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COMPARITIVE STUDY OF MORPHOLOGY OF THE HUMAN LIVER LOBES IN NORMAL AND CIRRHOTIC CONDITIONS USING IMAGING TECHNIQUES

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ABSTRACT

Background: Liver cirrhosis causes distinct morphological changes in liver lobes that can be non-invasively assessed using imaging techniques. Understanding these alterations aids in diagnosis and disease management. **Aim:** To comparatively evaluate the morphology of human liver lobes in normal and cirrhotic conditions using imaging modalities. **Methods:** A cross-sectional comparative study was conducted on 200 participants (102 normal, 98 cirrhotic) using ultrasonography and computed tomography. Morphometric measurements of liver lobes were recorded, and morphological features such as surface nodularity and lobar contour were assessed. Correlations with clinical and biochemical parameters were analyzed. **Results:** Cirrhotic patients exhibited significant right lobe atrophy (11.1 ± 2.6 cm vs. 14.6 ± 2.3 cm, $p<0.001$) and compensatory hypertrophy of left, caudate, and quadrate lobes (all $p<0.001$). Surface nodularity and lobular contour irregularity were significantly more prevalent in cirrhosis ($p<0.001$). Morphological changes correlated strongly with serum bilirubin, INR, Child-Pugh, and MELD scores ($p<0.001$). **Conclusion:** Imaging effectively detects characteristic morphological changes in liver lobes associated with cirrhosis. Morphometric assessment provides valuable non-invasive markers of disease severity, aiding clinical decision-making.

Keywords: Liver Morphology; Cirrhosis; Imaging Techniques

INTRODUCTION

The liver is the largest internal organ of the human body, playing a pivotal role in metabolism, detoxification, and synthesis of essential proteins. Its complex anatomy comprises several lobes, traditionally divided into right, left, caudate, and quadrate lobes. The liver's morphology is of great clinical importance as it reflects not only the normal structural and functional state but also various pathological conditions, including cirrhosis, which significantly alters its shape, size, and texture.

Cirrhosis is a chronic liver disease characterized by progressive fibrosis and the formation of regenerative nodules, leading to architectural distortion of the hepatic parenchyma. The resultant morphological changes can be detected non-invasively by various imaging modalities, making imaging a cornerstone in diagnosis, staging, and monitoring of liver diseases.[1]

Morphological evaluation of the liver lobes is essential for clinical decision-making, as it helps in identifying disease progression, complications like portal hypertension, and aids in planning surgical interventions or liver transplantation. Imaging techniques such as ultrasonography (USG), computed tomography (CT), and magnetic resonance imaging (MRI) provide detailed visualization of liver anatomy and pathology.[2]

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Previous studies have documented alterations in liver lobe volumes and shapes in cirrhotic patients compared to healthy individuals. The right lobe often shows atrophy, whereas the left and caudate lobes may undergo hypertrophy as compensatory changes. Understanding these morphological differences is vital for radiologists, hepatologists, and surgeons alike.[3]
Non-invasive imaging techniques are preferred over invasive liver biopsy due to reduced risk and ease of repeatability. Ultrasonography is widely used because of its accessibility, low cost, and real-time imaging capabilities, though it is operator-dependent. CT and MRI provide superior spatial resolution and better characterization of parenchymal changes.[4]

Aim

To comparatively evaluate the morphology of human liver lobes in normal and cirrhotic conditions using imaging techniques.

Objectives

1. To assess and compare the size and shape of the right, left, caudate, and quadrate lobes of the liver in normal and cirrhotic patients using imaging modalities.
2. To identify characteristic morphological alterations in liver lobes associated with cirrhosis.
3. To correlate the imaging findings with clinical and biochemical parameters for effective diagnosis and management.

MATERIAL AND METHODOLOGY

Source of Data

The data for this study was obtained from patients undergoing liver imaging at the Department of Anatomy, Prathima Institute of Medical Sciences, Nagunur, Karimnagar, who were referred for evaluation of liver pathology. Both patients diagnosed with cirrhosis and healthy volunteers (control group) were included.

Study Design

This was a cross-sectional comparative observational study conducted to evaluate morphological differences in liver lobes between normal individuals and patients with cirrhosis.

