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Caudate-to-Right Lobe Ratio in Imaging of Cirrhosis: A Marker of Disease Severity and Prognosis

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ABSTRACT

Cirrhosis leads to characteristic morphological changes in the liver, including hypertrophy of the caudate lobe and atrophy of the right lobe. The Caudate-to-right Lobe Ratio (CRLR), measurable on Computed Tomography (CT), has been proposed as a non-invasive imaging biomarker of cirrhosis severity and prognosis. This study aims to evaluate the utility of CRLR in assessing liver disease severity and predicting clinical outcomes in cirrhotic patients. A retrospective study was conducted on 45 patients with clinically and radiologically confirmed cirrhosis who underwent CT imaging. Measurements of the caudate and right hepatic lobes were taken to calculate the CRLR. Clinical parameters and the presence of complications such as ascites, variceal bleeding and hepatic encephalopathy were recorded. Statistical analysis was performed to assess correlations between CRLR and clinical severity indicators. CRLR was significantly higher in patients with more advanced cirrhosis. Patients with a CRLR of $\geq$0.6 showed a higher frequency of complications, including portal hypertension, ascites and variceal bleeding ($p<0.05$). These patients also experienced more frequent liver decompensation and had a poorer overall prognosis compared to those with lower CRLR values. The findings support the use of CRLR as a non-invasive imaging marker to help assess the severity and progression of cirrhosis. The caudate-to-right lobe ratio, as assessed on CT, is a reliable, non-invasive marker of cirrhosis severity and is predictive of adverse clinical outcomes. CRLR can aid in risk stratification, disease monitoring and clinical decision-making in patients with cirrhosis. Further prospective studies are needed to validate its use in routine clinical practice.

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Key Words
Lobe, cirrhosis, disease, prognosis

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INTRODUCTION

Cirrhosis is a progressive liver disease marked by fibrosis and hepatocyte destruction, leading to significant changes in liver morphology. Among the most important structural changes in cirrhosis are hypertrophy of the caudate lobe and atrophy of the right lobe, which can be identified on imaging modalities like Computed Tomography (CT). The caudate-to-right lobe ratio (CRLR) has emerged as an important radiological parameter, correlating with the degree of liver dysfunction, fibrosis and clinical outcomes. This paper aims to explore the role of CRLR as assessed by CT imaging in evaluating cirrhosis severity and its predictive value for clinical outcomes[1].

Aims and objectives: The primary aim of this study is to investigate the role of the caudate-to-right lobe ratio (CRLR) on CT imaging as a marker for the severity of cirrhosis. The specific objectives are:

- To determine whether higher CRLR values are associated with more advanced cirrhosis
- To assess the relationship between CRLR and clinical complications such as portal hypertension, ascites, variceal bleeding and hepatic encephalopathy

To evaluate CRLR as a potential non-invasive tool for tracking disease progression in cirrhotic patients.

MATERIALS AND METHODS

This retrospective study includes 45 cirrhotic patients who underwent CT scans within the past year. The following inclusion and exclusion criteria were applied:

Inclusion criteria:

- Patients aged 18-80 years
- A confirmed diagnosis of cirrhosis based on clinical, biochemical and imaging criteria
- Available high-quality CT scans for caudate and right lobe measurement

Exclusion criteria:

- Patients with other non-cirrhotic liver diseases.
- Patients with incomplete or low-quality CT imaging data

RESULTS AND DISCUSSION

A total of 45 patients with cirrhosis (mean age 55±12 years) were included in the study. The caudate-to-right lobe ratio (CRLR) increased with the severity of liver disease.

Patients with CRLR ≥ 0.6 had a much higher incidence of complications, including ascites, variceal bleeding and hepatic encephalopathy, compared to those with lower CRLR values.

No significant complications were observed in patients with CRLR <0.4, while patients in the 0.4-0.59 group showed an intermediate level of clinical severity (Table 1).

