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Computed Tomography–Based Assessment of Hepatic Steatosis and Liver Fibrosis in a Congolese Population: A Radiological Method-Comparison Study.

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Abstract

Background:
Hepatic steatosis and liver fibrosis are major contributors to chronic liver disease. In low-resource settings, computed tomography (CT) may serve as an accessible noninvasive tool for opportunistic hepatic assessment. However, CT-based evaluation of steatosis and fibrosis remains limited in sub-Saharan African populations. This study evaluated CT-derived parameters for hepatic steatosis and fibrosis in a Congolese population from Kinshasa and assessed agreement between hepatic attenuation and fibrosis-related morphology.

Methodology:
An analytical cross-sectional method-comparison study was conducted using 2,485 abdominal CT scans performed from January 2020 to June 2025 at Rocher Imaging Center, Kinshasa. Hepatic steatosis was assessed using mean hepatic attenuation and liver–spleen attenuation difference, while fibrosis was evaluated using morphological parameters, including caudate-right lobe ratio (CRL-R) and hepatic vein diameters. Agreement between mean hepatic attenuation and CRL-R was analyzed using Deming regression, Passing–Bablok regression, Bland–Altman analysis, Lin's concordance correlation coefficient (CCC), RMSE, and P10 agreement.

Results:
The mean age of participants was 50.6 ± 14.2 years, and women represented 52.2% of the study population. Hepatic steatosis was identified in 14.0% of participants, while liver fibrosis was present in 9.0%. The prevalence of both conditions increased significantly with advancing age ($p = 0.012$). Deming regression analysis demonstrated a slope coefficient of 0.967 (95% CI: 0.919–1.016) and an intercept of −2.885 (95% CI: −7.135 to 3.360), indicating no significant proportional or systematic bias. Passing–Bablok regression similarly showed excellent linear agreement between the two radiological parameters. However, overall concordance remained moderate (Lin's CCC = 0.423). Mean hepatic attenuation demonstrated a systematic underestimation of CRL-R values (bias = −5.392), although the P10 agreement metric remained high at 92.4%.

Conclusion:
CT-derived hepatic attenuation demonstrated a good linear relationship with the caudate-right lobe ratio, supporting the utility of CT-based radiological parameters in the noninvasive evaluation of hepatic abnormalities. However, moderate concordance and proportional bias suggest that these measurements should be considered complementary rather than fully interchangeable. CT may represent a practical opportunistic imaging tool for hepatic assessment in resource-limited settings where advanced fibrosis imaging techniques are not widely available.

Keywords:
Metabolic Dysfunction–Associated Steatotic Liver Disease,Computed Tomography, Hepatic Steatosis, Liver Fibrosis, Radiological Agreement Analysis, CT Imaging

Introduction

Hepatic steatosis and liver fibrosis are increasingly recognized as major global health concerns because of their strong association with chronic liver disease, cirrhosis, hepatocellular carcinoma, metabolic dysfunction, and cardiovascular complications [1]. Metabolic dysfunction–associated steatotic liver disease (MASLD), formerly termed non-alcoholic fatty liver disease (NAFLD), has emerged as one of the most prevalent chronic liver disorders worldwide, affecting nearly one-third of the adult population in several regions [2]. The progression from simple hepatic fat accumulation to advanced fibrosis and cirrhosis frequently occurs silently and asymptomatically, leading to delayed diagnosis and increased liver-related morbidity and mortality [3]. Early identification of hepatic abnormalities is therefore essential for timely intervention and prevention of long-term complications.

Liver biopsy remains the reference standard for the diagnosis and staging of hepatic steatosis and fibrosis. However, its routine clinical application is limited by several important disadvantages, including invasiveness, sampling variability, procedural complications, cost, and limited patient acceptability [4]. Consequently, noninvasive imaging techniques have become increasingly important for the evaluation of diffuse liver diseases. Among these modalities, computed tomography (CT) is widely available in routine clinical practice and offers the possibility of opportunistic hepatic assessment during abdominal imaging performed for unrelated clinical indications [5].

CT-based evaluation of hepatic steatosis primarily relies on quantitative attenuation measurements expressed in Hounsfield Units (HU). Fat accumulation within the hepatic parenchyma reduces liver attenuation values relative to splenic attenuation, and several studies have shown that low hepatic attenuation or a decreased liver-to-spleen attenuation difference may indicate moderate-to-severe steatosis [6,7]. CT imaging additionally offers the advantage of simultaneous evaluation of multiple abdominal and metabolic abnormalities during a single examination [8]. Although CT is less sensitive than magnetic resonance imaging or proton density fat fraction techniques for mild steatosis detection, it remains a practical and accessible imaging modality in many clinical environments.

