



Original Article

## Efficacy of Ultrasound in characterization of Hepatic lesions in a Rural Konkan region: A prospective diagnostic study

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### ABSTRACT

**Background** Focal liver lesions (FLLs) comprise a heterogeneous group of benign and malignant hepatic pathologies that pose a significant diagnostic challenge because of their overlapping clinical and imaging characteristics. Non-invasive imaging is crucial for assessing hepatic lesions. Common modalities include ultrasonography (USG), computed tomography (CT), and magnetic resonance imaging (MRI), which are regularly employed to detect, locate, and characterise liver abnormalities. Ultrasonography is often preferred for its availability, affordability, portability, no ionizing radiation, and real-time imaging. [4,5]. However, histopathological examination remains the gold standard for definitive diagnosis. Correlating ultrasonographic findings with histopathological diagnosis is essential to determine the diagnostic reliability of ultrasonography in routine clinical practice.

**Aim** To evaluate the ultrasonographic characteristics of focal liver lesions and correlate the ultrasonographic findings with histopathological diagnosis in patients from the Konkan region.

**Materials and Methods** A prospective observational study was conducted in the Department of Radiodiagnosis at a tertiary care teaching hospital in the Konkan region. Ninety consecutive patients with clinically suspected or radiologically detected focal liver lesions fulfilling the inclusion criteria were enrolled. All patients underwent detailed ultrasonographic evaluation, including grayscale and colour Doppler imaging.

**Results** The study included 90 patients, of whom 56 (62.2%) were males and 34 (37.8%) were females, with the majority of patients aged over 60 years. Histopathological examination revealed hepatocellular carcinoma as the most common lesion (44.4%), followed by metastatic liver lesions (31.1%), liver abscesses (8.9%), cavernous hemangiomas (6.7%), simple hepatic cysts (5.6%), and focal nodular hyperplasia (3.3%). Hypoechoic lesions, ill-defined margins, and internal vascularity were the predominant ultrasonographic features associated with malignant lesions.

**Conclusion** Ultrasonography is a highly reliable, accurate, and non-invasive imaging modality for the initial evaluation and characterization of focal liver lesions.

**Keywords:** Focal liver lesions; Ultrasonography; Histopathology; Hepatocellular carcinoma; Diagnostic accuracy; Colour Doppler; Liver biopsy; Konkan region.

## INTRODUCTION

The liver is the largest solid organ in the human body and performs numerous essential metabolic, synthetic, detoxification, and immunological functions. Because of its dual blood supply through the hepatic artery and portal vein, the liver is particularly susceptible to a wide spectrum of pathological conditions, including inflammatory, infectious, congenital, benign, and malignant lesions. Focal liver lesions (FLLs) are increasingly detected owing to the widespread use of abdominal imaging modalities during routine health evaluations and investigations for unrelated diseases. These lesions encompass a broad pathological spectrum, ranging from simple hepatic cysts and hemangiomas to primary hepatic malignancies such as hepatocellular carcinoma (HCC) and secondary metastatic deposits. Accurate differentiation between benign and malignant liver lesions is crucial because management strategies, prognosis, and patient survival vary considerably according to the underlying pathology [1,2].

Globally, liver diseases remain a major public health concern. Hepatocellular carcinoma is the sixth most common malignancy and the third leading cause of cancer-related mortality worldwide. In addition, the liver represents the most frequent site of metastasis from gastrointestinal, pancreatic, breast, and lung malignancies due to its rich vascular supply [3]. In India, the burden of chronic liver diseases and hepatic malignancies continues to rise owing to increasing prevalence of hepatitis B and C infections, alcohol-related liver disease, and non-alcoholic fatty liver disease (NAFLD). Early detection and accurate characterization of liver lesions are therefore essential to improve clinical outcomes and reduce disease-related mortality [4].

Imaging plays a central role in the evaluation of focal liver lesions. Ultrasonography (USG) is generally considered the first-line imaging modality because it is non-invasive, inexpensive, widely available, free from ionizing radiation, and capable of providing real-time assessment of hepatic morphology. Modern ultrasonography enables evaluation of lesion size, location, echogenicity, internal architecture, margins, posterior acoustic features, vascularity using Doppler imaging, and relationship with adjacent structures. Certain lesions, such as simple hepatic cysts and cavernous hemangiomas, exhibit characteristic sonographic appearances that facilitate diagnosis without additional imaging. However, considerable overlap exists in the sonographic features of many benign and malignant lesions, limiting the specificity of conventional ultrasonography [5,6].

Advances in ultrasonographic technology, including colour Doppler imaging, contrast-enhanced ultrasonography (CEUS), and elastography, have significantly enhanced lesion characterization by providing information regarding vascular perfusion and tissue stiffness. These innovations have improved diagnostic confidence, particularly in distinguishing hepatocellular carcinoma from regenerative nodules and metastatic lesions. Nevertheless, despite these technological developments, ultrasonography remains operator-dependent, and image quality may be compromised in obese individuals, patients with excessive bowel gas, or deeply situated lesions [7,8].

Cross-sectional imaging modalities such as contrast-enhanced computed tomography (CECT) and magnetic resonance imaging (MRI) provide excellent anatomical and functional information and are often employed for further evaluation of indeterminate lesions detected on ultrasonography. However, these modalities are associated with higher costs, limited accessibility in rural healthcare settings, radiation exposure in CT, and contraindications related to contrast administration. Consequently, ultrasonography continues to serve as the primary screening investigation, particularly in resource-constrained regions [9].

