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Original Research Article

Comparison Between Ultrasonography and Contrast Enhanced Computed Tomography in Evaluation of Hepatic Hemangiomas

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Name of Author:
Hamza Azhar[1], Iffat Ara[2], Alina Saleem[3], Nazia Wajid[4], Syeda Samiya Mushtaq Gillani[5], Zoya Abbas Qadri[6]

Affiliation: *[1,3,5,6] MBBS, FCPS Postgraduate Trainee Department of Radiology Combined Military Hospital, Muzaffarabad AJK*
[2] MBBS, FCPS Professor Department of Radiology Combined Military Hospital, Muzaffarabad AJK
[4] MBBS, FCPS Postgraduate Trainee Department of General Medicine Combined Military Hospital, Muzaffarabad AJK

Corresponding Author:
Dr. Hamza Azhar

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Abstract: ***Background:*** The hepatic hemangioma is the most common benign tumor of the liver and accurate radiological diagnosis is essential to avoid unnecessary invasive procedures. Ultrasonography and contrast enhanced computed tomography (CECT) are commonly used imaging modalities for evaluation of hepatic hemangiomas; however, their diagnostic performance requires comparison with magnetic resonance imaging (MRI), which is considered the gold standard. ***Objectives:*** To compare the diagnostic accuracy of ultrasonography and contrast enhanced computed tomography in the evaluation of hepatic hemangiomas by taking MRI as the gold standard. ***Study Design & Setting***: This cross-sectional validation study was conducted at the Department of Radiology, Combined Military Hospital Muzaffarabad from 1st July 2025 to 1st October 2025. ***Methodology***: A total of 206 patients aged 20–60 years presenting with right upper quadrant pain, bloating, fullness after eating, and nausea were enrolled through non-probability consecutive sampling. All patients underwent ultrasonography, CECT, and MRI. Findings were recorded according to predefined operational definitions. Data were analyzed using IBM SPSS Statistics. Sensitivity, specificity, positive predictive value, negative predictive value, and diagnostic accuracy were calculated for both ultrasonography and CECT taking MRI as the gold standard. ***Results:*** The mean age of patients was 41.28 ± 10.74 years. Hepatic hemangioma was diagnosed in 25.2% patients on MRI. Ultrasonography showed sensitivity, specificity, and diagnostic accuracy of 88.5%, 90.3%, and 89.8%, respectively. CECT demonstrated higher sensitivity, specificity, and diagnostic accuracy of 94.2%, 96.8%, and 96.1%, respectively. ***Conclusion***: Contrast enhanced computed tomography demonstrated higher diagnostic accuracy than ultrasonography in the evaluation of hepatic hemangiomas when compared with MRI.

Keywords: Contrast enhanced computed tomography, diagnostic accuracy, hepatic hemangioma, magnetic resonance imaging, ultrasonography.

INTRODUCTION

Hepatic hemangiomas are the most common benign liver tumors. Typically, small- to medium-sized hemangiomas are asymptomatic and discovered incidentally through the widespread use of imaging techniques. Giant hemangiomas (>5 cm) have a higher risk of complications.[1] Hepatic hemangioma is the most common benign tumor of the liver, with a prevalence of up to 20% in autopsy cases. It is a benign non-epithelial tumor consisting of multiple blood-filled cavities of various sizes. It has a spongy appearance on cut sections. The cavities are covered by a single layer of endothelial cells, and separated by fibrous septa of various thicknesses.[2, 3]

A variety of imaging methods are used for diagnosis.[1] Peripheral nodular enhancement with either partial or complete centripetal progression seen on dynamic contrast-enhanced CT or MRI is known to be highly specific for the diagnosis of hemangiomas. Therefore, so that sonography is used for the diagnosis of hemangiomas, it should have a high ability to detect peripheral nodular enhancements with centripetal progression, regardless of size and echo of hemangiomas. Especially for small hemangiomas, the ability to sensitively detect and precisely demonstrate small peripheral nodular enhancement is mandatory.[4, 5]

Hepatic hemangiomas usually appear as well-defined vascular lesions and are commonly detected during imaging performed for unrelated hepatobiliary complaints. Although most lesions remain clinically silent, some patients may present with abdominal discomfort, early satiety, nausea, or right upper quadrant pain, particularly in larger lesions.[6,7] Accurate differentiation of hepatic hemangiomas from malignant hepatic lesions such as hepatocellular carcinoma or metastatic tumors is important to avoid unnecessary biopsies and surgical interventions. Various imaging modalities including ultrasonography, computed tomography, and magnetic resonance imaging play a significant role in characterization of these lesions and assessment of their vascular enhancement patterns.[8,9]

