RESEARCH ARTICLE

Liver-spleen attenuation ratio in unenhanced and contrast enhanced computerized tomography in different grades of hepatic steatosis

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Abstract

Objective: To assess the average liver-spleen attenuation ratio on both plain and contrast-enhanced computed tomography (CECT) scan in various stages of hepatic steatosis.

Method: The descriptive, cross-sectional study was conducted at the Department of Radiology, Dow University of Health Sciences/Dr Ruth K.M. Pfau Civil Hospital, Karachi, from February 1, 2017, to July 31, 2024, and comprised patients aged 15-85 years of either gender who underwent abdominal computed tomography scans for various non-hepatic indications. The liver-spleen attenuation ratio was measured as the ratio of Hounsfield unit values of the hepatic and splenic parenchyma before and after administering contrast for computed tomography scanning, with simultaneous recording of the hepatic steatosis grade via abdominal sonography. The mean liver-spleen attenuation ratios for different stages of hepatic steatosis severity were analysed for both pre- and post-contrast computed tomography scans. Data was analysed using SPSS 21.

Result: Of the 334 patients, 206(61.7%) were females and 128(38.3%) were males. The overall mean age was 45.26±11.61 (30-70) years. The mean liver-spleen attenuation ratio values on pre- and post-contrast scans were 0.71±0.08 and 0.72±0.09 for mild, 0.61±0.08 and 0.65±0.13 for moderate, and 0.02±0.72 and 0.36±0.20 for severe steatosis, respectively, as against sonographic hepatic steatosis grading. The overall mean liver-spleen attenuation ratio was 0.49±0.45 for pre- and 0.60±0.20 for post-contrast scans. Complications such as dilated portal vein ($p<0.001$), dilated splenic vein($p<0.001$), splenomegaly ($p<0.001$), abdominal collaterals ($p<0.001$), and ascites ($p=0.014$) were significantly more frequent in those with L/S ratio of 0.7 or less on CECT.

Conclusion: The liver-spleen attenuation ratio decreased in fatty liver disease on both pre- and post-contrast computed tomography scans, with a more noticeable reduction seen on the post-contrast images, and with advanced grades of steatosis.

Key Words: Liver-spleen attenuation ratio, Hepatic steatosis, Computerised tomography, CT, Ultrasound, Grades of hepatic steatosis, Unenhanced, Contrast-enhanced CT.

(JPMA 75: 10 S-34 (Supple-3); 2025) **DOI: https://doi.org/10.47391/JPMA.DUHS-25-08**

Introduction

Hepatic steatosis, or fatty liver, is defined as a condition where fat constitutes more than 5% of the liver's weight.[1] An oversimplified aetiological classification is fatty liver disease caused by alcohol over-consumption, and non-alcoholic fatty liver disease (NAFLD), which includes the rest of the causes. NAFLD currently affects around 15-40% of the general population and its prevalence is increasing globally.[2] In South Asia, the overall population-based prevalence of NAFLD is 32%.[2] It is believed to be the next possible epidemic of chronic liver disease (CLD).[1,3] In Pakistan, the prevalence is estimated at 21.7% among general outpatients based on ultrasound,[4] and 4.5% based on naked-eye examination.[5]

The condition is particularly deleterious when associated with metabolic syndrome features, such as obesity, dyslipidaemia, insulin resistance (IR), type 2 diabetes mellitus (T2DM), hypertension (HTN) and aging.[4] Approximately a fifth of patients with NAFLD develop non-alcoholic steatohepatitis (NASH), which is said to be responsible for up to 80% of cryptogenic cirrhosis cases, and progresses to advanced fibrosis in 32-37%.[1] Between 5-20% cases of non-cirrhotic NASH are at the risk of progressing to frank cirrhosis within 10 years, and about one in every 200 patients is at the risk of developing hepatocellular carcinoma (HCC) within seven years.[1] Thus, NAFLD requires monitoring for progression once it is diagnosed. Although histopathology is the gold standard for diagnosis, it is invasive and painful, and carries high mortality and morbidity, making it unsuitable for routine screening and monitoring.[5,6]