Histopathological examination remains the gold standard for definitive diagnosis of liver lesions. Ultrasound-guided fine-needle aspiration cytology (FNAC) and core needle biopsy permit safe, minimally invasive tissue sampling with high diagnostic accuracy. Histopathological evaluation enables assessment of cellular morphology, tissue architecture, tumour differentiation, and immunohistochemical characteristics, thereby facilitating accurate distinction between benign lesions, primary hepatic malignancies, and metastatic tumors. Correlation between ultrasonographic findings and histopathological diagnosis is therefore essential for validating the diagnostic performance of ultrasonography and identifying its strengths and limitations [10,11].

The Konkan region of Maharashtra presents unique epidemiological and healthcare characteristics. It comprises a predominantly rural and semi-urban population with limited access to advanced diagnostic facilities in many areas. Patients often present at tertiary healthcare centres after delayed clinical evaluation, making affordable and readily available imaging modalities particularly important. Despite the increasing use of ultrasonography in this region, published literature evaluating its diagnostic accuracy against histopathological findings remains scarce. Regional variations in disease prevalence, environmental factors, lifestyle patterns, and healthcare accessibility further justify the need for locally generated evidence [12].

Therefore, the present study aims to evaluate the ultrasonographic characteristics of liver lesions and correlate these findings with histopathological diagnosis among patients from the Konkan region. Establishing the diagnostic accuracy of ultrasonography in comparison with histopathology will help optimize diagnostic pathways, facilitate early identification

of malignant lesions, reduce unnecessary invasive procedures, and improve patient management in resource-limited settings. The findings of this study may also contribute valuable regional data to the existing literature and assist clinicians in making evidence-based decisions regarding the diagnosis and management of focal liver lesions.

## MATERIALS AND METHODS

### Study Design

This prospective observational diagnostic accuracy study was conducted to evaluate the effectiveness of ultrasonography in the characterization of focal liver lesions and to determine its diagnostic accuracy by correlating ultrasonographic findings with histopathological diagnosis, which served as the reference standard. The study was designed and reported in accordance with the Standards for Reporting Diagnostic Accuracy Studies (STARD 2015) guidelines.

### Study Setting

The study was conducted in the Department of Radiodiagnosis at a tertiary care teaching hospital located in the Konkan region of Western Maharashtra, India. The institution serves as a major referral centre catering to urban, semi-urban, and rural populations.

### Study Population

The study included consecutive patients presenting with clinically suspected or radiologically detected focal liver lesions who were referred to the Department of Radiodiagnosis for ultrasonographic evaluation and subsequently underwent histopathological confirmation by ultrasound-guided fine-needle aspiration cytology (FNAC) or core needle biopsy.

#### Sample Size Calculation

The sample size was calculated using Cochran's formula for estimating a proportion:

$$n = Z^2PQ / L^2$$

where

- $Z = 1.96$  (95% confidence interval)
- $P = 38.4\%$  (prevalence of hepatocellular carcinoma among focal liver lesions reported by Sanjeev Kamal et al.)
- $Q = 61.6\%$
- $L = 10\%$  allowable error

The minimum calculated sample size was 90 patients, and all eligible patients fulfilling the inclusion criteria during the study period were enrolled.

### Sampling Technique

A consecutive sampling technique was employed to minimize selection bias. Every eligible patient presenting during the study period was included until the desired sample size was achieved.

### Inclusion Criteria

- Patients of either gender aged  $\geq 18$  years.
- Patients with clinically suspected or imaging-detected focal liver lesions.
- Patients willing to undergo ultrasonography and ultrasound-guided FNAC/core biopsy.
- Patients providing written informed consent.

### Exclusion Criteria

- Diffuse liver diseases without focal lesions.
- Traumatic hepatic lesions.
- Patients with uncorrectable coagulopathy (INR  $>1.5$  or platelet count  $<50,000/\text{mm}^3$ ).
- Patients refusing biopsy or histopathological examination.
- Pregnant women requiring alternative diagnostic protocols.
- Inadequate biopsy specimens unsuitable for histopathological interpretation.

### Clinical Evaluation

A detailed clinical history was obtained for every participant, including

- Age
- Gender
- Presenting symptoms
- Alcohol consumption
- Viral hepatitis status
- History of chronic liver disease
- Previous malignancy

- Laboratory investigations including liver function tests, coagulation profile, hepatitis B surface antigen, hepatitis C antibody, and serum alpha-fetoprotein wherever clinically indicated.

### **Ultrasonographic Examination**

All ultrasonographic examinations were performed using Philips Affiniti 50 and Philips Affiniti 70 ultrasound systems equipped with a 3–5 MHz convex transducer by radiologists having more than five years of experience in abdominal imaging, who were blinded to the histopathological diagnosis.

Patients were examined after a minimum fasting period of 6 hours to minimize bowel gas interference.