Interpretation: An increasing CRLR is associated with a higher frequency of complications such as ascites, variceal bleeding, encephalopathy and risk of liver transplant , suggesting that CRLR may be a useful imaging marker for disease severity in cirrhosis[2].

This study provides strong evidence that the caudate-to-right lobe ratio (CRLR), assessed through CT imaging, is a useful marker for evaluating cirrhosis severity and predicting clinical outcomes. The hypertrophy of the caudate lobe and atrophy of the right lobe are consistent findings in cirrhosis and are believed to occur as a result of portal hypertension and vascular remodeling. The liver has a dual blood supply from the portal vein and hepatic artery; in cirrhosis, fibrosis increases resistance to portal flow, leading to poor perfusion and atrophy of the right lobe, while the caudate lobe, which receives blood from both sides and drains directly into the inferior vena cava, maintains better perfusion and compensates by undergoing hypertrophy[3].

Importantly, the anatomical and vascular characteristics of the caudate lobe make it relatively resistant to the hemodynamic consequences of cirrhosis. Its direct drainage into the inferior vena cava allows it to bypass the high resistance encountered in the rest of the liver due to portal hypertension. This compensatory hypertrophy is not merely an anatomic curiosity but represents a measurable and clinically meaningful marker of disease progression[4].

The utility of CRLR as a non-invasive imaging biomarker is particularly valuable in resource-limited settings or in patients where liver biopsy is contraindicated. Compared to other radiological markers like liver surface nodularity or spleen size, CRLR provides a more direct reflection of hepatic parenchymal remodeling. Furthermore, CRLR can be easily quantified using standard CT imaging, making it a practical addition to routine radiological evaluation. From a clinical standpoint, CRLR may also aid in prognostication. Higher CRLR values have been correlated with more advanced stages of cirrhosis and may predict complications such as hepatic

Table 1: Complications observed in patients

CRLR range	No. of patients (n)	Ascites present	Variceal bleeding	Hepatic encephalopathy	Liver transplant
<0.4	12	1 (8.3%)	0 (0%)	0 (0%)	0 (0%)
0.4-0.59	18	6 (33.3%)	4 (22.2%)	2 (11.1)	1 (5.6%)
≥0.6	15	12 (80.0%)	9 (60.0%)	6 (40.0%)	4 (26.7%)

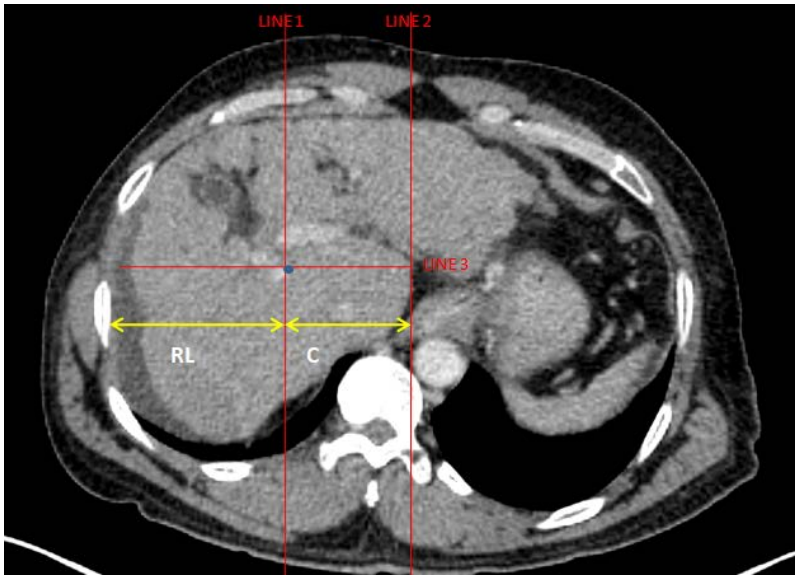

Fig. 1: Stages of cirrhosis

decompensation, variceal bleeding and poor post-operative outcomes in liver resections or transplant settings. As such, this ratio may complement established scoring systems such as Child-Pugh and MELD scores, potentially improving the accuracy of clinical risk stratification (Fig. 1).

