



## COMPUTED TOMOGRAPHY EVALUATION OF THE CAUDATE-TO-RIGHT LOBE RATIO IN PATIENTS WITH LIVER CIRRHOSIS AND SUBJECTS WITH NORMAL LIVER IN A TERTIARY CARE CENTRE

### Radio-Diagnosis

|                                      |                                                                                                                              |
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### KEYWORDS

#### INTRODUCTION

The histological development of regenerating nodules encircled by fibrous bands in response to chronic liver injury is known as cirrhosis, and it is the condition that causes portal hypertension and end-stage liver disease.<sup>1</sup> Chronic liver diseases are the usual cause of cirrhosis. In the developed world, the most prevalent causes of cirrhosis are hepatitis C virus (HCV), alcoholic liver disease, and non-alcoholic steatohepatitis (NASH); in the developing world, the most common causes are hepatitis B virus (HBV) and HCV.<sup>2</sup>

According to autopsy studies, 4.5% to 9.5% of the general population worldwide has cirrhosis. In underdeveloped nations, cirrhosis is a leading cause of illness and mortality.<sup>3</sup> Currently, liver biopsy is the gold standard for cirrhosis diagnosis. The majority of patients, however, will choose a non-invasive test over a biopsy due to the latter's risk of procedural pain and complications like bleeding, pneumothorax, biliary puncture, and even death.<sup>3</sup>

The non-invasive method of computed tomography has shown to be effective in diagnosing liver cirrhosis. In the context of chronic liver cirrhosis, computed tomography is useful for assessing the liver and its various diseases. It can evaluate nearby structures that are impacted during the disease, such as the spleen, gall bladder, and hepatic and portal veins, among other intra-abdominal organs. These characteristics make it a recommended technique for liver evaluation.<sup>4</sup> The caudate-right lobe ratio has been proposed as one of the best measurements for differentiating cirrhotic livers from non-cirrhotic livers. The caudate-right lobe ratio greater than 0.65 is considered highly specific for cirrhosis.<sup>5,6</sup> The main objective of prognostic scores in cirrhotic patients is to estimate the probability of death within a given time interval. It also estimates the reserve of liver function and the capacity to stand up surgery or other aggressive therapeutic interventions, (i.e. liver resection or arterial chemoembolization), and whether a resource-spending therapy (such as transplantation) is justified.<sup>6</sup>

This study was undertaken to evaluate the caudate to right lobe ratio by using computed tomography in subjects with liver cirrhosis and its comparison to normal persons and to find the predictive accuracy in the diagnosis of liver cirrhosis.

#### MATERIAL AND METHODS

A cross-sectional study was conducted in the Department of Radiology at Vydehi Institute of Medical Sciences and Research Centre among patients with and without cirrhosis between June 2023 to May 2024. A total of 30 patients undergoing Triple phase CECT abdomen and pelvis with a confirmed diagnosis of liver cirrhosis meeting the inclusion criteria were included in the study and an equal number of controls. The clearance from the institutional ethics committee was obtained before the study was started. An informed, bilingual and written consent was obtained from cases and controls before including them in the study. Once the consent was taken patients were subjected to triple-

phase CECT Abdomen and pelvis examinations using a 128-slice Siemens CT scanner. Participants were positioned supine in the CT gantry and scanned from approximately 2 cm above the diaphragm to the iliac region with standard protocols and pre & post contrast, images were obtained. Arterial phase scanning was acquired at 30-40s following dynamic injection of the contrast agent, portovenous phase at 70 s and equilibrium/delayed phase at 180 s. Liver measurements were documented and three different measurements of the liver was obtained, and the average was calculated. The caudate-to-right lobe ratio was calculated as the ratio of the transverse diameter of the caudate lobe to the transverse diameter of the right lobe. Other features such as the presence of atrophy of the right hepatic lobe, with compensatory hypertrophy of the caudate lobe and the left lateral segment, expanded gallbladder fossa sign, right posterior hepatic notch sign, nodular surface of liver, varices and portosystemic collaterals were observed. The images acquired was analysed by two consultant radiologists.