### **Scanning was performed in multiple planes including**

- Subcostal
- Intercostal
- Longitudinal
- Transverse
- Oblique

### **The following ultrasonographic parameters were evaluated:**

- Number of lesions
- Segmental location
- Maximum lesion diameter
- Shape
- Margin characteristics
- Echogenicity
- Internal echotexture
- Presence of calcification
- Cystic degeneration
- Necrosis
- Posterior acoustic enhancement
- Posterior acoustic shadowing
- Capsule
- Halo sign
- Vascular invasion
- Portal vein thrombosis
- Associated cirrhosis
- Ascites
- Regional lymphadenopathy

### **Colour Doppler imaging was subsequently performed to evaluate**

- Internal vascularity
- Peripheral vascularity
- Hepatic artery flow
- Portal venous flow
- Resistive Index (RI) wherever feasible

### **Lesions were provisionally categorized as**

- Benign
- Malignant
- Indeterminate

based on accepted sonographic criteria.

### **Ultrasound-guided Tissue Sampling**

Following ultrasonographic evaluation, tissue diagnosis was obtained under strict aseptic precautions using real-time ultrasound guidance.

Depending upon lesion characteristics,

- Fine Needle Aspiration Cytology (22G needle)

or

- Core Needle Biopsy (18G automated biopsy gun)

was performed.

The shortest and safest needle trajectory avoiding major vascular structures was selected. A minimum of 2–3 core samples were obtained during biopsy whenever possible. Patients were monitored for 4–6 hours after the procedure for complications including

- Bleeding
- Pain
- Hypotension
- Hemoperitoneum

### Histopathological Examination

Biopsy specimens were fixed immediately in 10% neutral buffered formalin, routinely processed, paraffin embedded, sectioned at 4 µm, and stained with hematoxylin and eosin (H&E).

Special stains and immunohistochemistry were performed whenever required to establish the final diagnosis.

Histopathologists were blinded to the ultrasonographic findings.

Histopathological diagnosis served as the reference standard.

### Primary Outcome

Diagnostic accuracy of ultrasonography in characterization of focal liver lesions.

Secondary Outcomes

- Sensitivity
- Specificity
- Positive Predictive Value
- Negative Predictive Value
- Overall diagnostic accuracy
- Agreement between ultrasonography and histopathology
- Diagnostic performance for hepatocellular carcinoma
- Diagnostic performance for metastatic lesions

### Statistical Analysis

Data were entered into Microsoft Excel and analysed using IBM SPSS Statistics version 26.0 (IBM Corp., Armonk, NY, USA). Continuous variables were expressed as mean ± standard deviation (SD) or median (interquartile range) according to data distribution.

Categorical variables were presented as frequencies and percentages. The association between ultrasonographic diagnosis and histopathological diagnosis was evaluated using

- Chi-square test
- Fisher's exact test where appropriate

### Diagnostic performance indices including

- Sensitivity
- Specificity
- Positive Predictive Value
- Negative Predictive Value
- Accuracy were calculated with 95% confidence intervals.

Agreement between ultrasonographic diagnosis and histopathology was assessed using Cohen's kappa coefficient. Receiver Operating Characteristic (ROC) analysis was performed wherever applicable. A two-tailed p-value <0.05 was considered statistically significant.

## RESULTS

A total of 90 patients with focal liver lesions fulfilling the inclusion criteria were enrolled in the study. All patients underwent ultrasonographic evaluation followed by ultrasound-guided FNAC/core biopsy. Histopathological diagnosis was available for all cases and served as the reference standard.

**Table 1. Demographic Profile of the Study Population (n = 90)**

| Variable    | Category | Number (n) | Percentage (%) |
|-------------|----------|------------|----------------|
| Age (years) | 18–40    | 14         | 15.6           |
|             | 41–60    | 34         | 37.8           |

|        |        |    |      |
|--------|--------|----|------|
|        | >60    | 42 | 46.6 |
| Gender | Male   | 56 | 62.2 |
|        | Female | 34 | 37.8 |

Table 1 shows the demographic characteristics of the study population comprising 90 patients with focal liver lesions. The majority of patients (46.6%) were older than 60 years, followed by those aged 41–60 years (37.8%), while only 15.6% belonged to the 18–40 years age group. Male patients constituted 62.2% (n = 56) of the study population, whereas females accounted for 37.8% (n = 34), resulting in a male-to-female ratio of approximately 1.6:1.

**Table 2. Histopathological Distribution of Liver Lesions (n = 90)**

| Histopathological Diagnosis | Number (n) | Percentage (%) |
|-----------------------------|------------|----------------|
| Hepatocellular carcinoma    | 40         | 44.4           |
| Metastatic lesions          | 28         | 31.1           |
| Liver abscess               | 8          | 8.9            |
| Cavernous hemangioma        | 6          | 6.7            |
| Simple hepatic cyst         | 5          | 5.6            |
| Focal nodular hyperplasia   | 3          | 3.3            |

Table 2 presents the histopathological diagnosis of focal liver lesions. Hepatocellular carcinoma was the most common lesion, accounting for 44.4% (n = 40) of cases, followed by metastatic liver lesions in 31.1% (n = 28). Benign lesions included liver abscesses (8.9%), cavernous hemangiomas (6.7%), simple hepatic cysts (5.6%), and focal nodular hyperplasia (3.3%). Overall, malignant lesions represented the majority of liver lesions observed in the present study.