Method:

- **Image level:** Axial slice immediately below the bifurcation of the main portal vein
- **line 1:** Parasagittal line drawn through the right lateral border of the main portal vein
- **line 2:** Parasagittal line drawn through the left lateral border of the caudate lobe
- **line 3:** Line orthogonal to lines 1 and 2 midway between the main portal vein and the inferior vena cava extended to the right liver edge
- **Caudate measurement (C):** Along line 3, between lines 1 and 2
- **Right lobe measurement (RL):** Along line 3, from right liver edge to line 1
- **Caudate-right lobe ratio:** C/RL

CRLR as a marker of disease severity: Our study shows that an increased caudate-to-right lobe ratio (CRLR) is closely linked to more advanced liver disease. Patients with higher CRLR values tended to have more severe liver dysfunction and clinical complications. This suggests that CRLR can serve as a useful, non-invasive imaging biomarker to assess the severity of cirrhosis (Table 2)[5].

The atrophy of the right lobe in cirrhosis is likely caused by vascular changes and loss of liver tissue due to fibrosis. Meanwhile, the caudate lobe undergoes hypertrophy to compensate for the liver's decreased functional capacity. Measuring the CRLR provides a simple way to capture this imbalance in liver structure and estimate disease progression.

Table 2: Category

Category	C/RL ration
Normal	≤0.55
Borderline	0.55-0.65
Abnormal (suggestive of cirrhosis)	>0.65

Crlr and clinical outcomes: The study also highlights the prognostic value of CRLR. Higher CRLR values were associated with an increased risk of portal hypertension, which is a key complication of cirrhosis. Portal hypertension leads to the development of complications such as ascites, variceal bleeding and hepatic encephalopathy, all of which were observed more frequently in patients with a higher CRLR. This suggests that CRLR may not only reflect the structural severity of cirrhosis but also predict the risk of clinical decompensation and liver-related complications.

Additionally, the significant correlation between CRLR and biochemical markers such as bilirubin and albumin further supports the role of CRLR as a useful indicator of liver function. Elevated bilirubin levels are indicative of impaired liver function, while decreased albumin levels reflect a loss of synthetic capacity, both of which are associated with more advanced cirrhosis.

CRLR in monitoring disease progression: One of the major advantages of using CRLR in cirrhosis management is that it provides a non-invasive, reproducible method to monitor disease progression. Traditional monitoring methods, such as liver biopsy, are invasive and carry risks. Imaging-based approaches like CRLR, especially through CT, allow for serial

monitoring without the need for invasive procedures. This is particularly beneficial in clinical practice, where frequent and timely assessments of cirrhosis progression are crucial for treatment decisions and patient management[6].

Implications and future perspectives: This study highlights the potential value of the caudate-to-right lobe ratio (CRLR) as a non-invasive imaging marker for assessing cirrhosis severity. While the findings are encouraging, they reflect the scope of a single-center study with a modest sample size. The use of CT, although effective, also raises considerations around radiation exposure for patients requiring ongoing monitoring.

Future research should aim to include larger, multicenter prospective cohorts to validate CRLR as a prognostic marker. Additionally, studies investigating its role in tracking treatment response, particularly in patients receiving antiviral therapy or emerging antifibrotic treatments could further establish CRLR as a practical tool in clinical hepatology and radiology.

CONCLUSION

The caudate-to-right lobe ratio (CRLR), as assessed via CT imaging, is a valuable tool for evaluating the severity of cirrhosis and predicting clinical outcomes. The ratio correlates well with liver dysfunction, portal hypertension and liver-related complications. CRLR has the potential to serve as a non-invasive marker for assessing disease progression and monitoring therapeutic responses in cirrhotic patients.

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