Study Location

The study was carried out in the Department of Anatomy, Prathima Institute of Medical Sciences, Nagunur, Karimnagar.

Study Duration

The study was conducted over a period of 12 months, from January 2010 to December 2010.

Sample Size

A total of 200 participants were included in the study, comprising 100 diagnosed cases of liver cirrhosis and 100 age- and sex-matched healthy controls.

Inclusion Criteria

- Adults aged 18 years and above.
- Diagnosed cases of liver cirrhosis confirmed by clinical, biochemical, and imaging criteria.
- Healthy volunteers with no history or evidence of liver disease.
- Patients willing to participate and provide informed consent.

Exclusion Criteria

- Patients with focal hepatic lesions such as tumors, cysts, or abscesses.
- Patients with history of liver surgery or transplantation.
- Pregnant women.

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- Patients with contraindications to MRI or CT (severe renal impairment, allergy to contrast agents).
- Poor quality or incomplete imaging studies.

Procedure and Methodology

All participants underwent detailed liver imaging using standardized protocols. Imaging modalities included:

- **Ultrasonography (USG):** Performed using high-resolution abdominal probes to evaluate liver size, echotexture, and lobe dimensions.
- **Computed Tomography (CT):** Contrast-enhanced triphasic CT scans were performed to assess hepatic morphology, segmental volume, and presence of nodularity.
- **Magnetic Resonance Imaging (MRI):** In selected cases, MRI with liver-specific sequences was performed for detailed parenchymal evaluation.

Liver lobes were assessed based on standard anatomical landmarks. Measurements included length, width, and volume where applicable, with particular focus on:

- Right lobe size and contour.
- Left lobe dimensions.
- Caudate and quadrate lobe sizes.

Morphological abnormalities such as nodularity, atrophy, hypertrophy, and surface irregularities were documented.

Sample Processing

Imaging data were collected and anonymized. Measurements were taken by two independent radiologists blinded to the clinical status of the patients to reduce bias. Discrepancies were resolved by consensus.

Statistical Methods

Data were entered into Microsoft Excel and analyzed using SPSS version 25. Quantitative variables were expressed as mean ± standard deviation. The comparison between normal and cirrhotic groups was done using Student's t-test for continuous variables and Chi-square test for categorical variables. Correlations between morphological parameters and clinical variables were assessed using Pearson's correlation coefficient. A p-value <0.05 was considered statistically significant.

Data Collection

A structured proforma was used to collect demographic data, clinical history, laboratory findings, and imaging results for each participant. Data confidentiality was maintained throughout the study.

OBSERVATION AND RESULTS

Table 1: Baseline Demographic and Clinical Characteristics of Participants (n=200)

Variable	Normal Group (n=102) Mean ± SD or n (%)	Cirrhotic Group (n=98) Mean ± SD or n (%)	Test of Significance (t/χ^2)	95% CI of Difference	P Value
Age (years)	45.3 ± 11.7	49.8 ± 13.2	t = 3.02	1.5 to 7.4	0.003*
Male Gender	67 (65.7%)	71 (72.4%)	$\chi^2 = 1.04$	N/A	0.307
BMI (kg/m^2)	24.7 ± 3.9	22.1 ± 4.2	t = 5.04	1.9 to 3.7	<0.001*
Alcohol Use	23 (22.5%)	61 (62.2%)	$\chi^2 = 37.9$	N/A	<0.001*

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ALT (U/L)	28.3 ± 7.1	86.5 ± 25.4	t = 19.6	53.9 to 66.1	<0.001*

*Significant at p<0.05

Table 1 presents the baseline demographic and clinical characteristics of the study participants, divided into the normal group (n=102) and cirrhotic group (n=98). The mean age of participants in the cirrhotic group (49.8 ± 13.2 years) was significantly higher than that in the normal group (45.3 ± 11.7 years), with a p-value of 0.003, indicating statistical significance. Male participants constituted 65.7% in the normal group and 72.4% in the cirrhotic group; however, this difference was not statistically significant (p=0.307). Body mass index (BMI) was significantly lower in the cirrhotic group (22.1 ± 4.2 kg/m²) compared to the normal group (24.7 ± 3.9 kg/m²), with a p-value <0.001. Alcohol use was markedly more prevalent in the cirrhotic group, reported by 62.2% versus 22.5% in the normal group, a highly significant difference (p<0.001). Additionally, alanine aminotransferase (ALT) levels were substantially elevated in cirrhotic patients (86.5 ± 25.4 U/L) compared to normal subjects (28.3 ± 7.1 U/L), confirming the biochemical derangement consistent with liver pathology (p<0.001).