Anthropometric measurements, including height and weight, will be obtained and recorded. Body Mass Index (BMI) will be derived from the measured weight and height using the formula:  $BMI = \text{Weight (kg)} / \text{Height (m)}^2$ .

The data thus obtained was analysed using Statistical Package for Social services (SPSS ver 20). The quantitative data was presented as mean and standard deviation. Independent Sample T test was used as tests of significance. The categorical data was presented as frequencies and percentages and chi square test was used as test of significance. A p value of less than 0.5 was considered as statistically significant.



**Figure 1:** An illustration of the method for liver measurement on CT image

A first line was drawn through the right lateral wall of the main portal vein and parallel to the midsagittal plane of the body. A second line was

drawn through the most medial margin of the caudate lobe and parallel to Line 1. Line 3 was drawn perpendicular to Lines 1 and 2 and midway between the portal vein and the inferior vena cava.<sup>3</sup> The distances along Line 3 between Lines 1 and 2 and between Line 1 and the right lateral margin of the liver was expressed as the caudate-right lobe ratio.<sup>3</sup> A value of 0.65 was considered significant.

#### Inclusion Criteria:

- Patients aged 18 years and above.
- Patients undergoing abdominal CT imaging at the tertiary care centre.
- Subjects with normal liver morphology on CT imaging, serving as controls.
- Patients with a histopathological confirmation of liver cirrhosis.
- Patients with radiological evidence of liver cirrhosis on CT imaging, including nodular liver contour, regenerative nodules, and signs of portal hypertension (e.g., splenomegaly, ascites).
- Patients and subjects with available demographic and clinical data.
- Patients and subjects who provide informed consent to participate in the study.

#### Exclusion Criteria:

- Patients with contraindications to CT imaging (e.g., pregnancy, severe contrast allergy).
- Patients with other severe liver diseases, such as hepatocellular carcinoma, hepatic abscess, or liver metastases, that may affect liver morphology.
- Patients with previous liver resection or transplantation.
- Patients with inadequate CT imaging quality for accurate assessment of the caudate-to-right lobe ratio.
- Patients with incomplete clinical or demographic data.

## RESULTS

**Table 1. Distribution of the study groups according to age group**

| Age group          | Cirrhosis of liver group | Control group |
|--------------------|--------------------------|---------------|
| < 40 years         | 5 (16.7)                 | 5 (16.7)      |
| 40 – 49 years      | 7 (23.3)                 | 10 (33.3)     |
| 50 – 59 years      | 6 (20.0)                 | 2 (6.7)       |
| 60 years and above | 12 (40.0)                | 13 (43.3)     |
| Total              | 30 (100)                 | 30 (100)      |

$$\chi^2 \text{ value} = 2.569 \quad df = 3 \quad p \text{ value} = 0.463, \text{NS}$$

This study had shown that, about 40.0% of the cases with cirrhosis and 43.3% of the cases with normal liver were aged 60 years and above. The p value was not significant and hence ensuring the comparability.

**Table 2. Distribution of the study groups according to anthropometric measurements**

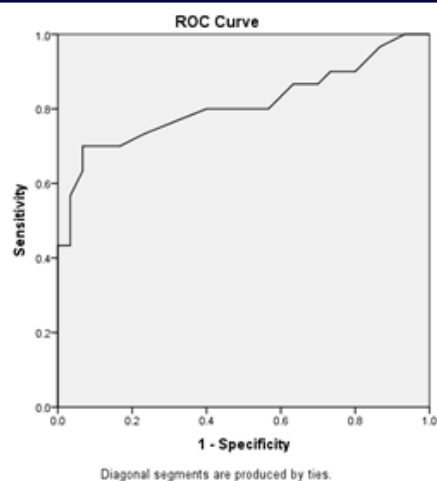
| Anthropometric measurements | Cirrhosis of liver group | Control group | T value | P value, Sig |
|-----------------------------|--------------------------|---------------|---------|--------------|
| Weight                      | 69.8 ± 13.6              | 72.4 ± 12.06  | -0.793  | 0.431, NS    |
| Height                      | 165.1 ± 9.2              | 167.2 ± 6.3   | -1.035  | 0.305, NS    |
| BMI                         | 25.89 ± 6.02             | 25.93 ± 4.38  | -0.027  | 0.979, NS    |

The mean weight was not significantly higher in controls in comparison with the cases. The mean height and BMI were also not significantly higher in the control group.