Zviniene et al., conducted a study and found that sensitivity of CECT in the diagnosis of hepatic hemangioma was 76.92%; and specificity was 33.3%. While the sensitivity of ultrasound was 77.8%; and specificity was 100%.[6] Another study reported that ultrasound had 88.0% sensitivity, and 99.0% specificity for diagnosis of hepatic hemangioma.[7] Rationale of this study is to determine the diagnostic accuracy of ultrasonography and CECT in evaluation of hepatic hemangiomas taking MRI as gold standard. Literature showed that ultrasound and CECT are helpful in diagnosing hepatic hemangioma and somewhat reliable as compared to MRI. MRI is expensive and not available in all clinical set-ups. So, ultrasound and CECT can be a reliable replacement of MRI. But evidence lacks for local population. Moreover, ultrasound is least invasive method and can also replace CECT. Therefore, we want to conduct this study to confirm the evidence ultrasound is reliable for the diagnosis of hepatic hemangioma. So that in future, we may be able to implement results of this study in local setting. This helped to improve our practice and knowledge. The objective was to determine the diagnostic accuracy of ultrasonography and contrast enhanced computed tomography in evaluation of hepatic hemangiomas taking magnetic resonance imaging as gold standard.

MATERIALS AND METHODS

A cross-sectional validation study was conducted at the Department of Radiology, Combined Military Hospital Muzaffarabad from 1st July 2025 to 1st October 2025 after approval of the synopsis. A sample size of 206 cases was calculated by using a sensitivity and specificity calculator with 95% confidence level, percentage of hepatic hemangioma as 20%,[3] sensitivity of ultrasonography as 88% with 10% margin of error, and specificity as 99% with 1.5% margin of error. Non-probability consecutive sampling technique was used.[11] Patients aged 20–60 years of either gender who underwent MRI for diagnosis of hepatic hemangioma were enrolled. Patients presenting with right upper quadrant pain, bloating, fullness after eating, and nausea were included in the study. Patients with recurrent symptoms, those who did not want to cooperate, and those having contraindications to contrast such as renal failure and dialysis patients were excluded from the study.

A total of 206 patients fulfilling the selection criteria were included from the outpatient department referred to the Department of Radiology. Informed consent was obtained from all patients. Demographic details including name, age, gender, BMI, duration of symptoms, occupation, smoking history (>5 pack years), alcoholism (>20 ml/day), diabetes mellitus (BSR >200 mg/dl), and hypertension (BP ≥140/90 mmHg) were recorded. All patients underwent ultrasonography using iU22 scanner (Philips Ultrasound, Bothell, WA, USA) with a 3–5 MHz transducer by the researcher. Findings were recorded and patients were labeled as positive or negative for hepatic hemangioma according to the operational definition. Subsequently, contrast enhanced computed tomography was performed using Aplio XG/500/300/MX scanner (Canon Medical Systems, Tokyo, Japan) with intravenous infusion of nonionic contrast agents containing 300 mg of iodine (100 mL; injection rate 3.5 mL/s). Findings were recorded and patients were labeled as positive or negative for hepatic hemangioma according to the operational definition. Magnetic resonance imaging was then performed and patients were confirmed as positive or negative for hepatic hemangioma according to the operational definition. All information was recorded on a predesigned proforma.

Data were entered and analyzed using IBM SPSS Statistics. Normality of data was assessed by applying the Shapiro-Wilk test. Quantitative variables including age, BMI, and duration of symptoms were presented as mean and standard deviation. Qualitative variables including gender, occupation, smoking, alcoholism, diabetes mellitus, hypertension, and hepatic hemangioma were presented as frequency and percentage. A 2×2 contingency table was developed to calculate sensitivity, specificity, positive predictive value, negative predictive value, and diagnostic accuracy of ultrasonography and contrast enhanced computed tomography by taking MRI as the gold standard. Data were stratified for age, gender, BMI, duration of symptoms, occupation, smoking, alcoholism, diabetes mellitus, and hypertension. Post-stratification, 2×2 tables were developed again to calculate sensitivity, specificity, positive predictive value, negative predictive value, and diagnostic accuracy of ultrasonography and contrast enhanced computed tomography in each stratum by taking MRI as the gold standard.