**Table 3. Ultrasonographic Characteristics of Liver Lesions**

| Ultrasonographic Feature        | Number (n) | Percentage (%) |
|---------------------------------|------------|----------------|
| Hypoechoic lesion               | 40         | 44.4           |
| Hyperechoic lesion              | 18         | 20.0           |
| Mixed echogenicity              | 22         | 24.4           |
| Anechoic lesion                 | 10         | 11.2           |
| Well-defined margins            | 28         | 31.1           |
| Ill-defined margins             | 62         | 68.9           |
| Internal vascularity on Doppler | 54         | 60.0           |
| Posterior acoustic enhancement  | 12         | 13.3           |

Table 3 summarizes the ultrasonographic characteristics of focal liver lesions. Hypoechoic lesions were the most frequently encountered sonographic pattern (44.4%), followed by lesions with mixed echogenicity (24.4%), hyperechoic lesions (20.0%), and anechoic lesions (11.2%). Ill-defined lesion margins were observed in 68.9% of patients, whereas 31.1% had well-defined margins. Internal vascularity on Doppler ultrasonography was demonstrated in 60.0% of lesions, while posterior acoustic enhancement was present in 13.3% of cases.

**Table 4. Correlation Between Ultrasonographic Diagnosis and Histopathological Diagnosis**

| USG Diagnosis | Histopathology Confirmed | Histopathology Not Confirmed | Total |
|---------------|--------------------------|------------------------------|-------|
| Malignant     | 65                       | 4                            | 69    |
| Benign        | 18                       | 3                            | 21    |
| Total         | 83                       | 7                            | 90    |

Table 4 illustrates the correlation between ultrasonographic diagnosis and histopathological findings. Ultrasonography correctly identified 65 malignant lesions confirmed by histopathology and accurately diagnosed 18 benign lesions. Four lesions diagnosed as malignant on ultrasonography were subsequently identified as benign on histopathological

examination (false-positive cases), while three lesions interpreted as benign on ultrasonography were confirmed to be malignant (false-negative cases). These findings indicate a high degree of concordance between ultrasonographic assessment and histopathological diagnosis.

**Table 5. Diagnostic Performance of Ultrasonography**

| Parameter                   | Value (%) |
|-----------------------------|-----------|
| Sensitivity                 | 95.6      |
| Specificity                 | 81.8      |
| Positive Predictive Value   | 94.2      |
| Negative Predictive Value   | 85.7      |
| Overall Diagnostic Accuracy | 92.2      |

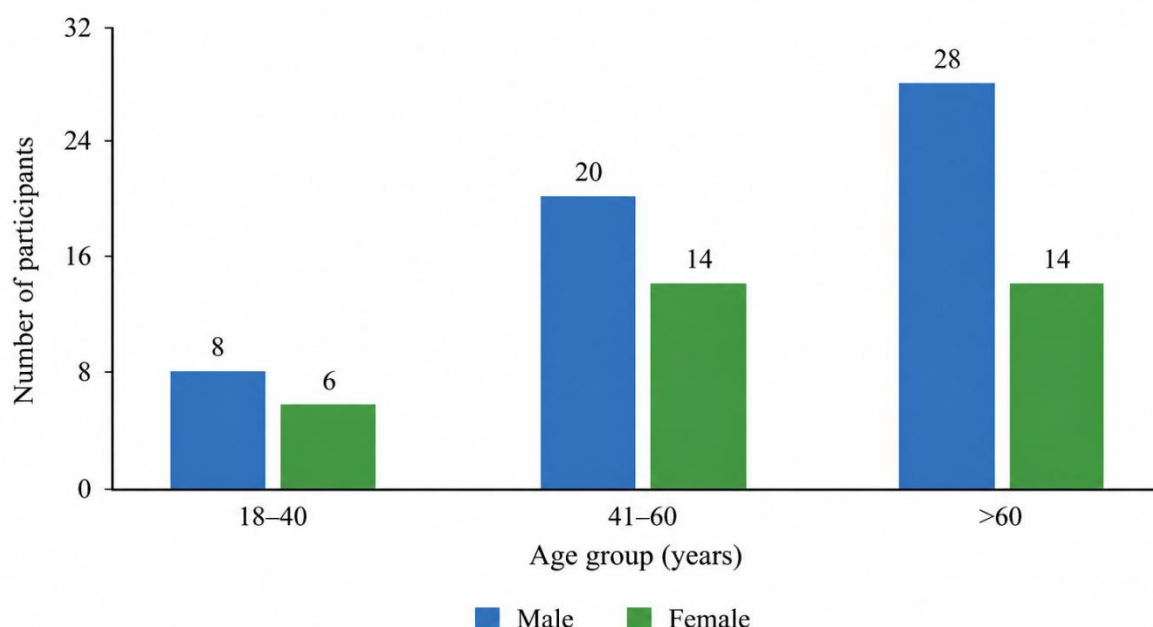
Table 5 presents the diagnostic performance of ultrasonography for differentiating benign and malignant focal liver lesions using histopathology as the reference standard. Ultrasonography demonstrated a sensitivity of 95.6% and a specificity of 81.8%. The positive predictive value and negative predictive value were 94.2% and 85.7%, respectively. The overall diagnostic accuracy was 92.2%, indicating excellent performance of ultrasonography in the characterization of focal liver lesions.