Imaging methods, such as ultrasound, computed tomography (CT) scan and magnetic resonance imaging (MRI), are non-invasive and free of the risks associated with other methods for monitoring fatty liver.[7] Among

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these, MRI and ultrasound are considered the most accurate for quantifying hepatic fat, although they have limitations. MRI is expensive and not widely accessible, while ultrasound is subjective and dependent on the operator.[7] Until recently, CT was thought to be less accurate, with reported sensitivity and specificity of 73% and 77.7%, respectively.[7] However, the introduction of the liver-spleen (L/S) attenuation ratio in Hounsfield units (HU) has improved specificity.[8] This method addresses the operator bias of subjective ultrasound, and the high cost of MRIs, which lack measurable units and rely on visual interpretation. CT not only detects diffuse steatosis, but also identifies focal fatty infiltrations within the liver parenchyma.[9]

The current study was planned to assess the mean L/S attenuation ratio on both plain CT and CECT scans in various stages of hepatic steatosis.

Patients and Methods

The descriptive, cross-sectional study was conducted from February to July 2024 at the Department of Radiology, Dow University of Health Sciences/Dr Ruth K.M. Pfau Civil Hospital, Karachi (DUHS/CHK), from February 1, 2017, to July 31, 2024, and comprised data of patients aged 15-85 years of either gender who underwent abdominal CT scans for various non-hepatic indications. Patients with known positive hepatic viral markers, primary or secondary hepatic malignancy, storage or deposition disorders, autoimmune hepatitis and alcoholism were excluded. Informed consent was taken from all the patients, and approval was obtained from the ethics review board of the College of Physicians and Surgeons Pakistan (CPSP). Plain CT and CECT scans were performed in all cases with 16-32 slice CT (Toshiba CT scanners, ActivionTM and Asterion TM JAPAN. The patients also underwent ultrasound scan of the abdomen for the grading of fatty liver within two days before or after the CT scan.

The mean L/S attenuation ratio was determined by dividing the mean CT attenuation of liver in HUs by the mean CT attenuation of spleen in HUs. Both the values were taken from three different areas of interest of spleen in pre-contrast CT images and in portal venous phase of post-contrast CT images.

Hepatic steatosis was graded as I for mild steatosis when hepatic parenchymal attenuation (echogenicity) was as high as pancreatic parenchyma, with no obscuring of either posterior hemi-diaphragm or intrahepatic vascular margins. Grade II indicated moderate steatosis based on raised hepatic parenchymal attenuation with obscured posterior diaphragm and vascular margins. Grade III indicated severe steatosis based on high hepatic parenchymal echogenicity with markedly obscured visualisation of the posterior hemi-diaphragm, vascular margins and adjacent hepatic segments. Mean CT L/S ratio values were compared with ultrasound grading of the same patient.

Data was analysed using SPSS 21. Mean values with standard deviation were determined for age, serum alanine aminotransferase (ALT) values, L/S ratio for different grades of hepatic steatosis, and body mass index (BMI). BMI <30kg/m2 were considered non-obese and BMI ≥30kg/m2 was considered obese. Frequencies and percentages were calculated for categorical variables, such as gender, co-morbid conditions, grade of steatosis on ultrasound and complications. T-test was applied to compare mean L/S ratio of plain CT and CECT. T-test was also applied for stratified categories of gender, age, BMI, T2DM, HTN, smoking, irregu liver outline, enlarged spleen size, ascites , dilated portal vein and splenic vein size>6 mm. Level of significance was kept at $p \leq 0.05$.

Results

A total of 334 patients aged between 15 to 85 years meeting inclusion criteria of study were evaluated. They comprised of 128 males (38.3%) and 206 females (61.7%).