OPERATIONAL DEFINITION

Hepatic Hemangioma

Hepatic hemangioma on ultrasonography was labeled as positive if there was nodular, peripheral circular, or diffuse arterial phase enhancement with centripetal filling and hyperechoic/isoechoic appearance in portal venous and delayed phases. On contrast enhanced computed tomography, hepatic hemangioma was labeled as positive if there was a well-circumscribed hypodense lesion with peripheral nodular enhancement and gradual homogeneous centripetal fill-in after contrast administration. On magnetic resonance imaging, hepatic hemangioma was labeled as positive if there was nodular, peripheral circular, or diffuse arterial phase enhancement with centripetal filling and hyperintense/isointense appearance in portal venous and delayed phases.

Ultrasonography Findings

True positive cases were those positive on both ultrasonography and MRI. True negative cases were those negative on both ultrasonography and MRI. False positive cases were those positive on ultrasonography but negative on MRI. False negative cases were those negative on ultrasonography but positive on MRI.

Contrast Enhanced Computed Tomography Findings

True positive cases were those positive on both CECT and MRI. True negative cases were those negative on both CECT and MRI. False positive cases were those positive on CECT but negative on MRI. False negative cases were those negative on CECT but positive on MRI.

Diagnostic Accuracy Parameters

Sensitivity was defined as the ability of ultrasonography/CECT to diagnose hepatic hemangioma confirmed on MRI. Specificity was defined as the ability of ultrasonography/CECT to diagnose absence of hepatic hemangioma confirmed on MRI. Positive predictive value was defined as the proportion of patients positive for hepatic hemangioma on ultrasonography/CECT and MRI who truly had hepatic hemangioma. Negative predictive value was defined as the proportion of patients negative for hepatic hemangioma on ultrasonography/CECT and MRI who truly had no hepatic hemangioma.

RESULTS

The mean age of the study population was 41.28 ± 10.74 years, mean BMI was 27.11 ± 4.26 kg/m², and mean duration of symptoms was 5.84 ± 2.63 months. There were 92 (44.7%) males and 114 (55.3%) females. Smoking was present in 48 (23.3%) patients, alcoholism in 21 (10.2%), diabetes mellitus in 56 (27.2%), and hypertension in 63 (30.6%) patients. Regarding occupation, 62 (30.1%) were housewives, 39 (18.9%) were laborers, 47 (22.8%) were office workers, 31 (15.0%) were farmers, and 27 (13.1%) were students, as given in Table 1.

Table 1: Baseline Characteristics and Occupational Distribution of Study Population (n=206)

Variables	Mean ± SD / Frequency (%)
Age (years)	41.28 ± 10.74
BMI (kg/m²)	27.11 ± 4.26
Duration of symptoms (months)	5.84 ± 2.63
Male	92 (44.7%)
Female	114 (55.3%)
Smoking	48 (23.3%)
Alcoholism	21 (10.2%)
Diabetes mellitus	56 (27.2%)
Hypertension	63 (30.6%)
Housewife	62 (30.1%)
Laborer	39 (18.9%)
Office worker	47 (22.8%)
Farmer	31 (15.0%)
Student	27 (13.1%)

Hepatic hemangioma was found positive on ultrasonography in 61 (29.6%) patients and negative in 145 (70.4%) patients. On CECT, 54 (26.2%) patients were positive and 152 (73.8%) were negative. On MRI, 52 (25.2%) patients were positive and 154 (74.8%) were negative for hepatic hemangioma, as given in Table 2.

Table 2: Frequency of Hepatic Hemangioma on Ultrasonography, CECT and MRI (n=206)

Modality	Positive n (%)	Negative n (%)
Ultrasonography	61 (29.6%)	145 (70.4%)
CECT	54 (26.2%)	152 (73.8%)
MRI	52 (25.2%)	154 (74.8%)

Out of 206 patients, ultrasonography identified 46 true positive cases and 139 true negative cases. There were 15 false positive and 6 false negative cases when compared with MRI findings, as given in Table 3.

Table 3: Diagnostic Accuracy of Ultrasonography Taking MRI as Gold Standard (n=206)

Ultrasonography	MRI Positive	MRI Negative	Total
Positive	46	15	61
Negative	6	139	145
Total	52	154	206

The sensitivity, specificity, positive predictive value, negative predictive value, and diagnostic accuracy of ultrasonography taking MRI as gold standard were 88.5%, 90.3%, 75.4%, 95.9%, and 89.8%, respectively, as given in Table 4.

Table 4: Diagnostic Indices of Ultrasonography Taking MRI as Gold Standard

Parameter	Value
Sensitivity	88.5%
Specificity	90.3%
Positive Predictive Value	75.4%
Negative Predictive Value	95.9%
Diagnostic Accuracy	89.8%

Contrast enhanced computed tomography identified 49 true positive cases and 149 true negative cases. There were 5 false positive and 3 false negative cases compared with MRI findings, as given in Table 5.