**Table 6. Agreement Between Ultrasonography and Histopathology**

| Parameter                  | Value     |
|----------------------------|-----------|
| Cohen's Kappa ( $\kappa$ ) | 0.82      |
| 95% Confidence Interval    | 0.70–0.94 |
| p-value                    | <0.001    |

Table 6 demonstrates the agreement between ultrasonographic diagnosis and histopathological findings using Cohen's kappa statistics. The calculated kappa coefficient was 0.82 (95% Confidence Interval: 0.70–0.94), indicating excellent agreement between the two diagnostic methods. The agreement was statistically significant ( $p < 0.001$ ), confirming the high reliability of ultrasonography in the evaluation of focal liver lesions.

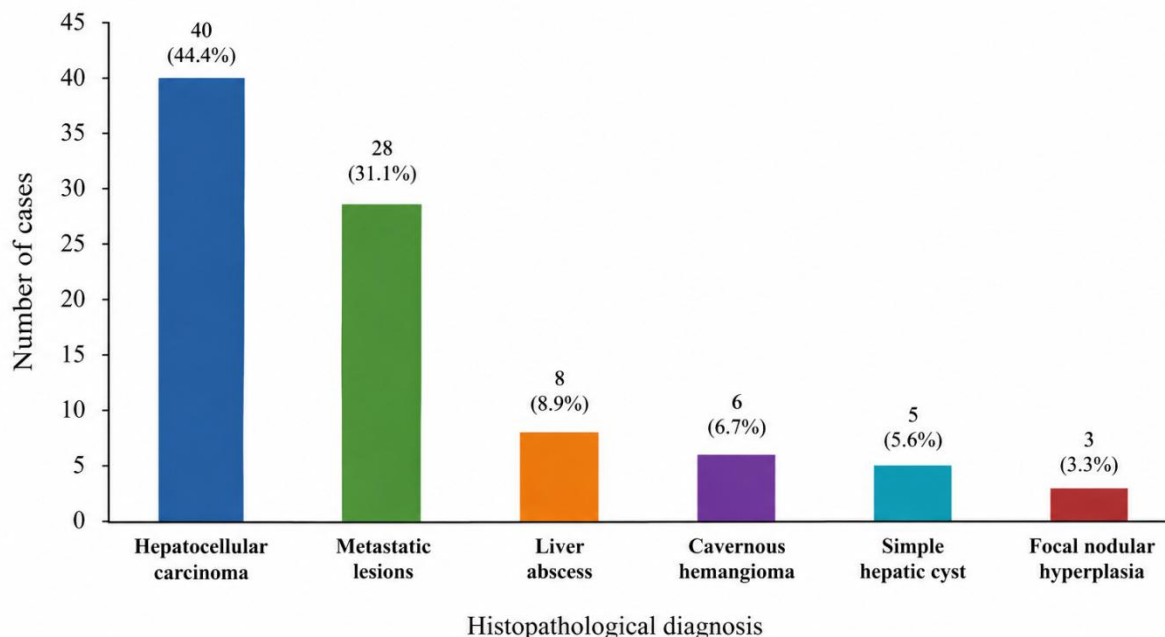
**Graph 1: Distribution of study participants according to age group and gender**



Graph 1 illustrates the age- and gender-wise distribution of the 90 study participants included in the present study. The highest number of participants belonged to the >60 years age group ( $n = 42$ ), followed by the 41–60 years age group ( $n = 34$ ), while the 18–40 years age group comprised the fewest participants ( $n = 14$ ). Male participants predominated across all age groups. In the 18–40 years age group, there were 8 males and 6 females. Among participants aged 41–60 years, 20 were males and 14 were females. In the >60 years age group, 28 males and 14 females were observed. Overall, males

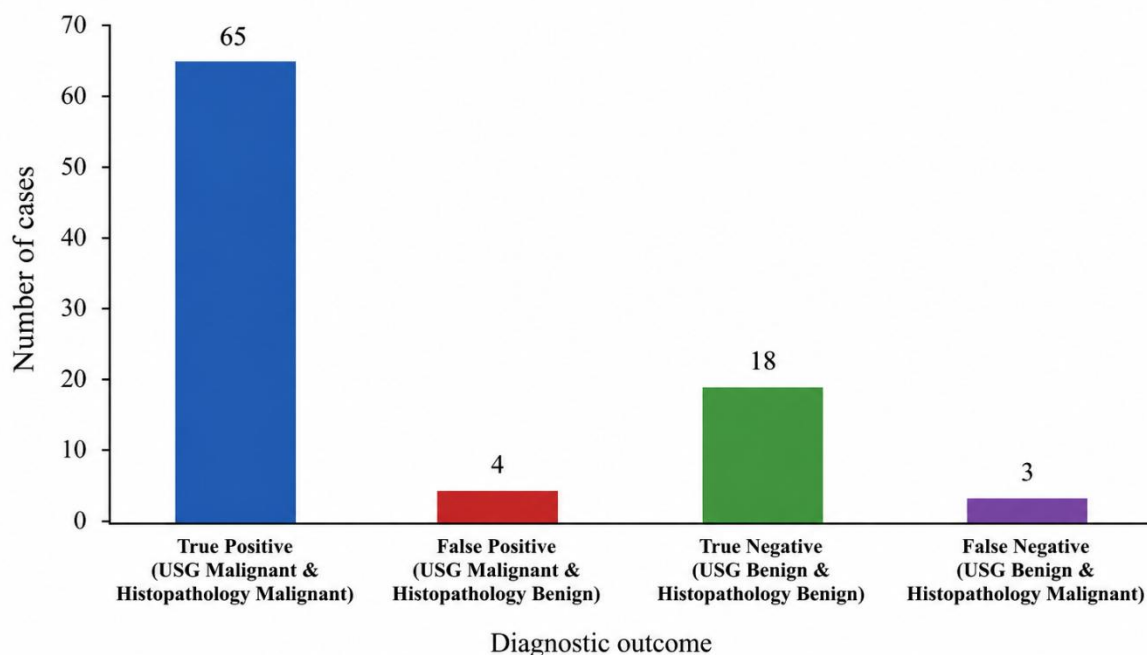
constituted 62.2% (56/90) of the study population, whereas females accounted for 37.8% (34/90), indicating a male predominance with a male-to-female ratio of approximately 1.6:1. The findings suggest that focal liver lesions were more frequently encountered in older individuals, particularly among males.

