



CORRELATION BETWEEN DIFFUSE HEPATIC STEATOSIS SEVERITY AND HEMOGLOBIN LEVELS ON NON-CONTRAST ABDOMINAL CT

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ABSTRACT

Metabolic dysfunction-associated steatotic liver disease (MASLD) is a common chronic liver disease, and hemoglobin has been reported to be associated with hepatic steatosis. This study evaluated the correlation between the degree of diffuse hepatic steatosis assessed by non-contrast computed tomography (NCCT) and hemoglobin levels. This observational analytic cross-sectional study included 81 patients who underwent non-contrast abdominal CT at Adam Malik Hospital. Hepatic attenuation was measured using three 100-mm² regions of interest in the posterior right lobe, anterior right lobe, and left lobe. Diffuse hepatic steatosis was categorized as mild (41.4–48.9 HU), moderate (36.4–41.4 HU), or severe (21.4–36.4 HU). Hemoglobin was categorized into quartiles. Associations with hemoglobin, body mass index (BMI), diabetes mellitus, and sex were analyzed using Pearson chi-square tests. Inter-reader agreement was assessed using Cohen's kappa. The median age was 51 years. Women comprised 54.3% of participants, and the median BMI was 25.71 kg/m². Severe diffuse hepatic steatosis was present in 64 participants (79.0%), mild in 9 (11.1%), and moderate in 8 (9.9%). Mean hemoglobin was 12.9 ± 2.2 g/dL. Inter-reader agreement for hepatic steatosis grading was very good ($\kappa=0.837$). No significant association was found between hepatic steatosis grade and hemoglobin quartile ($p=0.422$), diabetes mellitus ($p=0.077$), or sex ($p=0.965$). BMI was significantly associated with hepatic steatosis grade ($p=0.011$). In this study population, the degree of diffuse hepatic steatosis on NCCT was not significantly associated with hemoglobin level. BMI showed a significant association with hepatic steatosis severity.

Keywords: body mass index; computed tomography; diffuse hepatic steatosis; hemoglobin; MASLD

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INTRODUCTION

Metabolic dysfunction-associated steatotic liver disease (MASLD), previously termed non-alcoholic fatty liver disease (NAFLD), is a common chronic liver disease characterized by hepatic steatosis in association with at least one cardiometabolic risk factor. The terminology change emphasizes the central role of metabolic dysfunction in the disease spectrum (Han et al., 2023; Abdelhameed et al., 2024). MASLD has become a major public-health concern because of its high prevalence and its association with progressive liver disease, cardiovascular disease, and hepatocellular carcinoma. Global epidemiologic studies have documented a substantial and increasing burden of fatty liver disease, including among people with type 2 diabetes (Riazi et al., 2022; Younossi et al., 2023, 2024). Regional prevalence estimates also suggest that the burden is considerable in Asian populations (Eslam et al., 2020; Powell et al., 2021).

MASLD is closely linked to obesity, insulin resistance, dyslipidemia, and other components of metabolic syndrome. Excess energy intake and adipose tissue dysfunction increase the delivery of

free fatty acids to the liver and stimulate hepatic lipogenesis, contributing to triglyceride accumulation in hepatocytes (Grander et al., 2023; Powell et al., 2021). The relationship between body mass index (BMI) and steatosis is nevertheless not absolute: hepatic steatosis may also occur in individuals with a normal BMI, often described as lean or non-obese fatty liver disease (Ye et al., 2020). Cumulative metabolic risk factors may influence the severity of hepatic steatosis, and glycemic markers have also been associated with steatosis severity (Egresi et al., 2025; Qu et al., 2025; Xie et al., 2022).

Histopathology can characterize hepatic steatosis and accompanying inflammation or fibrosis, but liver biopsy is invasive and is not required for every patient. Non-invasive approaches, including ultrasonography, computed tomography (CT), magnetic resonance imaging (MRI), and serum-based scores, are therefore important in clinical assessment (Altamirano et al., 2020; Kechagias et al., 2022; Abdelhameed et al., 2024). Ultrasonography is widely accessible but can be subjective and has limited sensitivity for mild steatosis. Non-contrast CT (NCCT) offers an objective measure of hepatic attenuation in Hounsfield units (HU); attenuation generally decreases as fat accumulates in the liver. CT attenuation can support grading of steatosis, although performance varies with the degree of fat accumulation and technical factors (Lee, 2017; Alshoabi et al., 2024).