**Table 3. Distribution of the study groups according to liver measurements**

|              | Cirrhosis of liver group | Control group | T value | P value, Sig |
|--------------|--------------------------|---------------|---------|--------------|
| Liver span   | 14.1 ± 2.3               | 16.3 ± 1.53   | 4.405   | 0.000, Sig   |
| Right lobe   | 8.03 ± 1.6               | 9.0 ± 2.0     | 2.063   | 0.044, Sig   |
| Caudate lobe | 5.73 ± 1.8               | 3.83 ± 0.83   | 5.343   | 0.000, Sig   |
| C/ RL ratio  | 0.76 ± 0.3               | 0.44 ± 0.13   | 5.05    | 0.000, Sig   |

The mean liver span was 14.1 cm in cases and 16.3 cm in the control group and it was statistically significant. The mean right lobe measurement in cases was 8.03 cms and 9.0 cms in controls which was also statistically significant. The mean caudate lobe was 5.73 cms in cases and 3.83 cms in controls. The mean C/RL ratio was 0.76 in cases and 0.44 in controls and was statistically significant.



**Chart 1. Receiver operating characteristic curve of C/RL ratio**

**Table 4. Area under the curve for the C/RL ratio**

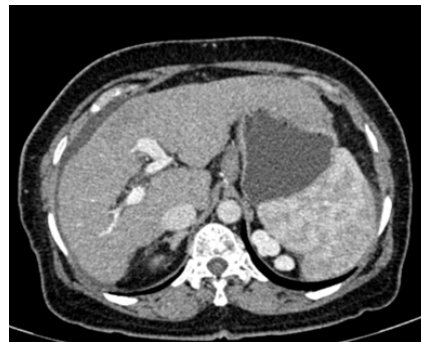
| Area Under the Curve                                                                                                                                                |            |                              |                                    |             |
|---------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------|------------------------------|------------------------------------|-------------|
| Test Result Variable(s): C/RL ratio                                                                                                                                 |            |                              |                                    |             |
| Area                                                                                                                                                                | Std. Error | Asymptotic Sig. <sup>a</sup> | Asymptotic 95% Confidence Interval |             |
|                                                                                                                                                                     |            |                              | Lower Bound                        | Upper Bound |
| .811                                                                                                                                                                | .059       | .000                         | .695                               | .926        |
| The test result variable(s): C/RL ratio has at least one tie between the positive actual state group and the negative actual state group. Statistics may be biased. |            |                              |                                    |             |
| a. Under the nonparametric assumption                                                                                                                               |            |                              |                                    |             |
| b. Null hypothesis: true area = 0.5                                                                                                                                 |            |                              |                                    |             |

**Table 5. Coordinates of curve**

| Coordinates of the Curve                                                                                                                                                                                                                       |             |                 |
|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------|-----------------|
| Test Result Variable(s): C/RL ratio                                                                                                                                                                                                            |             |                 |
| Positive if Greater Than or Equal To <sup>a</sup>                                                                                                                                                                                              | Sensitivity | 1 - Specificity |
| .2600                                                                                                                                                                                                                                          | 1.000       | .070            |
| .3900                                                                                                                                                                                                                                          | .867        | .330            |
| .4150                                                                                                                                                                                                                                          | .867        | .370            |
| .5300                                                                                                                                                                                                                                          | .733        | .770            |
| .5650                                                                                                                                                                                                                                          | .700        | .830            |
| .7900                                                                                                                                                                                                                                          | .433        | .970            |
| .8150                                                                                                                                                                                                                                          | .433        | 1.000           |
| The test result variable(s): C/RL ratio has at least one tie between the positive actual state group and the negative actual state group.                                                                                                      |             |                 |
| a. The smallest cutoff value is the minimum observed test value minus 1, and the largest cutoff value is the maximum observed test value plus 1. All the other cutoff values are the averages of two consecutive ordered observed test values. |             |                 |

The ROC curve showed that, the area under the curve was 81.1% in this study. The sensitivity was 100% and specificity was 7% at a level of C/RL ratio of 0.26. At a level of 0.53, the sensitivity was 73.3% and specificity was 77% in this study.