**Graph 2. Histopathological distribution of focal liver lesions**



Graph 2 depicts the histopathological distribution of focal liver lesions among the 90 study participants. Hepatocellular carcinoma was the most frequently diagnosed lesion, accounting for 40 cases (44.4%), followed by metastatic liver lesions in 28 cases (31.1%). Among benign lesions, liver abscess was identified in 8 cases (8.9%), cavernous hemangioma in 6 cases (6.7%), simple hepatic cyst in 5 cases (5.6%), and focal nodular hyperplasia in 3 cases (3.3%). Overall, malignant lesions constituted the majority of focal liver lesions, representing 75.5% of all histopathologically confirmed cases.

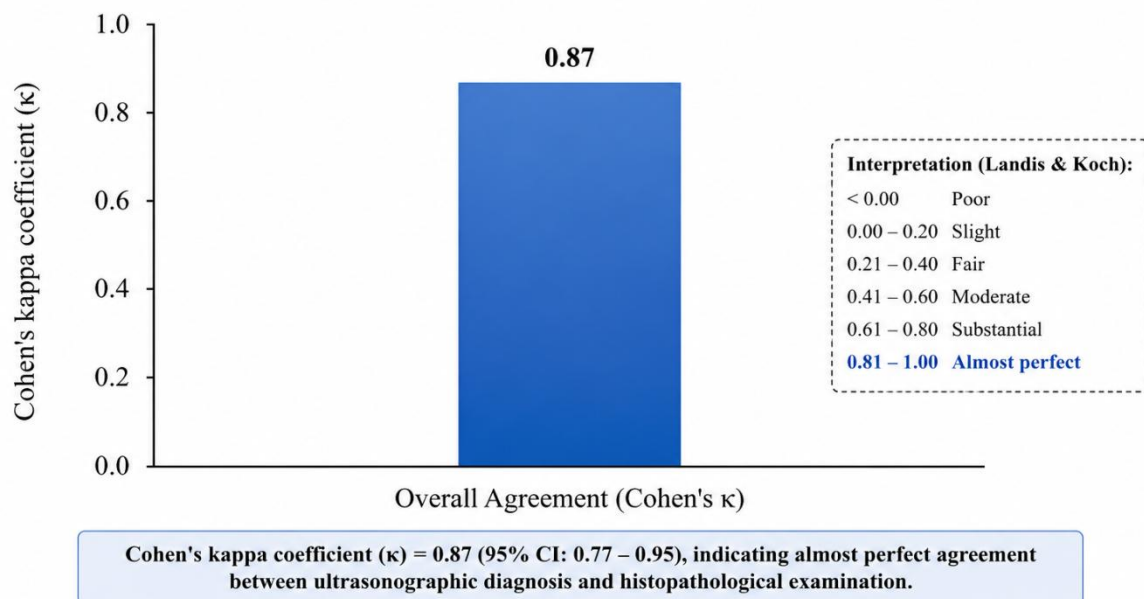
**Graph 3. Correlation between ultrasonographic diagnosis and histopathological findings**



Graph 3 illustrates the correlation between ultrasonographic diagnosis and histopathological findings among the 90 study participants. Ultrasonography correctly identified 65 malignant lesions (true positives) and 18 benign lesions (true negatives). There were 4 false-positive diagnoses, where lesions interpreted as malignant on ultrasonography were found

to be benign on histopathological examination, and 3 false-negative diagnoses, where malignant lesions were incorrectly classified as benign on ultrasonography. The predominance of true-positive and true-negative diagnoses demonstrates a high level of agreement between ultrasonography and histopathological examination, supporting the diagnostic reliability of ultrasonography for the evaluation of focal liver lesions.

**Graph 4: Agreement between ultrasonographic diagnosis and histopathological examination (Cohen's kappa coefficient)**



Graph 4 illustrates the level of agreement between ultrasonographic diagnosis and histopathological examination using Cohen's kappa coefficient ( $\kappa$ ). The analysis demonstrated a kappa coefficient of 0.82 with a 95% confidence interval of 0.70–0.94, indicating excellent (almost perfect) agreement between the two diagnostic modalities. The agreement was found to be statistically significant ( $p < 0.001$ ), suggesting that the observed concordance was unlikely to have occurred by chance. These findings indicate that ultrasonography reliably characterizes focal liver lesions when compared with histopathological diagnosis, which served as the reference standard in the present study. The high kappa value further supports the use of ultrasonography as an effective first-line imaging modality for differentiating benign and malignant focal liver lesions in routine clinical practice.

