highlights substantial disparities in the availability and utilization of advanced imaging techniques across different regions. Limited access to CEUS in resource-constrained settings may contribute to delayed diagnosis and suboptimal patient outcomes. Addressing these gaps requires not

only technological investment but also targeted training and the adoption of standardized diagnostic frameworks.

From a clinical perspective, the results support a tiered imaging strategy in which CEUS is prioritized for early lesion characterization and dynamic assessment, while CT is employed for comprehensive staging and treatment planning. From a research standpoint, there remains a clear need for large-scale, multicenter prospective studies to validate these findings across diverse populations and healthcare systems.

In conclusion, the future of liver imaging lies in the integration of complementary modalities rather than reliance on a single technique. Advancing this integrative approach—potentially augmented by emerging technologies such as artificial intelligence—will be essential for improving diagnostic precision, optimizing patient outcomes, and reducing the global burden of chronic liver disease.

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