In addition to hepatic steatosis assessment, CT imaging can provide indirect morphological indicators of liver fibrosis and cirrhosis. Morphometric features such as caudate lobe hypertrophy, nodular hepatic contour, reduction in hepatic vein diameters, and changes in lobar ratios, including the caudate-right lobe ratio (CRL-R), have demonstrated potential utility in the noninvasive radiological evaluation of chronic liver disease [9,10]. Previous radiological studies have shown that these CT-derived morphological changes correlate with progressive hepatic architectural remodeling and fibrosis severity [10]. Advanced imaging techniques such as elastography and magnetic resonance elastography may provide greater diagnostic sensitivity for fibrosis staging; however, their high cost and limited accessibility restrict widespread implementation in many low- and middle-income countries [4].

In sub-Saharan Africa, and particularly in the Democratic Republic of the Congo, epidemiological data regarding CT-based hepatic assessment remain limited despite the growing burden of obesity, metabolic syndrome, diabetes mellitus, alcohol-related liver disease, and chronic viral hepatitis [3]. Most available studies from African populations have focused primarily on ultrasonography or laboratory-based markers, whereas CT-based radiological evaluation of hepatic abnormalities has received comparatively little attention. Furthermore, access to advanced noninvasive fibrosis assessment modalities such as transient elastography and magnetic resonance imaging remains restricted in many healthcare settings within the region.

Given the increasing availability of CT imaging in urban African medical centers, opportunistic radiological evaluation of hepatic steatosis and fibrosis may provide a practical alternative for large-scale noninvasive screening and assessment. Therefore, the present study aimed to evaluate CT-derived parameters for the assessment of hepatic steatosis and liver fibrosis in a Congolese population from Kinshasa and to analyze the agreement between mean hepatic attenuation and fibrosis-related morphological parameters using method-comparison statistical approaches.

Methodology

Study Design

This study was designed as an analytical cross-sectional radiological method-comparison study conducted to evaluate computed tomography (CT)-based parameters for the assessment of hepatic steatosis and liver fibrosis in a Congolese population from Kinshasa. The study retrospectively analyzed archived abdominal CT examinations performed between January 1, 2020, and June 30, 2025, at Rocher Imaging Center, Kinshasa. The methodological framework was specifically structured to assess the association and agreement between hepatic densitometric attenuation measurements and CT-derived morphological fibrosis indicators rather than to establish diagnostic validation. The study focused on evaluating the relationship between mean hepatic attenuation and the caudate-right lobe ratio (CRL-R) using advanced method-comparison statistical approaches.

Ethics

The study was conducted in accordance with the ethical principles outlined in the Declaration of Helsinki for research involving human participants [4]. Because the study was retrospective and based on archived radiological imaging data, no direct patient intervention was performed. All collected information was anonymized before analysis to ensure confidentiality and privacy protection. Patient identifiers were removed from the database prior to statistical processing, and all imaging data were handled exclusively for scientific and research purposes.

Setting

The study was carried out at Rocher Imaging Center (CIMR/Kinshasa), Democratic Republic of the Congo, a specialized radiological center routinely performing abdominal CT imaging for diagnostic and clinical evaluation. The center serves a large urban population and receives patients referred for diverse abdominal indications. Archived CT examinations stored within the institutional Picture Archiving and Communication System (PACS) and DICOM imaging database were reviewed for eligibility and inclusion in the study. Standardized abdominal CT acquisition protocols routinely used at the institution during the study period were considered for radiological analysis.

Participants

The study population included adult patients aged 18 years and older who underwent abdominal CT examinations during the study period and whose scans were considered technically interpretable for hepatic and splenic evaluation. A total of 2,485 abdominal CT scans met the eligibility criteria and were included in the final analysis.

Examinations presenting significant motion artifacts, incomplete radiological information, distorted anatomical structures, extensive focal hepatic lesions, prior major hepatic surgery, or poor image quality that could interfere with attenuation or morphological measurements were excluded. The study population included both male and female participants across multiple age categories.

Variables

The principal study variables consisted of CT-based densitometric and morphological radiological parameters associated with hepatic steatosis and liver fibrosis. Variables related to hepatic steatosis included mean hepatic attenuation, mean splenic attenuation, and liver-to-spleen attenuation difference measured in Hounsfield Units (HU). Variables associated with liver fibrosis included the caudate-right lobe ratio (CRL-R), right hepatic vein diameter, middle hepatic vein diameter, left hepatic vein diameter, and the cumulative sum of hepatic venous diameters (LD-score). Additional demographic variables included age and sex. Hepatic steatosis and fibrosis were categorized according to predefined CT-based radiological thresholds and morphological criteria described in previous literature [6,7,10].

Data Sources / Measurement

Data were extracted from archived CT images and radiological reports available in the institutional imaging database. CT attenuation measurements were performed using standardized circular regions of interest (ROIs) placed within homogeneous areas of hepatic and splenic parenchyma while carefully avoiding blood vessels, bile ducts, calcifications, beam-hardening artifacts, focal lesions, and image distortions. Multiple ROIs were used whenever necessary to improve measurement consistency. Morphological fibrosis parameters were obtained from axial and reconstructed CT images using validated anatomical landmarks described in previous radiological studies [10,14]. The caudate-right lobe ratio (CRL-R) was calculated according to standard morphometric methods. Hepatic vein diameters were measured at predefined anatomical levels to minimize variability. All measurements were performed using archived DICOM images under standardized viewing conditions.