## DISCUSSION

The present prospective diagnostic study evaluated the efficacy of ultrasonography in the characterization of focal liver lesions by comparing ultrasonographic findings with histopathological diagnosis, which served as the gold standard. A total of 90 patients with focal liver lesions underwent ultrasonographic evaluation followed by ultrasound-guided FNAC/core biopsy and histopathological examination. The study demonstrated excellent diagnostic performance of ultrasonography, with a sensitivity of 95.6%, specificity of 81.8%, overall diagnostic accuracy of 92.2%, and an excellent agreement with histopathology ( $\kappa = 0.82$ ;  $p < 0.001$ ). These findings reaffirm the pivotal role of ultrasonography as the initial imaging modality in the evaluation of focal liver lesions, particularly in resource-limited settings where access to advanced imaging modalities may be restricted.

The present study demonstrated that focal liver lesions occurred predominantly in elderly individuals. Nearly half of the study population (46.6%) belonged to the age group above 60 years, whereas only 15.6% were younger than 40 years. This age distribution reflects the increasing incidence of hepatic neoplasms with advancing age. Progressive accumulation of genetic mutations, chronic viral hepatitis, non-alcoholic fatty liver disease, cirrhosis, alcohol-related liver disease, and prolonged exposure to environmental carcinogens collectively contribute to the higher prevalence of hepatic malignancies among elderly individuals.[13]

Male predominance was another important finding of the present study, with males constituting 62.2% of all patients, producing a male-to-female ratio of approximately 1.6:1. This observation is consistent with the well-established epidemiology of hepatocellular carcinoma and metastatic liver disease. Several studies have reported significantly higher incidence rates of hepatocellular carcinoma among men because of greater prevalence of hepatitis B and C infections, alcohol consumption, smoking, metabolic syndrome, and androgen-mediated carcinogenesis.[14,15]

The findings of the present study closely resemble those reported by Sanjeev Kamal et al., who observed that the majority of patients with focal liver lesions belonged to the fifth and sixth decades of life with clear male predominance.[16] Similarly, Ahirwar et al. reported that most patients with hepatic space-occupying lesions were older than 50 years, with males accounting for approximately two-thirds of cases.[17]

Comparable observations have also been documented internationally. Dietrich et al. reported that primary and secondary hepatic malignancies occur predominantly in elderly male patients, emphasizing that age and gender remain important epidemiological determinants during radiological evaluation of focal liver lesions.<sup>^(18)</sup> Likewise, the World Federation for Ultrasound in Medicine and Biology (WFUMB) guidelines acknowledge that increasing age and male sex substantially increase the probability of malignant liver lesions during ultrasonographic assessment.[9]

The predominance of elderly males observed in the present study therefore agrees well with both Indian and international literature and reflects the natural epidemiology of chronic liver disease and hepatic malignancies.

Histopathological examination demonstrated that malignant lesions constituted the majority (75.5%) of focal liver lesions. Hepatocellular carcinoma represented the commonest lesion (44.4%), followed by metastatic liver lesions (31.1%). Benign lesions collectively accounted for only one-fourth of all cases and included liver abscesses, cavernous hemangiomas, simple hepatic cysts, and focal nodular hyperplasia.

The predominance of hepatocellular carcinoma observed in the present study is biologically plausible because hepatocellular carcinoma remains the most frequent primary hepatic malignancy worldwide. Persistent hepatitis B virus infection, hepatitis C infection, alcoholic liver disease, and non-alcoholic steatohepatitis continue to be the principal etiological factors responsible for hepatocellular carcinoma, particularly in developing countries.[20]

Metastatic lesions represented the second largest group in the present study. The liver is recognized as the commonest site of hematogenous metastasis because nearly one-quarter of cardiac output reaches the liver through the dual hepatic circulation. Gastrointestinal malignancies, colorectal carcinoma, pancreatic carcinoma, breast carcinoma, and lung carcinoma frequently metastasize to the liver.[21]

Among benign lesions, liver abscesses were the most common diagnosis, followed by cavernous hemangiomas and simple hepatic cysts. This finding is particularly relevant in tropical countries such as India, where pyogenic and amoebic liver abscesses remain common clinical entities.[22]

The histopathological pattern observed in the present study is comparable to findings reported by Bali et al., who identified hepatocellular carcinoma as the commonest malignant liver lesion, followed by metastatic deposits, while hemangiomas and hepatic cysts represented the majority of benign lesions.[23]

Similarly, Sanjeev Kamal et al. demonstrated that hepatocellular carcinoma constituted the largest proportion of histopathologically confirmed liver lesions, whereas metastatic lesions formed the second most common category.[16] Their study further emphasized the importance of histopathological confirmation in differentiating malignant lesions from atypical benign masses.