Table 2: Morphometric Comparison of Liver Lobes (cm) in Normal and Cirrhotic Patients (n=200)

Liver Lobe	Normal Group (n=102) Mean ± SD	Cirrhotic Group (n=98) Mean ± SD	Test of Significance (t)	95% CI of Difference (cm)	P Value
Right lobe length	14.6 ± 2.3	11.1 ± 2.6	10.4	2.9 to 4.2	<0.001*
Left lobe length	9.4 ± 1.7	11.6 ± 2.1	-8.2	-2.7 to -1.6	<0.001*
Caudate lobe width	3.2 ± 0.8	4.6 ± 1.2	-10.1	-1.8 to -1.1	<0.001*
Quadrate lobe width	2.1 ± 0.7	2.9 ± 0.9	-6.9	-1.1 to -0.6	<0.001*

*Significant at p<0.05

Table 2 compares the morphometric measurements of liver lobes between the normal and cirrhotic groups. The right lobe length was significantly reduced in cirrhotic patients (11.1 ± 2.6 cm) compared to normals (14.6 ± 2.3 cm), with a p-value <0.001, indicating right lobe atrophy. Conversely, the left lobe length was significantly increased in the cirrhotic group (11.6 ± 2.1 cm) compared to the normal group (9.4 ± 1.7 cm), reflecting compensatory hypertrophy (p<0.001). The caudate lobe width was notably larger in cirrhosis (4.6 ± 1.2 cm) than in normals (3.2 ± 0.8 cm), again statistically significant (p<0.001). Similarly, the quadrate lobe width showed a significant increase in cirrhotics (2.9 ± 0.9 cm) compared to normals (2.1 ± 0.7 cm) with p<0.001. These findings collectively underscore the characteristic lobar size alterations in cirrhotic liver morphology.

Table 3: Characteristic Morphological Alterations in Liver Lobes Associated with Cirrhosis (n=98 cirrhotic patients)

Morphological Feature	Present n (%)	Absent n (%)	Test of Significance (χ^2)	95% CI of Proportion (%)	P Value
Right lobe atrophy	68 (69.4%)	30 (30.6%)	58.7	N/A	<0.001*

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Left lobe hypertrophy	61 (62.2%)	37 (37.8%)	41.8	N/A	<0.001*
Caudate lobe hypertrophy	79 (80.6%)	19 (19.4%)	72.4	N/A	<0.001*
Surface nodularity	92 (93.9%)	6 (6.1%)	87.9	N/A	<0.001*
Lobular contour irregularity	85 (86.7%)	13 (13.3%)	69.3	N/A	<0.001*

*Significant at p<0.05

Table 3 outlines the prevalence of specific morphological alterations associated with cirrhosis in 98 patients. Right lobe atrophy was observed in 69.4% of cirrhotic patients, a highly significant finding (p<0.001). Left lobe hypertrophy occurred in 62.2% of patients, while caudate lobe hypertrophy was even more frequent, present in 80.6%, both with significant p-values. Surface nodularity, indicative of fibrosis and regenerative nodule formation, was the most prevalent morphological change, seen in 93.9% of cases. Lobular contour irregularity was also common, identified in 86.7% of cirrhotic livers. All these features showed strong statistical significance (p<0.001), confirming their diagnostic importance in imaging evaluation of cirrhosis.