Bias

Several methodological precautions were implemented to minimize potential sources of bias. Selection bias was reduced by including all eligible CT examinations performed during the study period that fulfilled predefined inclusion criteria. Measurement bias was minimized through the use of standardized radiological acquisition protocols, predefined ROI placement methodology, and validated anatomical landmarks for fibrosis assessment. Examinations with poor image quality or artifacts were excluded to reduce analytical variability. Nevertheless, the retrospective nature of the study may have introduced unavoidable limitations related to incomplete clinical information and variability in CT acquisition parameters over time. In addition, no histopathological confirmation, elastography, or magnetic resonance imaging reference standard was available, which limits direct diagnostic validation. Inter-observer and intra-observer reproducibility analyses were also not performed due to the retrospective design.

Study Size

The study included a total sample of 2,485 abdominal CT examinations collected over a five-year period. The study size was determined by the total number of eligible archived CT scans available during the study period that satisfied the inclusion criteria. The relatively large sample size increased the statistical power of the study and improved the precision of radiological agreement analyses between hepatic attenuation and fibrosis-related parameters.

Quantitative Variables

Continuous quantitative variables were expressed as mean ± standard deviation (SD) after assessment of data distribution. Quantitative radiological measurements included mean liver attenuation, mean splenic attenuation, liver-to-spleen attenuation difference, CRL-R, hepatic vein diameters, and LD-score. Age was also analyzed as a continuous quantitative variable and further categorized into predefined age groups for subgroup analyses. Agreement metrics including bias, proportional bias, Root Mean Square Error (RMSE), and Lin's Concordance Correlation Coefficient (CCC) were additionally treated as continuous analytical indicators for method-comparison evaluation.

Statistical Methods

Statistical analyses were performed using MedCalc version 9.2 and SPSS version 25. Descriptive statistics were used to summarize demographic and radiological characteristics of the study population. Continuous variables were presented as mean ± SD, whereas categorical variables were expressed as frequencies and percentages. Comparisons of proportions were performed using Pearson's Chi-square test or Fisher's exact test when appropriate. Comparisons of continuous variables between groups were conducted using Student's t-test or analysis of variance (ANOVA) depending on the number of comparison groups. A p-value < 0.05 was considered statistically significant.

To evaluate the relationship and agreement between mean hepatic attenuation and the fibrosis-related parameter CRL-R, advanced method-comparison statistical approaches were applied. Deming regression analysis was performed to account for measurement errors in both variables simultaneously [15,16]. Passing–Bablok regression analysis was additionally used to evaluate the presence of systematic or proportional bias between the two radiological measurements. Agreement analysis was further assessed using Lin's Concordance Correlation Coefficient (CCC), Bland–Altman analysis, mean bias estimation, proportional bias evaluation, Root Mean Square Error (RMSE), and the proportion of observations falling within 10% agreement limits (P10). Corresponding 95% confidence intervals were calculated for all major analytical indicators to improve statistical reliability and interpretability.

Results

Participants

A total of 2,485 abdominal computed tomography (CT) examinations performed between January 2020 and June 2025 were initially screened for eligibility. After exclusion of scans with incomplete radiological information, poor image quality, significant imaging artifacts, or major hepatic lesions that could interfere with densitometric and morphological assessment, 2,485 CT scans were included in the final analysis. The study population consisted of adult participants aged between 18 and 75 years, with a mean age of 50.6 ± 14.2 years. Women represented 52.2% (n = 1,297) of the study population, while men accounted for 47.8% (n = 1,188), demonstrating a slight female predominance. The overall prevalence of CT findings compatible with hepatic steatosis was 14.0% (n = 336), whereas morphological signs suggestive of liver fibrosis were observed in 9.0% (n = 232) of participants (Table 1).

Descriptive data

The demographic and radiological characteristics of the study population are summarized in Tables 1 and 2. The frequency of hepatic steatosis and liver fibrosis demonstrated progressive variation across different age categories. Hepatic steatosis was least frequent

among participants aged 18–29 years (5.6%) and progressively increased with advancing age, reaching 18.0% in the 50–59 years age group and 17.9% among participants aged ≥60 years. Similarly, liver fibrosis showed a marked increase in older age groups, with the highest prevalence observed among participants aged 60 years and above (26.4%). The association between age category and the presence of hepatic steatosis or fibrosis was statistically significant (p = 0.012) (Table 2).

Sex-related distribution showed a relatively higher proportion of hepatic steatosis and fibrosis among men compared with women. Among patients with hepatic steatosis, 204 men (17.2%) and 132 women (10.2%) were affected. Likewise, fibrosis-related CT findings were identified in 126 men (10.6%) and 106 women (8.2%). However, the association between sex and hepatic abnormalities did not reach statistical significance (p = 0.086) (Table 2).