Hemoglobin has been investigated as a readily available hematologic marker associated with fatty liver and metabolic dysfunction. Studies in different populations have reported associations between hemoglobin concentration or red blood cell count and the presence of fatty liver disease (Bai et al., 2014; Jiang et al., 2014; Wang et al., 2017; Juárez-Hernández et al., 2018). Other work has examined hemoglobin in relation to hepatic steatosis and cardiometabolic outcomes, including studies of Korean adults, pregnant women, and United States adults (Jung et al., 2021; Li et al., 2021; Yao et al., 2024). Ma et al. (2021) also included hemoglobin-related and metabolic information in a predictive approach to fatty liver disease. However, these studies differ in population, outcome definition, and measurement method, and an association with the presence of fatty liver does not necessarily establish a relationship with imaging-defined severity.

Several biological pathways have been proposed to explain a potential relationship between hemoglobin and MASLD. Hemoglobin may be related indirectly to iron stores, while iron excess can contribute to oxidative stress; insulin resistance and metabolic abnormalities may also be shared determinants of both hematologic and hepatic findings. Nonetheless, hemoglobin is affected by hydration, nutritional status, chronic illness, iron status, and hematologic conditions, so it is not a specific marker of hepatic fat. Sex-related differences in fatty liver risk have also been described and may vary with age and menopausal status (Lonardo et al., 2019). The relationship between hemoglobin concentration and the radiologic severity of diffuse hepatic steatosis therefore remains an important question. This study aimed to determine the association between the degree of diffuse hepatic steatosis measured on non-contrast abdominal CT and hemoglobin levels. Secondary analyses evaluated associations with BMI, diabetes mellitus, and sex. This study aimed to determine the correlation between the degree of diffuse hepatic steatosis assessed on non-contrast abdominal CT and hemoglobin levels. Secondary analyses evaluated the associations of hepatic steatosis grade with body mass index (BMI), diabetes mellitus, and sex.

METHOD

This observational analytic study used a cross-sectional design. The study was conducted in the Radiology Department of Adam Malik Hospital, Medan, Indonesia. Data collection included 81 consecutive patients who underwent non-contrast abdominal CT and met the predefined inclusion and exclusion criteria. The inclusion criteria were age 18–65 years, availability of anthropometric measurements, complete blood count and random blood glucose data, and diffuse hepatic steatosis on non-contrast abdominal CT. Patients with chronic liver disease other than MASLD, previous liver transplantation, hematologic disorders, recent blood transfusion or bleeding within three

months, pregnancy, malignancy, acute or chronic kidney failure, or incomplete medical records were excluded.

Hepatic attenuation was measured on non-contrast CT using RadiAnt software. Three 100-mm² regions of interest were placed in the posterior right hepatic lobe, anterior right hepatic lobe, and left hepatic lobe. Based on the study protocol, diffuse hepatic steatosis was categorized as mild (41.4–48.9 HU), moderate (36.4–41.4 HU), and severe (21.4–36.4 HU). CT examinations were acquired using Philips 128-slice and GE 16-slice scanners with a slice thickness of 1.25 mm. Hemoglobin data were obtained from medical records and divided into four quartiles. Diabetes mellitus was categorized according to the available random blood glucose data. BMI was categorized as underweight (<18.5 kg/m²), ideal (18.5–24.9 kg/m²), overweight (25–29.9 kg/m²), and obesity (>30 kg/m²). Two readers assessed hepatic attenuation, and inter-reader agreement was evaluated using Cohen's kappa. Associations between categorical variables were assessed using Pearson chi-square tests. Statistical significance was defined as $p < 0.05$.

RESULT

Table 1.
Demographic and clinical characteristics of the study population

Characteristics	Value (n=81)
Age (years)	51 (18-72)
Sex	
Male	37 (45,7%)
Female	44 (54,3%)
Diabetes Melitus	
Yes	17 (21,0%)
No	64 (79,0%)
Body Mass Index (kg/m ²)	25,71 (14,34–47,62)
Underweight (IMT<18,5)	3 (3,7%)
Ideal (IMT:18,5-24,9)	33 (40,7%)
Overweight (IMT:25-29,9)	33 (40,7%)
Obesity (IMT >30)	12 (14,8%)
Hemoglobin (g/dL)	12,9 ± 2,2
Quartile 1 (<11.5)	15 (18,5%)
Quartile 2 (≥11.5 – 13)	25 (30,9%)
Quartile 3 (≥13 – 14.4)	20 (24,7%)
Quartile 4 (≥14.4)	21 (25,9%)
Diffuse hepatic steatosis severity	
Mild (HU: 41,4 - 48,9)	9 (11,1%)
Moderate (HU: 36,4 - 41,4)	8 (9,9%)
Severe (HU:21,4 - 36,4)	64 (79%)

Age and BMI are presented as median (minimum–maximum), whereas hemoglobin is presented as mean ± standard deviation. Among the 81 participants, the median age was 51 years. Women accounted for 44 participants (54.3%) and men for 37 (45.7%). The median BMI was 25.71 kg/m². Severe diffuse hepatic steatosis was the predominant category, occurring in 64 participants (79.0%). Mean hemoglobin was 12.9 ± 2.2 g/dL. Inter-reader agreement for hepatic steatosis grading was very good ($\kappa=0.837$).