The overall average age of patients was 45.26±11.61 (30-70) years. Average height and weight was 1.41±0.07 (1.26-1.56) m and 66.25±8.63 (48-85) kg respectively. Average BMI was 33.13±4.96 (24.7-43.4) kg/m^2. Two hundred and one patients (60.2%) were obese with BMI >30 kg/m^2.

Mean serum ALT, liver size, spleen size, portal vein size and splenic size was 32.00±36.06 (17-172) IU/L, 172.7±295 (110-290) mm, 106.4±21.6 (70-190) mm,12.69±2.53(8-22) mm and 7.68±2.17 (3-18) mm.

Overall, there were 88(26.3%) patients with T2DM, 224(32.9%) with HTN and 82(24.6%) with smoking addiction.

On ultrasound, 82(24.6%) patients had mild steatosis, 170(50.9%) had moderate, and 82(24.6%) had severe steatosis.

The mean liver span was 172.7± 29.50 (153-204) mm and mean diagonal splenic span was 106.4±20.16 (85-228) mm. The mean diameters of portal and splenic veins were 12.7 ± 2.53 (9.6-15.8) mm and 7.68±2.17 (5.8-11. 7) mm, respectively.

The mean liver attenuation in plain CT was 28.99+15.53HU (range: -47-64HU) and it was

Table-1: Overall Mean Of L/S Ratio On Unenhanced And Enhanced Scan in patients with hepatic steatosis (n=334)

	Mean	SD	P-Value
Enhanced Scan	0.602	0.203	<0.001*
Unenhanced Scan	0.494	0.454	

Dependent t-test was applied
P-value≤0.05 considered as significant.

Table-2: Comparison Of L/S Ratio On Unenhanced And Enhanced Scan According To Ultrasound Grading(n=334)

	Mean	SD	P-Value
Mild (n=82)			0.33
Enhanced Scan	0.723	0.097	
Unenhanced Scan	0.7111	0.086	
Moderate (n=170)			0.001
Enhanced Scan	0.659	0.137	
Unenhanced Scan	0.616	0.080	
Severe (n=82)			<0.001
Enhanced Scan	0.361	0.201	
Unenhanced Scan	0.025	0.724	

Dependent t-test was applied.
P-value≤0.05 considered as significant.

Table-3: Frequency distribution of complication in patients with hepatic steatosis – reference bar set at CECT L /s ratio according to the values described in table 2

	Frequency (%)		P value
	present	Absent	(significance at <0.05)
Irregular Liver outline	4 (1.2)	330 (98.8)	0.613
Enlarged Spleen Size (>130 mm)	79 (23.7)	255 (76.3)	<0.001
Ascites	23 (6.9)	311 (93.1)	0.014
Dilated Portal Vein(>13 mm)	168 (50.3)	166 (49.7)	0.001
Splenic vein size>8 mm	90 (26.9)	244 (73.1)	<0.001
Abdominal collateral	53 (15.9)	281 (84.1)	<0.001

54.66+18.65HU (range: -21-87HU) on CECT. The mean spleen attenuation was 53.8+11.10HU on plain CT and 90.1+14.11HU on CECT (Table 1).

The mean L/S attenuation ratio values on plain CT and CECT scans were 0.71±0.08 and 0.72±0.09 for mild, 0.61±0.08 and 0.65±0.13 for moderate, and 0.02±0.72 and 0.36±0.20 for severe steatosis, respectively, as against sonographic hepatic steatosis grading (Table 2). Complications including dilated portal vein (p<0.001), dilated splenic vein(p<0.001), splenomegaly (p<0.001), abdominal collaterals (p<0.001), and ascites (p=0.014) were significantly more frequent in those with L/S ratio of 0.7 or less on CECT (Table 3).

Discussion

NAFLD is a well-established condition that has become a significant public health concern, particularly due to rising obesity and T2DM rates. It is often suspected on nonspecific digestive symptoms with abnormal liver function tests, making its radiological detection crucial for appropriate management.