Radiological densitometric parameters revealed a mean hepatic attenuation value of 36.5 ± 7.8 Hounsfield Units (HU), while the mean splenic attenuation measured 55.0 ± 6.7 HU. The mean liver-to-spleen attenuation difference was −18.5 ± 6.2 HU, reflecting reduced hepatic attenuation associated with steatotic changes. Morphological fibrosis parameters demonstrated a mean caudate-right lobe ratio (CRL-R) of 0.72 ± 0.12. The mean diameters of the right, middle, and left hepatic veins were 6.4 ± 1.1 mm, 6.1 ± 1.0 mm, and 5.8 ± 1.2 mm, respectively, while the mean LD-score reached 18.3 ± 3.0 (Table 2).

Outcome data

Agreement and method-comparison analyses between mean hepatic attenuation and the fibrosis-related parameter CRL-R were performed using Deming regression, Passing–Bablok regression, Bland–Altman analysis, and concordance statistics. Deming regression analysis demonstrated a slope coefficient of 0.967 (95% CI: 0.919–1.016) and an intercept of −2.885 (95% CI: −7.135 to 3.360), indicating the absence of significant proportional or systematic bias between the two radiological measurements. The regression line demonstrated a strong linear relationship between mean hepatic attenuation and CRL-R values (Figure 1 and Table 3).

Similarly, Passing–Bablok regression analysis showed a slope coefficient of 0.989 (95% CI: 0.959–1.019) and an intercept of −2.930 (95% CI: −3.418 to 8.776), further confirming the absence of significant systematic and proportional bias between the compared methods. The confidence intervals of both slope and intercept included the ideal values of 1 and 0, respectively, supporting good analytical comparability between the two CT-derived measurements (Figure 2 and Table 4).

Main results

Although both regression analyses demonstrated strong linear association and acceptable structural agreement between mean hepatic attenuation and CRL-R, concordance analysis revealed moderate overall agreement between the two parameters. Lin's Concordance Correlation Coefficient (CCC) was 0.423 (95% CI: 0.320–0.441), indicating weak-to-moderate concordance and suggesting that the two measurements cannot be considered fully interchangeable at the individual patient level (Table 5).

The Bland–Altman analysis demonstrated a mean bias of −5.392 (95% CI: −6.155 to −4.632), indicating that mean hepatic attenuation systematically underestimated CRL-R values (Figure 3 and Table 5). Furthermore, proportional bias analysis yielded a value of 3.941 (95% CI: 2.59–4.58), suggesting that discrepancies between the two methods increased progressively with increasing measurement magnitude. The standard deviation of differences was 3.091 (95% CI: 2.77–5.44), reflecting moderate variability between paired measurements.

Despite the moderate concordance, the P10 agreement metric was high at 92.4% (95% CI: 88.9–96.8), indicating that most observations remained within clinically acceptable agreement limits. However, the Root Mean Square Error (RMSE) value of 19.24 (95% CI: 15.77–22.52) suggested substantial variability in prediction performance between the two CT-derived parameters. Collectively, these findings demonstrate that mean hepatic attenuation and CRL-R exhibit good linear association and acceptable analytical agreement but limited complete interchangeability for individual-level assessment of hepatic abnormalities (Figure 3 and Table 5).

Table 1: General Demographic and Clinical Characteristics of the Study Population (N = 2,485).

Variables		N(%)
Total number of CT scans analyzed		2,485
Age (years); Mean ± SD		50.6 ± 14.2
Age range (years)		18–75
Gender	Female	1,297 (52.2)
	Male	1,188 (47.8)
Hepatic steatosis	No	2,149 (86.0)
	Yes	336 (14.0)
Liver fibrosis	No	2,253 (91.0)
	Yes	232 (9.0)
CT Parameters of Hepatic Steatosis; Mean ± SD	Mean liver attenuation (HU)	36.5 ± 7.8
	Mean splenic attenuation (HU)	55.0 ± 6.7
	Liver–spleen attenuation difference (HU)	−18.5 ± 6.2
	Caudate-right lobe ratio (CRL-R)	0.72 ± 0.12
CT Parameters of Liver Fibrosis; Mean ± SD	Right hepatic vein diameter (mm)	6.4 ± 1.1
	Middle hepatic vein diameter (mm)	6.1 ± 1.0
	Left hepatic vein diameter (mm)	5.8 ± 1.2
	Sum of venous diameters (LD-score)	18.3 ± 3.0

Table 2: Distribution of Hepatic Steatosis, Liver Fibrosis, and CT-Based Radiological Parameters.