Table 2.
Associations between diffuse hepatic steatosis grade and hemoglobin quartile

DHS severity	Hemoglobin				<i>p value</i>
	Quartile I (n=15)	Quartile II (n=25)	Quartile III (n=20)	Quartile IV (n=21)	
Mild	3(33,3%)	2(22,2%)	2(22,2%)	2(22,2%)	^a 0,422
Moderate	3(37,5%)	3(37,5%)	0(0%)	2(25%)	
Severe	9(14,1%)	20(31,2%)	18(28,1%)	17(26,6%)	

^a Pearson Chi square test

There was no statistically significant association between diffuse hepatic steatosis grade and hemoglobin quartile ($p=0.422$). The distribution of hemoglobin quartiles did not demonstrate a consistent linear pattern across mild, moderate, and severe steatosis.

Table 3.

Associations between diffuse hepatic steatosis grade and BMI category

BMI Category	DHS severity			<i>p value</i>
	Mild f (%)	Moderate f (%)	Severe f (%)	
Underweight	2 (66,7%)	1 (33,3%)	0 (0%)	^a 0,011
Ideal	4 (12,1%)	4 (12,1%)	25 (75,8%)	
Overweight	3 (9,1%)	1 (3%)	29 (87,9%)	
Obesity	0 (0%)	2 (16,7%)	10 (83,3%)	

^a Pearson Chi square test

BMI was significantly associated with diffuse hepatic steatosis grade ($p=0.011$). Severe steatosis predominated among participants with ideal BMI, overweight, and obesity, while no underweight participant was categorized as having severe steatosis.

Table 4.

Associations between diffuse hepatic steatosis grade and diabetes mellitus

Diabetes Mellitus	DHS severity			<i>p value</i>
	Mild f (%)	Moderate f (%)	Severe f (%)	
Yes	4 (23,5%)	0 (0%)	13 (76,5%)	^a 0,077
No	5 (7,8%)	8 (12,5%)	51 (79,7%)	

^a Pearson Chi square test

No statistically significant association was observed between diabetes mellitus status and diffuse hepatic steatosis grade ($p=0.077$). Severe steatosis was present in 76.5% of participants with diabetes and 79.7% of those without diabetes.

Table 5.

Associations between diffuse hepatic steatosis grade and sex

Sex	DHS severity			<i>p value</i>
	Mild f (%)	Moderate f (%)	Severe f (%)	
Male	4 (10,8%)	4 (10,8%)	29 (78,4%)	^a 0,965
Female	5 (11,4%)	4 (9,1%)	35 (79,5%)	

^a Pearson Chi square test

There was no statistically significant association between sex and diffuse hepatic steatosis grade ($p=0.965$). Severe steatosis was observed in 78.4% of men and 79.5% of women.

DISCUSSION

The principal finding was that hemoglobin quartile was not significantly associated with the degree of diffuse hepatic steatosis assessed by NCCT ($p=0.422$). This result does not support a clear relationship between hemoglobin level and imaging-defined steatosis severity in this sample. It differs from studies reporting associations between hemoglobin or red blood cell measures and the presence of fatty liver disease (Bai et al., 2014; Jiang et al., 2014; Wang et al., 2017; Juárez-Hernández et al., 2018). More recent studies have also explored hemoglobin in relation to MASLD and associated outcomes (Jung et al., 2021; Yao et al., 2024). These findings are not directly interchangeable, because detecting the presence of fatty liver is different from testing whether hemoglobin varies across radiologic severity categories.

The distribution of severity in the present cohort is an important consideration: 64 of 81 participants (79.0%) were classified as having severe steatosis, while only nine (11.1%) had mild and eight (9.9%) had moderate steatosis. The small and imbalanced mild and moderate groups may have limited the statistical ability to detect differences across grades. The study was also conducted at a tertiary referral hospital, so the high proportion of severe steatosis may reflect referral and case-selection patterns rather than the distribution in the general population. A cross-sectional design further limits interpretation because it cannot establish whether changes in hemoglobin precede,

follow, or occur independently of steatosis progression.

Biologically, a relationship remains plausible but is not necessarily specific or linear. Hemoglobin may correlate with iron stores, and excess iron can contribute to oxidative stress, while insulin resistance and other metabolic disturbances are central to MASLD pathophysiology (Grander et al., 2023; Powell et al., 2021). Nevertheless, hemoglobin concentration is also influenced by hydration, nutritional status, chronic illness, and hematologic factors. The current study did not include comprehensive measurements such as ferritin, transferrin saturation, insulin resistance, or longitudinal hematologic values. These unmeasured factors may partly explain why hemoglobin quartile did not track with CT-based severity. Findings from pregnancy-related and cardiovascular studies should also be interpreted cautiously when applied to a general adult CT cohort (Li et al., 2021; Jung et al., 2021).