Most of the diagnostic CT researches on fatty liver have been conducted using intravenous contrast, defining fatty liver as a hepatic parenchymal attenuation value minus splenic parenchymal attenuation value of ≤-10HU. [10,11] However, there is scarce research on its detection using CECT, necessitating the establishment of specific parameters for identifying fatty liver in contrast-enhanced studies, especially when non-enhanced CT is not included in a CT scanning protocol.

The current study determined the mean L/S ratio for plain CT and CECT as 0.71 and 0.72 for mild, 0.61 and 0.65 for moderate, and 0.02 and 0.36 for severe steatosis, when compared with sonographic findings. Kan et al. suggested an optimal L/S ratio of at least 1.[1] for detecting steatosis, with sensitivity and specificity of 83.3% and 93.3%, respectively.[12] They observed that an L/S ratio of 1.296 in histological findings indicated 0% steatosis, which could serve as a useful cut-off to rule out significant hepatic steatosis. Additionally, the study found a significant correlation between steatosis percentage and grade, with L/S ratios of 0.88±0.28 for mild, 0.76±0.20 for moderate, and 0.40±0.18 for severe steatosis. These values are slightly higher than those in the current study possibly due to differences in study populations and demographic characteristics.

The current findings align with Ricci et al., who defined fatty liver as an L/S CT ratio of <0.9.[13] Similarly, Longo et al. compared MR spectroscopy, CT and histology for diagnosing liver fat infiltration, finding a significant concordance between CT scan imaging and histological findings (R=0.77, p<0.001). [14]

Kodama et al. compared plain CT and CECT scans to assess fatty liver severity against histological diagnoses, 15 and reported that a liver attenuation of 40HU on non-contrast computed tomography (NCCT) corresponds to approximately 30% hepatic parenchymal fat, while 30HU corresponds to around 50% hepatic parenchymal fat. Park et al. investigated hepatic and splenic parenchymal attenuation, determining the L/S ratio, and the attenuation differences to identify ≥30% steatosis.[16] Their findings indicated that setting the bar at 0.9HU value for L/S ratio and 58HU for liver attenuation has reliable sensitivity and specificity for detecting >30% hepatic parenchymal fat content on CT images.

Kim et al. concluded that CT scans done with or without intravenous contrast administration yield comparable accuracy in assessing hepatic steatosis.[17] CT imaging is also valuable for identifying moderate-to-severe hepatic steatosis in potential liver transplant donors.[18] Limanond et al. recommended excluding individuals with hepatic fat content exceeding 30% from liver donation due to increased post-resection morbidity risks.[19]

Although many studies have explored imaging-based evaluation of NAFLD, only a few have examined its progression to portal HTN. The current study assessed portal HTN indicators using quantitative measures, such as liver span, portal and splenic vein diameters, splenic size, abdominal collateral circulation, ascites and PE. The results are comparable to Kulali et al., reporting mean values of 18.27cm for liver span, 12.7mm for portal vein diameter, and 7.35mm for splenic vein diameter.[20] As these complications are mostly diagnosed only at the time of transplantation, preoperative awareness of such complications leads to better patient and donor selection, and optimal perioperative morbidity after liver transplantation procedure.[21]

The current study has some limitations, like the absence of liver biopsies for histological confirmation of fatty liver. However, the applied criteria have been validated against histological analyses, indicating that liver attenuation values <40HU and L/S ratio <0.9 are reliable for diagnosing moderate-to-severe hepatic steatosis.

Conclusion

The L/S attenuation ratio on both plain CT and CECT decreased with a greater severity of hepatic parenchymal fat deposition and provided an objective, non-invasive measure for detecting steatosis and staging hepatic parenchymal fatty infiltration.

Disclaimer: The text is based on an academic thesis. The preliminary results were part of an oral presentation at the Annual Conference of the Radiological Society of Pakistan, in October 2017. .

Conflict of Interest: None.

Source of Funding: None.

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