#### Illustrative Cases



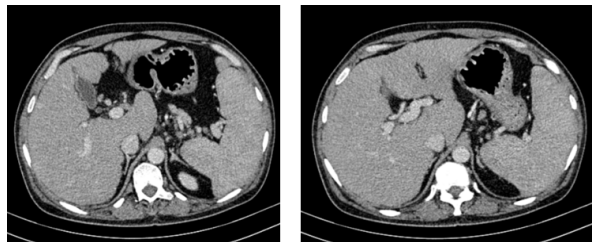
**Case 1:** The patient presented with abdominal distension since 1 month.

**Findings-** CT image showing portal phase: Liver -Shrunk in size with hypertrophy of left lobe and caudate lobe (caudate/right lobe ratio is increased). Surface irregularity and altered attenuation.



**Case 2:** Complaints of yellowish discoloration for one month.

**Findings-CECT image showing Liver:** Appears mildly enlarged in size with surface nodularity and altered parenchymal attenuation. Hypertrophy of the caudate lobe with concomitant atrophy of the right lobe of the liver [C/RL ratio: 50/63 mm = 0.8].



**Case3:** Complaints of generalized weakness since 6 months, c/o weight loss since 6 months and known alcoholic.

**Findings-** CT image showing Liver: is enlarged in size with hypertrophy of the caudate lobe (caudate: Right lobe ratio 0.6).

## DISCUSSION

This study was undertaken in order to evaluate the caudate to right lobe ratio by using triple-phase computed tomography in liver cirrhosis cases and its comparison to the normal persons and to find the predictive accuracy in the diagnosis of cirrhosis of the liver. This study showed that the majority of the cases with cirrhosis of liver were aged more than 60 years. In a study by Ilione et al, the mean age was 60.14 years in cases with liver cirrhosis and 46.97 years in controls with normal liver similar to the results of this study.<sup>7</sup> A study by Ye et al reported that the mean age was 51 years in contrary to these study results.<sup>8</sup> This has been attributed to the dangerous progression of liver cirrhosis and chronic liver disease, which may not show clinical symptoms until around 75% of the hepatic cells are impacted. Despite the fact that the hepatic injury happened fairly early, the disease's gradual course may cause clinical symptoms to appear later in life.<sup>9</sup>

The anthropometric measurements was not significantly different in cases with cirrhosis and controls. In contrary to these results, Ilione et al had observed a statistically significant difference in weight, height and BMI between the cases with cirrhosis and controls with normal livers.<sup>7</sup>

There was a statistically significant difference in liver span, right lobe, caudate lobe and C/RL ratio in this study. A study by Ilione et al also observed similar findings.<sup>7</sup> A study by Ye et al had shown that, the caudate – right lobe ratio mean difference was much further away from the zero line.<sup>8</sup> This may be explained by the fact that the caudate lobe's venous drainage is maintained by emissary veins that run straight from the lobe to the vena cava. As a result, increased blood flow through the caudate lobe in cirrhosis due to fibrosis and subsequent narrowing that obstructs the hepatic veins causes hypertrophy.<sup>10</sup>

At a C/RL ratio cut-off of 0.26, the specificity was 7% and the sensitivity was 100%. In this investigation, the specificity was 77% and the sensitivity was 73.3% at a significance level of 0.53. In a study by Ye et al, the caudate-right lobe ratio threshold was established at

0.915, with corresponding values for accuracy, sensitivity, and specificity of 64.5%, 30.7%, and 98.4%.

## CONCLUSION

This study showed that, when compared to controls, patients with liver cirrhosis had considerably larger caudate lobes and a higher caudate-to-right lobe ratio. When compared to normal subjects, the caudate-to-right lobe ratio of subjects with established liver cirrhosis was significantly higher, and there was a significant difference between subjects with suspected/established liver cirrhosis and subjects with apparently normal liver.

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