BMI was significantly associated with steatosis grade ($p=0.011$), and severe steatosis was common among participants classified as overweight or obese. This observation is consistent with the established metabolic basis of MASLD: excess adiposity, particularly visceral adiposity, promotes insulin resistance, increased free-fatty-acid flux to the liver, and hepatic triglyceride accumulation (Egresi et al., 2025; Powell et al., 2021; Grander et al., 2023). The relationship between metabolic risk factors and steatosis severity has also been described in larger observational populations (Qu et al., 2025). These mechanisms provide a plausible explanation for the association observed in this study, although the cross-sectional analysis cannot establish causality.

Steatosis was also present in participants with an ideal BMI. This is compatible with reports of lean or non-obese fatty liver disease, demonstrating that normal BMI does not exclude hepatic steatosis (Ye et al., 2020). BMI does not directly measure visceral fat distribution, and metabolic risk may occur at lower BMI thresholds in Asian populations. Accordingly, BMI is useful for risk assessment but should not be interpreted as a complete measure of an individual's metabolic health. The broader MASLD framework places emphasis on cardiometabolic risk rather than body size alone (Han et al., 2023; Eslam et al., 2020).

Diabetes mellitus was not significantly associated with steatosis grade in this cohort ($p=0.077$). Only 17 participants were classified as having diabetes, limiting the size of that subgroup. In addition, diabetes status was determined from available clinical information and random blood glucose rather than a more comprehensive assessment of long-term glycemic control. A single glucose value may be affected by recent food intake, acute illness, stress, and treatment, and therefore may not represent cumulative glycemic exposure. Previous research has associated HbA1c or fasting glucose with hepatic steatosis and its severity (Xie et al., 2022; Qu et al., 2025), while the global burden of fatty liver is particularly high among patients with type 2 diabetes (Younossi et al., 2024). The nonsignificant result here should therefore be interpreted in light of measurement and sample-size limitations rather than as evidence that diabetes is unrelated to MASLD.

This study has several limitations. Its cross-sectional, single-center design limits causal inference and generalizability. The predominance of severe steatosis may have reduced power to identify differences between grades. Diabetes classification relied on available records and random blood glucose, and potentially relevant variables—including HbA1c, lipid profile, ferritin, transferrin saturation, medication use, alcohol exposure, and detailed measures of insulin resistance—were not comprehensively assessed. These limitations are important because MASLD is multifactorial and diagnostic approaches may differ across studies and populations (Riazi et al., 2022; Abdelhameed et al., 2024; Ma et al., 2021). Future studies should recruit larger cohorts with more balanced severity groups and include longitudinal hemoglobin measurements and comprehensive metabolic markers.

Inter-reader agreement for CT-based grading was very good ($\kappa=0.837$), supporting the reproducibility of the ROI-based attenuation method used in this study. NCCT can provide objective attenuation measurements when steatosis is incidentally encountered on abdominal imaging. However, CT has limitations in detecting mild steatosis and entails ionizing radiation; imaging findings should therefore be interpreted alongside clinical and laboratory information. Comparisons of CT attenuation with ultrasonography-based grading have shown that modality-specific thresholds and grading methods should be considered when interpreting results (Lee, 2017; Alshoabi et al., 2024). Non-invasive diagnosis is best understood as a complementary approach rather than a replacement for all clinical assessment (Altamirano et al., 2020; Kechagias et al., 2022).

No significant association was observed between sex and steatosis grade ($p=0.965$). Severe steatosis was present in 78.4% of men and 79.5% of women. Sex-related differences in fatty liver epidemiology are recognized, but they may vary with age, hormonal status, and metabolic risk profile (Lonardo et al., 2019). The median age in this cohort was 51 years; menopausal status was not available for analysis, so its possible influence cannot be evaluated directly. Similar proportions in this sample may also reflect the predominance of severe steatosis across both sex groups and the limited number of participants in the other severity categories.

CONCLUSION

In this study, the degree of diffuse hepatic steatosis was not significantly associated with hemoglobin level ($p=0.422$). BMI was significantly associated with hepatic steatosis grade ($p=0.011$), whereas diabetes mellitus ($p=0.077$) and sex ($p=0.965$) were not. ROI-based hepatic attenuation assessment demonstrated very good inter-reader agreement ($\kappa=0.837$). Further studies with larger and more balanced severity groups and comprehensive metabolic variables, including HbA1c and lipid profiles, are warranted.

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