Variables		Hepatic Steatosis (n = 336)	Liver Fibrosis (n = 232)	p-value
Gender	Female	204 (17.2)	126 (10.6)	0.086
	Male	132 (10.2)	106 (8.2)	
Age Group (years)	18–29	18 (5.6)	4 (1.3)	0.012*
	30–39	42 (8.8)	10 (2.1)	
	40–49	74 (13.2)	22 (3.9)	
	50–59	110 (18.0)	60 (9.8)	
	≥60	92 (17.9)	136 (26.4)	

*p<0.05 is considered statistically significant.

Table 3: Deming Regression Analysis Between Mean Hepatic Attenuation and Caudate-Right Lobe Ratio (CRL-R).

Parameter	Estimate	95% Confidence Interval	
		Lower Bound	Upper Bound
Intercept	−2.885	−7.135	3.360
Slope coefficient	0.967	0.919	1.016

Table 4: Passing–Bablok Regression Analysis Between Mean Hepatic Attenuation and Caudate-Right Lobe Ratio (CRL-R).

Parameter	Estimate	95% Confidence Interval	
		Lower Bound	Upper Bound
Intercept	−2.930	−3.418	8.776
Slope coefficient	0.989	0.959	1.019

Table 5: Agreement and Performance Analysis of Mean Hepatic Attenuation Compared with Caudate-Right Lobe Ratio (CRL-R).

Performance Indicator	Value (95% Confidence Interval)
Lin's Concordance Correlation Coefficient (CCC)	0.423 (0.320–0.441)
P10 Agreement Metric (%)	92.4 (88.9–96.8)
Mean Bias	−5.392 (−6.155 to −4.632)
Standard Deviation of Differences (SD)	3.091 (2.77–5.44)
Proportional Bias	3.941 (2.59–4.58)
Root Mean Square Error (RMSE)	19.24 (15.77–22.52)

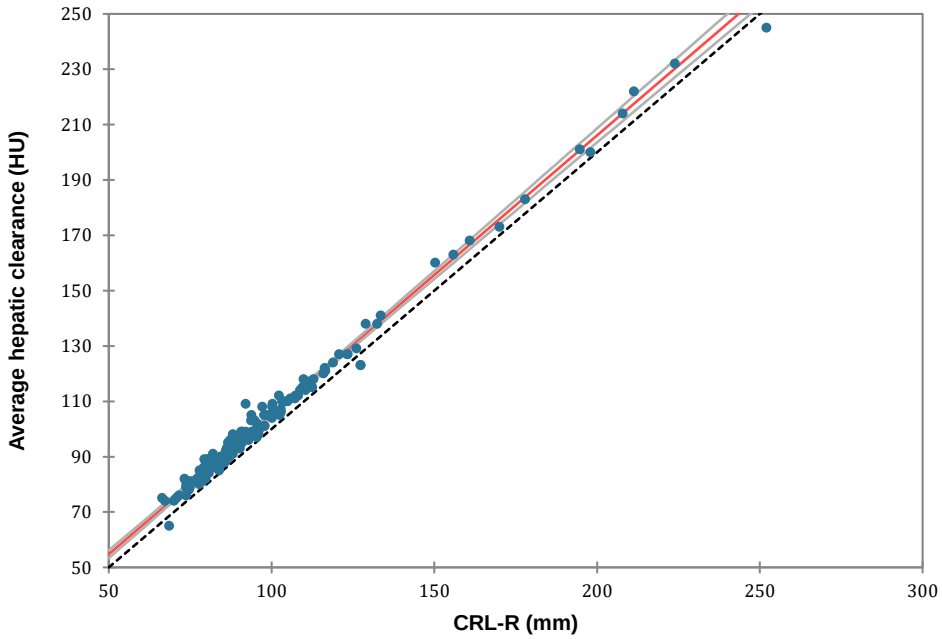

Figure 1: Deming regression analysis demonstrating the linear relationship between mean hepatic attenuation and caudate-right lobe ratio (CRL-R).