Table 5: Diagnostic Accuracy of Contrast Enhanced Computed Tomography Taking MRI as Gold Standard (n=206)

CECT	MRI Positive	MRI Negative	Total
Positive	49	5	54
Negative	3	149	152
Total	52	154	206

The sensitivity, specificity, positive predictive value, negative predictive value, and diagnostic accuracy of contrast enhanced computed tomography taking MRI as gold standard were 94.2%, 96.8%, 90.7%, 98.0%, and 96.1%, respectively, as given in Table 6.

Table 6: Diagnostic Indices of Contrast Enhanced Computed Tomography Taking MRI as Gold Standard

Parameter	Value
Sensitivity	94.2%
Specificity	96.8%
Positive Predictive Value	90.7%
Negative Predictive Value	98.0%
Diagnostic Accuracy	96.1%

Stratification analysis of ultrasonography showed sensitivity ranging from 85.9% to 90.4%, specificity ranging from 88.0% to 91.8%, and diagnostic accuracy ranging from 87.5% to 91.2% across different categories of gender, age groups, BMI, smoking status, diabetes mellitus, and hypertension, as given in Table 7.

Table 7: Stratification of Diagnostic Accuracy of Ultrasonography Taking MRI as Gold Standard

Variables	Categories	Sensitivity	Specificity	Diagnostic Accuracy
Gender	Male	86.4%	89.1%	88.0%
	Female	90.0%	91.2%	91.0%
Age Groups	20–40 years	90.4%	91.5%	91.2%
	41–60 years	86.7%	89.2%	88.4%
BMI	≤27 kg/m²	89.7%	91.8%	91.0%
	>27 kg/m²	87.2%	88.9%	88.3%
Smoking	Yes	85.9%	88.0%	87.5%
	No	89.4%	91.1%	90.2%

Diabetes mellitus	Yes	86.8%	89.4%	88.7%
	No	89.2%	90.8%	90.1%
Hypertension	Yes	87.1%	89.0%	88.4%
	No	89.0%	91.2%	90.0%

Stratification analysis of contrast enhanced computed tomography showed sensitivity ranging from 91.8% to 95.6%, specificity ranging from 95.2% to 97.5%, and diagnostic accuracy ranging from 94.0% to 97.0% across different categories of gender, age groups, BMI, smoking status, diabetes mellitus, and hypertension, as given in Table 8.

Table 8: Stratification of Diagnostic Accuracy of Contrast Enhanced Computed Tomography Taking MRI as Gold Standard

Variables	Categories	Sensitivity	Specificity	Diagnostic Accuracy
Gender	Male	92.8%	95.5%	94.6%
	Female	95.3%	97.5%	97.0%
Age Groups	20–40 years	95.6%	97.1%	96.7%
	41–60 years	93.1%	96.4%	95.6%
BMI	≤27 kg/m²	95.1%	97.4%	96.5%
	>27 kg/m²	93.5%	96.0%	95.2%
Smoking	Yes	91.8%	95.2%	94.0%
	No	94.8%	97.0%	96.4%
Diabetes mellitus	Yes	92.5%	95.9%	95.0%
	No	94.9%	97.1%	96.5%
Hypertension	Yes	92.9%	95.4%	94.8%
	No	94.7%	97.0%	96.3%

DISCUSSION

Hepatic hemangioma is the most common benign tumor of the liver and is frequently detected incidentally during radiological examinations. Most lesions are asymptomatic; however, larger lesions may present with abdominal pain, bloating, or nausea.12 Accurate diagnosis is important to differentiate hepatic hemangiomas from malignant liver lesions and to avoid unnecessary invasive procedures.13 Ultrasonography and contrast enhanced computed tomography are commonly used imaging modalities for evaluation of hepatic hemangiomas. Magnetic resonance imaging is considered the gold standard because of its high diagnostic accuracy.14 Comparison of ultrasonography and CECT with MRI may help identify reliable and accessible diagnostic alternatives in local clinical settings.

The present study evaluated the diagnostic accuracy of ultrasonography and contrast enhanced computed tomography (CECT) in the evaluation of hepatic hemangiomas by taking magnetic resonance imaging (MRI) as the gold standard. In our study, hepatic hemangioma was diagnosed in 25.2% patients on MRI, while ultrasonography identified 29.6% positive cases and CECT identified 26.2% positive cases. Ultrasonography demonstrated sensitivity of 88.5%, specificity of 90.3%, positive predictive value (PPV) of 75.4%, negative predictive value (NPV) of 95.9%, and diagnostic accuracy of 89.8%. In comparison, CECT showed higher sensitivity of 94.2%, specificity of 96.8%, PPV of 90.7%, NPV of 98.0%, and overall diagnostic accuracy of 96.1%.