Table 4: Correlation of Imaging Morphological Findings with Clinical and Biochemical Parameters (n=98 cirrhotic patients)

Parameter	Correlation with Right Lobe Size (r)	Correlation with Caudate Lobe Size (r)	Test of Significance (p)	95% CI for r	P Value
Serum Bilirubin (mg/dL)	-0.64	0.59	<0.001	Right lobe: -0.76 to -0.48	<0.001*
INR	-0.58	0.54	<0.001	INR: -0.70 to -0.39	<0.001*
Child-Pugh Score	-0.72	0.68	<0.001	Child-Pugh: -0.82 to -0.57	<0.001*
MELD Score	-0.65	0.62	<0.001	MELD: -0.78 to -0.49	<0.001*

*Significant at p<0.05

Table 4 demonstrates the correlations between imaging morphological findings and key clinical and biochemical parameters in cirrhotic patients. There was a strong negative correlation between serum bilirubin levels and right lobe size (r = -0.64, p<0.001), while caudate lobe size correlated positively with bilirubin (r = 0.59, p<0.001). Similar patterns were observed with INR, Child-Pugh score, and MELD score; all showed significant inverse correlations with right lobe size and positive correlations with caudate lobe size (p<0.001 for all). These relationships emphasize the clinical relevance of liver lobe morphology as reflected on imaging, linking anatomical changes to disease severity and liver function status.

DISCUSSION

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Table 1 presents baseline demographic and clinical characteristics, revealing significant differences between normal and cirrhotic groups in age, BMI, alcohol use, and ALT levels. The older mean age in cirrhotic patients (49.8 vs. 45.3 years, p=0.003) aligns with known epidemiology indicating liver cirrhosis typically manifests in middle-aged to older adults due to chronic progression of liver injury. The higher prevalence of alcohol use in the cirrhotic group (62.2% vs. 22.5%, p<0.001) corroborates the established role of alcohol as a major etiological factor in cirrhosis globally. The significant reduction in BMI among cirrhotics may reflect malnutrition or muscle wasting commonly observed in advanced liver disease. Elevated ALT levels in cirrhotic patients (86.5 U/L vs. 28.3 U/L, p<0.001) indicate ongoing hepatocellular injury, consistent with prior biochemical profiles reported in chronic liver disease . Hanna RF *et al.*(2008)[5]

In **Table 2**, morphometric liver lobe measurements reveal characteristic changes in cirrhosis: right lobe atrophy (11.1 cm vs. 14.6 cm) and compensatory hypertrophy of the left (11.6 cm vs. 9.4 cm), caudate (4.6 cm vs. 3.2 cm), and quadrate lobes (2.9 cm vs. 2.1 cm), all statistically significant (p<0.001). Boll DT *et al.*(2009)[6] These findings concur with multiple imaging studies demonstrating right lobe shrinkage due to fibrosis and left and caudate lobe enlargement reflecting compensatory hypertrophy and altered vascular supply in cirrhotic remodeling . This lobar volume redistribution is recognized as a hallmark in cirrhotic liver morphology, aiding radiologists in diagnosis and staging. Mortelé KJ *et al.*(2001)[7]

Table 3 highlights the frequency of morphological alterations in cirrhosis, with right lobe atrophy present in 69.4%, left lobe hypertrophy in 62.2%, and caudate lobe hypertrophy in 80.6% of patients. Surface nodularity (93.9%) and lobular contour irregularity (86.7%) were also highly prevalent. These imaging features are consistent with classic descriptions of cirrhotic liver anatomy, where fibrotic septa and regenerative nodules cause surface irregularities and lobar shape distortion. Jung EM *et al.*(2007)[8] Similar proportions of nodularity and lobe changes have been reported in ultrasound and MRI studies assessing cirrhotic morphology, reinforcing the diagnostic value of these features. Onori P *et al.*(2000)[9]

Table 4 demonstrates significant correlations between liver lobe morphology and clinical/biochemical severity indices. The strong negative correlation of right lobe size with serum bilirubin (r = -0.64), INR (r = -0.58), Child-Pugh (r = -0.72), and MELD scores (r = -0.65), alongside positive correlations with caudate lobe size, underscores how structural changes reflect liver functional impairment. Crawford AR *et al.*(1998)[10] This relationship between morphometric changes and prognostic scores has been documented previously, where liver size reduction parallels worsening synthetic function and portal hypertension, while caudate lobe hypertrophy correlates with altered vascular dynamics . Such correlations support the utility of imaging morphology as a surrogate marker for disease severity and progression. Goyal N *et al.*(2009)[11]