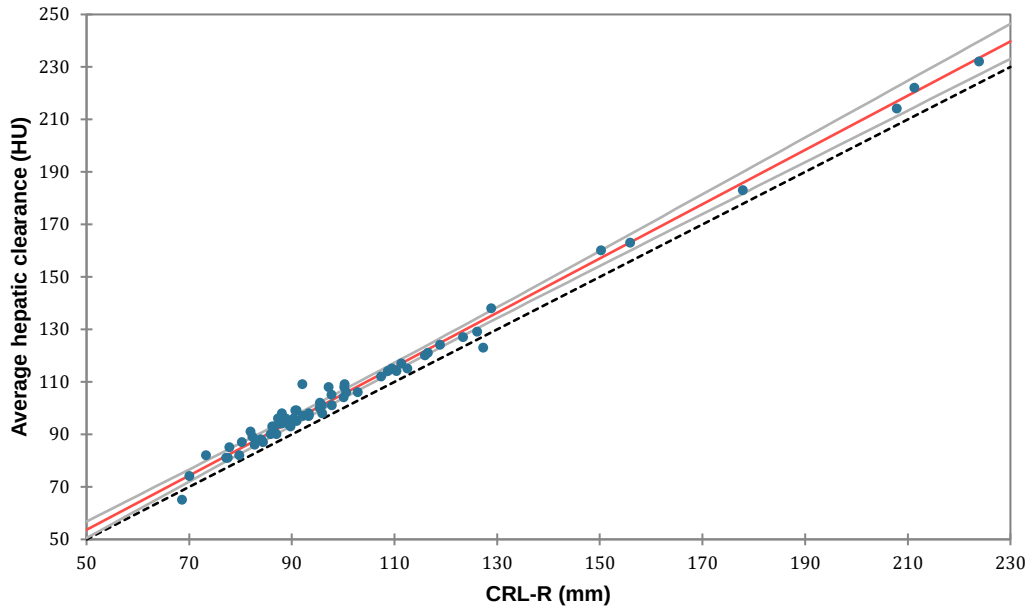

Figure 2: Passing–Bablok regression plot illustrating agreement between mean hepatic attenuation and caudate-right lobe ratio (CRL-R).

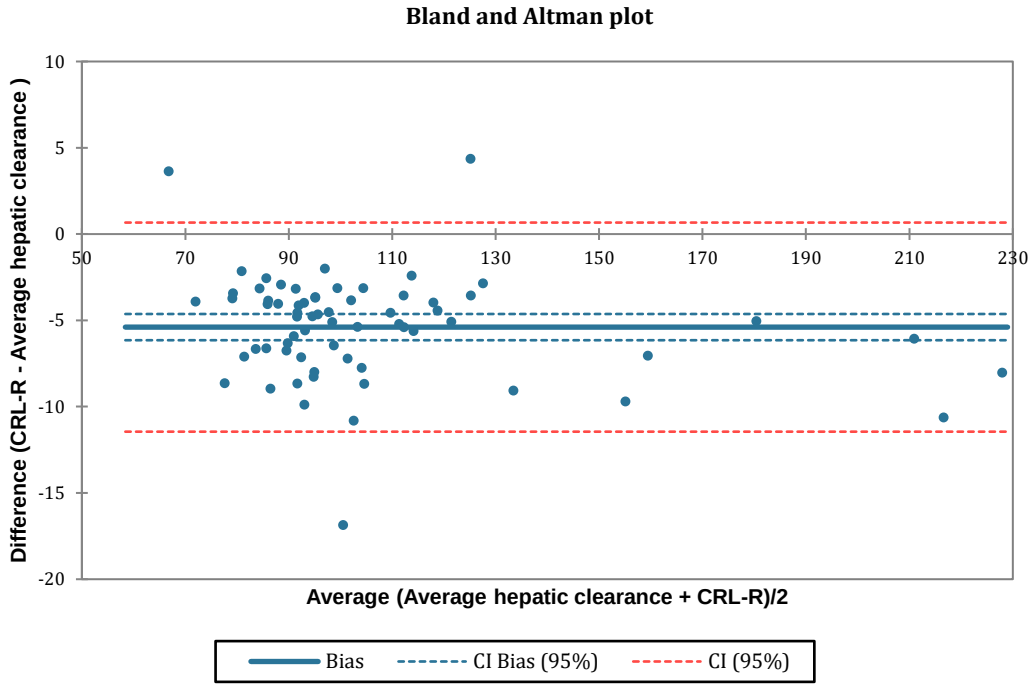

Figure 3: Bland–Altman plot showing agreement and bias analysis between mean hepatic attenuation and caudate-right lobe ratio (CRL-R).

Discussion

The present study evaluated the relationship and agreement between computed tomography (CT)-derived hepatic attenuation measurements and morphological fibrosis-related parameters in a large Congolese population from Kinshasa. The findings demonstrated that mean hepatic attenuation showed a good linear relationship with the caudate-right lobe ratio (CRL-R), although overall concordance between the two radiological approaches remained moderate. These results support the potential utility of CT-based imaging parameters in the opportunistic noninvasive evaluation of hepatic abnormalities, particularly in resource-limited settings where access to advanced fibrosis imaging modalities remains restricted.

In the current study, hepatic steatosis was identified in 14.0% of participants, while CT findings compatible with liver fibrosis were present in 9.0% of the study population. These findings are consistent with the growing global and regional burden of metabolic liver diseases described in previous epidemiological studies [11,12]. The prevalence observed in our study may reflect the increasing impact of urbanization, obesity, metabolic syndrome, diabetes mellitus, and lifestyle-related risk factors within African populations [1,12]. The progressive increase in hepatic steatosis and fibrosis with advancing age observed in our study is also supported by previous reports demonstrating that aging contributes to chronic hepatic inflammation, metabolic dysfunction, and progressive fibrotic remodeling [13].