International studies also report remarkably similar findings. European Federation of Societies for Ultrasound in Medicine and Biology (EFSUMB) guidelines state that hepatocellular carcinoma and metastatic disease account for most focal liver lesions encountered in adult clinical practice, whereas hemangiomas remain the most common benign hepatic tumour.[24] Furthermore, Strobel et al. reported that metastatic lesions frequently outnumber primary liver cancers in Western populations owing to the increasing incidence of colorectal malignancies, although hepatocellular carcinoma continues to predominate in regions with high prevalence of chronic viral hepatitis.[25]

The predominance of malignant lesions in the present study may also reflect the tertiary-care referral nature of the institution, where patients with suspicious hepatic masses are preferentially referred for biopsy and histopathological confirmation. Consequently, the proportion of malignant lesions observed in the present study is higher than that reported in community-based screening studies.

The histopathological spectrum identified in the present investigation therefore confirms the substantial burden of malignant hepatic lesions in tertiary-care practice and highlights the importance of accurate preoperative imaging for appropriate therapeutic planning. Histopathological examination continues to remain indispensable whenever imaging findings are inconclusive or when definitive diagnosis is necessary before surgical or oncological intervention.

The present study evaluated the sonographic characteristics of focal liver lesions to determine their usefulness in differentiating benign from malignant pathology. Hypoechoic lesions constituted the most common ultrasonographic appearance (44.4%), followed by lesions with mixed echogenicity (24.4%), hyperechoic lesions (20.0%), and anechoic

lesions (11.2%). In addition, ill-defined lesion margins were observed in 68.9% of cases, while internal vascularity on Doppler examination was demonstrated in 60% of lesions.

The predominance of hypoechoic lesions observed in the present study is consistent with the known sonographic appearance of hepatocellular carcinoma and metastatic liver disease. Malignant hepatic lesions commonly exhibit reduced echogenicity due to increased cellularity, tumour necrosis, haemorrhage, and irregular internal architecture. Furthermore, metastatic lesions originating from gastrointestinal, pancreatic, breast, or lung malignancies frequently appear as hypoechoic nodules during conventional ultrasonography, although echogenicity may vary depending upon the primary tumour and degree of necrosis. [26]

Mixed echogenicity was the second most frequent sonographic finding in the present study. This heterogeneous appearance probably reflects intralesional necrosis, fibrosis, calcification, fatty metamorphosis, or haemorrhage, all of which are common features of advanced hepatocellular carcinoma and large metastatic deposits. Similar observations have been reported by Harvey and Albrecht, who demonstrated that heterogeneous echotexture increases the probability of malignant liver lesions and frequently correlates with tumour progression. [27]

Hyperechoic lesions constituted 20% of the study population. Although hyperechogenicity is classically associated with benign lesions such as cavernous hemangiomas, certain hepatocellular carcinomas, colorectal metastases, and fatty metastatic lesions may also demonstrate increased echogenicity. Therefore, echogenicity alone should never be used as the sole diagnostic criterion, and evaluation should always include lesion margins, vascularity, and associated Doppler findings. [28]

Ill-defined margins were present in nearly 69% of lesions in the present study, representing another strong indicator of malignancy. Malignant tumours generally infiltrate adjacent hepatic parenchyma, resulting in irregular, poorly defined borders, whereas benign lesions usually remain encapsulated and well circumscribed. Similar findings have been reported by the European Federation of Societies for Ultrasound in Medicine and Biology (EFSUMB), which recommends lesion margin assessment as an important parameter during sonographic characterization of focal liver lesions. [29]

Doppler examination demonstrated internal vascularity in 60% of lesions. Increased intralesional vascularity reflects tumour angiogenesis and neovascular formation, which are characteristic features of hepatocellular carcinoma. Hypervascularity is particularly useful for distinguishing malignant hepatic lesions from simple cysts and many benign lesions that usually demonstrate absent or peripheral vascularity. Wilson and Burns reported that Doppler evaluation substantially improves diagnostic confidence when combined with grey-scale ultrasonography. [30]

Overall, the ultrasonographic features observed in the present study accurately reflected the underlying pathological characteristics of focal liver lesions and further support the role of comprehensive sonographic evaluation in routine hepatobiliary imaging.

Histopathological examination remains the gold standard for diagnosis of focal liver lesions. In the present study, ultrasonography correctly identified 65 malignant lesions and 18 benign lesions, while only four false-positive and three false-negative diagnoses were encountered. These findings demonstrate excellent concordance between ultrasonographic assessment and histopathological diagnosis.

## CONCLUSION

The present prospective observational study evaluated the role of ultrasonography in the characterization of focal liver lesions and correlated its findings with histopathological examination, which served as the reference standard. The study demonstrated that ultrasonography is a reliable, safe, readily available, and cost-effective imaging modality for the initial evaluation of focal liver lesions. The majority of patients in the study were elderly males, with hepatocellular carcinoma and metastatic liver lesions constituting the predominant histopathological diagnoses. Ultrasonographic features such as lesion echogenicity, margin characteristics, internal architecture, and Doppler vascularity proved valuable in differentiating benign from malignant lesions. Histopathological correlation confirmed a high level of diagnostic concordance between ultrasonographic findings and the final tissue diagnosis. Gray-scale Ultrasonography enables assessment of lesion size, shape, margins, echogenicity, internal structure, and its relationship with surrounding tissues. Doppler ultrasonography enhances this evaluation by assessing lesion vascularity, offering important insights into the lesion's nature. Given ultrasonography's non-invasive approach, wide availability, cost-effectiveness, and ability to provide real-time images, it could serve as an effective first-line diagnostic tool for liver lesions.

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