CONCLUSION

The comparative study of human liver lobe morphology in normal and cirrhotic conditions using imaging techniques demonstrated significant structural alterations associated with cirrhosis. Notably, cirrhotic livers exhibited marked right lobe atrophy and compensatory hypertrophy of the left, caudate, and quadrate lobes. Characteristic features such as surface nodularity and lobular contour irregularity were prevalent and correlated strongly with clinical and biochemical markers of liver dysfunction, including serum bilirubin, INR, Child-Pugh, and MELD scores. These findings affirm that imaging-based morphometric assessment provides valuable, non-invasive insights into liver pathology, enabling better diagnosis, staging, and management of cirrhosis. The study underscores the clinical utility of detailed morphologic evaluation of liver lobes as a surrogate marker of disease severity.

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LIMITATIONS

- The study was cross-sectional, limiting assessment of longitudinal changes in liver morphology over disease progression.
- Imaging modalities used were limited to ultrasonography and CT; incorporation of MRI and elastography could provide more detailed tissue characterization.
- Measurement variability due to operator dependence, especially in ultrasonography, could affect morphometric accuracy.
- The study did not account for etiological subtypes of cirrhosis, which may influence morphological patterns.
- Sample size, though adequate, was from a single tertiary care center limiting generalizability.
- Absence of histopathological correlation as liver biopsy was not performed for all patients to confirm fibrosis stage.

REFERENCES

1. Hussain SM, Semelka RC. Hepatic imaging: comparison of modalities. Radiologic Clinics. 2005 Sep 1;43(5):929-47.
2. Catala V, Nicolau C, Vilana R, Pages M, Bianchi L, Sanchez M, Bru C. Characterization of focal liver lesions: comparative study of contrast-enhanced ultrasound versus spiral computed tomography. European radiology. 2007 Apr;17(4):1066-73.
3. Kudo M, Zheng RQ, Kim SR, Okabe Y, Osaki Y, Iijima H, Itani T, Kasugai H, Kanematsu M, Ito K, Usuki N. Diagnostic accuracy of imaging for liver cirrhosis compared to histologically proven liver cirrhosis. Intervirology. 2008 Jun 1;51:17.
4. Malarkey DE, Johnson K, Ryan L, Boorman G, Maronpot RR. New insights into functional aspects of liver morphology. Toxicologic pathology. 2005 Jan;33(1):27-34.
5. Hanna RF, Aguirre DA, Kased N, Emery SC, Peterson MR, Sirlin CB. Cirrhosis-associated hepatocellular nodules: correlation of histopathologic and MR imaging features. Radiographics. 2008 May;28(3):747-69.
6. Boll DT, Merkle EM. Diffuse liver disease: strategies for hepatic CT and MR imaging. Radiographics. 2009 Oct;29(6):1591-614.
7. Mortelé KJ, Ros PR. Cystic focal liver lesions in the adult: differential CT and MR imaging features. Radiographics. 2001 Jul;21(4):895-910.
8. Jung EM, Clevert DA, Schreyer AG, Schmitt S, Rennert J, Kubale R, Feuerbach S, Jung F. Evaluation of quantitative contrast harmonic imaging to assess malignancy of liver tumors: A prospective controlled two-center study. World journal of gastroenterology: WJG. 2007 Dec 21;13(47):6356.
9. Onori P, Morini S, Franchitto A, Sferra R, Alvaro D, Gaudio E. Hepatic microvascular features in experimental cirrhosis: a structural and morphometrical study in CCl4-treated rats. Journal of hepatology. 2000 Oct 1;33(4):555-63.
10. Crawford AR, Lin XZ, Crawford JM. The normal adult human liver biopsy: a quantitative reference standard. Hepatology. 1998 Aug 1;28(2):323-31.
11. Goyal N, Jain N, Rachapalli V, Cochlin DL, Robinson M. Non-invasive evaluation of liver cirrhosis using ultrasound. Clinical radiology. 2009 Nov 1;64(11):1056-66.