The Deming and Passing–Bablok regression analyses demonstrated excellent structural agreement between mean hepatic attenuation and CRL-R measurements. The slope coefficients obtained from both analyses were very close to the ideal value of 1, while intercepts remained close to 0, indicating the absence of significant proportional or systematic bias between the two radiological measurements. These findings suggest that variations in hepatic attenuation are closely associated with CT-derived morphological alterations reflecting hepatic remodeling and fibrosis progression. Similar observations have been reported in previous radiological studies evaluating morphometric liver changes associated with chronic liver disease [10,14].

The use of Deming and Passing–Bablok regression analyses represents an important methodological strength of the present study because these statistical approaches account for measurement variability in both compared variables and are considered appropriate for analytical method-comparison studies [15,16]. Unlike conventional linear regression models, these methods reduce analytical bias and provide a more robust evaluation of agreement between radiological parameters. The combined use of multiple agreement indicators, including Lin's concordance correlation coefficient (CCC), Bland–Altman analysis, proportional bias estimation, and Root Mean Square Error (RMSE), further strengthened the analytical rigor of the study.

Despite the strong linear relationship observed in regression analyses, Lin's CCC demonstrated only moderate concordance between mean hepatic attenuation and CRL-R values. This finding indicates that although the two radiological parameters are statistically associated, they cannot be considered fully interchangeable at the individual patient level. Previous imaging studies have similarly demonstrated that strong correlation does not necessarily imply clinical interchangeability between different radiological or biochemical measurements [6,17]. Correlation primarily evaluates the strength of association between variables, whereas concordance reflects the extent to which measurements produce similar values in the same individual. Therefore, the moderate concordance observed in this study suggests that hepatic attenuation and CRL-R may provide complementary rather than identical information regarding hepatic abnormalities.

The negative mean bias observed in Bland–Altman analysis indicates that mean hepatic attenuation systematically underestimated CRL-R values. Several factors may explain this observation. CT attenuation measurements may be influenced by variations in scanner calibration, acquisition protocols, tissue composition, inflammatory changes, iron deposition, and coexistence of diffuse hepatic abnormalities [6,7]. Furthermore, morphological fibrosis parameters such as CRL-R reflect structural remodeling of hepatic architecture, whereas hepatic attenuation primarily reflects changes in tissue density related to fat accumulation. These distinct radiological constructs may partially explain the observed discrepancies between the two methods.

The presence of proportional bias additionally suggests that disagreement between measurements increased with greater severity of hepatic abnormalities. This finding indicates that the relationship between hepatic attenuation and fibrosis-related morphological changes may become less stable in advanced disease stages. Similar limitations of CT attenuation measurements have been described in previous studies evaluating diffuse liver disease, particularly in the context of severe fibrosis, inflammation, or mixed hepatic pathology [7,17,18]. Consequently, caution is required when interpreting CT-derived attenuation values as isolated indicators of fibrosis severity.

Nevertheless, the high P10 agreement metric observed in our study suggests that the majority of measurements remained within acceptable agreement limits. This finding supports the potential role of CT-based hepatic attenuation as a practical opportunistic screening or preliminary assessment tool, especially in settings where elastography, magnetic resonance imaging, or liver biopsy are not routinely available. In many sub-Saharan African healthcare environments, CT imaging may provide one of the few accessible noninvasive modalities for simultaneous assessment of abdominal pathology and chronic liver disease. Opportunistic CT-based hepatic evaluation could therefore contribute to earlier identification of individuals at risk for progressive hepatic disease.

The present study also contributes important data regarding CT-based hepatic assessment in an African population, an area where radiological evidence remains relatively limited. Most previous African studies have focused primarily on ultrasonography or laboratory markers, whereas CT-derived radiological assessment of steatosis and fibrosis has been insufficiently explored. The relatively large sample size used in this study improves the reliability of the findings and provides additional evidence regarding the applicability of CT-based hepatic evaluation in resource-constrained settings.

Limitations

Several limitations of the present study should be acknowledged. First, the retrospective cross-sectional design limits the ability to establish causal or temporal relationships between hepatic attenuation and fibrosis-related morphological changes. Second, the study relied exclusively on CT-derived radiological parameters without histopathological confirmation, transient elastography, magnetic resonance elastography, or FibroScan validation. Consequently, the study should not be interpreted as a formal diagnostic validation study, and the observed associations do not establish diagnostic equivalence between the compared parameters. Third, CT attenuation measurements may be affected by variability in scanner acquisition protocols, technical calibration, reconstruction algorithms, and patient-related factors. Although standardized measurement procedures were applied whenever possible, some degree of measurement variability may persist. Fourth, inter-observer and intra-observer reproducibility analyses were not available because measurements were retrospectively obtained from archived imaging examinations. Therefore, formal repeatability and reproducibility assessments according to CLSI EP05 recommendations could not be performed. Additionally, the study population originated from a single imaging center in Kinshasa, which may limit the generalizability of findings to other African populations or healthcare settings. Potential clinical confounding factors such as alcohol consumption, obesity, diabetes mellitus, viral hepatitis status, metabolic syndrome, and medication use were not comprehensively available within the retrospective database and therefore could not be fully incorporated into the analysis. Future prospective multicenter studies incorporating histological or elastographic reference standards and reproducibility testing are required to further validate the clinical applicability of CT-derived hepatic parameters.