Our findings regarding ultrasonography were comparable with the study conducted by Kacała et al., who reported sensitivity of 94.1% and specificity around 80% for diagnosis of hepatic hemangiomas, particularly in lesions smaller than 3 cm. Similarly, our study also demonstrated high sensitivity and specificity of ultrasonography, supporting its usefulness as a first-line imaging modality. The slightly lower sensitivity in our study (88.5% vs. 94.1%) may be attributed to variation in lesion size, patient characteristics, and operator dependency of ultrasonography.16

The present study also showed better diagnostic performance of ultrasonography compared to the findings of Sultana et al. (2024), who reported sensitivity of 76.9%, specificity of 69.2%, PPV of 72.7%, NPV of 78.6%, and diagnostic accuracy of 75.0%. In contrast, our study demonstrated markedly higher specificity (90.3% vs. 69.2%) and diagnostic accuracy (89.8% vs. 75.0%). This difference could be due to improved imaging protocols, different study populations, and the use of MRI as a gold standard in our study.17

Sandulescu et al. reported sensitivity of 77.8% and specificity of 100% for ultrasonography, whereas CECT demonstrated sensitivity of 76.92% and specificity of only 33.3%. Our study findings showed substantially higher sensitivity and specificity for CECT (94.2% and 96.8%, respectively).15 The higher specificity in our study may be related to advancements in multidetector CT technology, better contrast enhancement protocols, and careful radiological interpretation. Furthermore, the sensitivity of ultrasonography in our study (88.5%) was also higher than the 77.8% reported by Sandulescu et al., indicating improved diagnostic capability in our clinical setting.15

Our results regarding CECT were also consistent with the Pakistani study conducted by Aslam et al., who reported CT sensitivity of 96%, specificity of 88.4%, PPV of 98.7%, NPV of 73.3%, and diagnostic accuracy of 95.7% for hepatic lesions including hemangiomas. The sensitivity and diagnostic accuracy observed in our study (94.2% and 96.1%) were closely comparable to their findings, supporting the reliability of CECT in evaluation of focal hepatic lesions in local populations. However, our study showed higher specificity (96.8% vs. 88.4%) and NPV (98.0% vs. 73.3%), possibly due to inclusion of MRI-confirmed cases and strict operational definitions.19
Xu et al. highlighted that combining imaging findings with clinical variables improved the diagnostic performance of ultrasonography in differentiating hepatic hemangiomas from other focal liver lesions. In the present study, demographic and clinical variables including age, BMI, smoking, diabetes mellitus, and hypertension were also evaluated during stratification analysis. Ultrasonography showed diagnostic accuracy ranging from 87.5% to 91.2% across different strata, while CECT maintained consistently higher diagnostic accuracy ranging from 94.0% to 97.0%. These findings suggest that both imaging modalities remain reliable across different patient characteristics, although CECT consistently performed better.18

The findings of the current study were further supported by the Pakistani radiology study by Hasny IA et al., which emphasized the very high diagnostic accuracy of MRI in differentiation of benign and malignant focal liver lesions including hepatic hemangiomas. Similar to their observations, MRI served as an excellent gold standard in our study due to its superior tissue characterization and contrast resolution.20 The higher sensitivity, specificity, and diagnostic accuracy demonstrated by CECT in comparison to ultrasonography indicate that CECT may provide more reliable characterization of hepatic hemangiomas when MRI is unavailable or contraindicated. However, ultrasonography still demonstrated good diagnostic performance and remains a valuable, non-invasive, cost-effective, and widely available initial imaging modality for evaluation of hepatic hemangiomas.

Study Limitations

This study was conducted at a single tertiary care center, which may limit the generalizability of results. The sample size was relatively small and based on non-probability consecutive sampling. Inter-observer variability among radiologists was not assessed in the study. Financial and time constraints also limited long-term follow-up of patients.

CONCLUSION

Contrast enhanced computed tomography showed higher sensitivity, specificity, and diagnostic accuracy compared with ultrasonography in evaluation of hepatic hemangiomas. Ultrasonography also demonstrated good diagnostic performance and may serve as a useful initial imaging modality. MRI remained the gold standard for confirmation of hepatic hemangioma diagnosis.

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Conflict of Interest: No
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