Conclusion

The present study demonstrated that mean hepatic attenuation showed a good linear relationship with the caudate-right lobe ratio (CRL-R), with no major systematic or proportional bias identified by Deming and Passing–Bablok regression analyses. These findings support the potential utility of CT-derived radiological parameters in the noninvasive assessment of hepatic abnormalities. However, overall concordance between the two measurements remained moderate, and

significant variability persisted, indicating that hepatic attenuation and CRL-R should not be considered fully interchangeable at the individual patient level.

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References

1. Asrani SK, Devarbhavi H, Eaton J, Kamath PS. Burden of liver diseases in the world. J Hepatol. 2019;70(1):151–71. doi:10.1016/j.jhep.2018.09.014
2. European Association for the Study of the Liver, European Association for the Study of Diabetes, European Association for the Study of Obesity. EASL–EASD–EASO clinical practice guidelines on the management of metabolic dysfunction-associated steatotic liver disease (MASLD). J Hepatol. 2024;81(3):492–542. doi:10.1016/j.jhep.2024.04.031
3. World Health Organization. Global hepatitis report 2024. Geneva: World Health Organization; 2024. Available from: https://www.who.int/publications/i/item/9789240091672
4. Castera L, Friedrich-Rust M, Loomba R. Noninvasive assessment of liver disease in patients with nonalcoholic fatty liver disease. Gastroenterology. 2019;156(5):1264–81.e4. doi:10.1053/j.gastro.2018.12.036
5. Pickhardt PJ, Malecki K, Hunt OF, Beaumont C, Kloke J, Ziemlewicz TJ. Hepatic steatosis at abdominal CT: prevalence and association with metabolic risk factors in a general population sample. Radiology. 2022;302(3):528–36. doi:10.1148/radiol.210979
6. Park SH, Kim PN, Kim KW, Lee SW, Yoon SE, Park SW, et al. Macrovesicular hepatic steatosis in living liver donors: use of CT for quantitative and qualitative assessment. Radiology. 2006;239(1):105–12.
7. Kodama Y, Ng CS, Wu TT, Ayers GD, Curley SA, Abdalla EK, et al. Comparison of CT methods for determining the fat content of the liver. AJR Am J Roentgenol. 2007;188(5):1307–12.
8. Lee SS, Park SH. Radiologic evaluation of nonalcoholic fatty liver disease. World J Gastroenterol. 2014;20(23):7392–402.
9. Pickhardt PJ, Graffy PM, Zea R, Lee SJ, Liu J, Sandfort V, et al. Automated CT biomarkers for opportunistic prediction of future cardiovascular events and mortality in an asymptomatic screening population: a retrospective cohort study. Lancet Digit Health. 2020;2(4):e192–200.
10. Smith AD, Branch CR, Zand K, Subramony C, Zhang H, Thaggard K, et al. Liver surface nodularity quantification from routine CT images as a biomarker for detection and evaluation of cirrhosis. Radiology. 2016;280(3):771–81.
11. Shah AG, Lydecker A, Murray K, Tetri BN, Contos MJ, Sanyal AJ. Comparison of noninvasive markers of fibrosis in patients with nonalcoholic fatty liver disease. Clin Gastroenterol Hepatol. 2009;7(10):1104–12.
12. Younossi ZM, Koenig AB, Abdelatif D, Fazel Y, Henry L, Wymer M. Global epidemiology of nonalcoholic fatty liver disease. Hepatology. 2016;64(1):73–84.
13. Eslam M, Newsome PN, Sarin SK, Anstee QM, Targher G, Romero-Gomez M, et al. A new definition for metabolic dysfunction-associated fatty liver disease: an international expert consensus statement. J Hepatol. 2020;73(1):202–9.
14. Friedman SL, Neuschwander-Tetri BA, Rinella M, Sanyal AJ. Mechanisms of NAFLD development and therapeutic strategies. Nat Med. 2018;24(7):908–22.
15. Limanond P, Raman SS, Lassman C, Sayre J, Ghobrial RM, Busuttil RW, et al. Macronodular cirrhosis: utility of caudate-right lobe ratio in diagnosis with US. Radiology. 2004;230(2):446–52.
16. Passing H, Bablok W. A new biometrical procedure for testing the equality of measurements from two different analytical methods. J Clin Chem Clin Biochem. 1983;21(11):709–20.
17. Linnet K. Evaluation of regression procedures for methods comparison studies. Clin Chem. 1993;39(3):424–32.
18. McPherson S, Hardy T, Henderson E, Burt AD, Day CP, Anstee QM. Evidence of NAFLD progression from steatosis to fibrosis. Hepatology. 2017;66(6):1813–25.