

Correlation between Hepatic Attenuation and Visceral Fat Area on Computed Tomography: A Narrative Review

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ABSTRACT

Nonalcoholic fatty liver disease (NAFLD) is one of the most common chronic liver disorders worldwide and is closely associated with obesity, insulin resistance, metabolic syndrome, and increased visceral adiposity. Computed tomography (CT) has emerged as an important imaging modality for evaluating hepatic steatosis through quantitative assessment of hepatic attenuation values. Visceral fat area (VFA), measured on CT, is considered a significant indicator of metabolic dysfunction and cardiovascular risk. Recent studies have demonstrated a strong inverse relationship between hepatic attenuation and visceral fat accumulation, suggesting that increasing visceral obesity contributes to progressive hepatic fat deposition. This review summarizes the current evidence regarding the correlation between hepatic attenuation and visceral fat area on CT imaging, discusses CT-based diagnostic criteria for hepatic steatosis, and highlights the clinical implications of combining hepatic attenuation and visceral fat measurements in the assessment of metabolic liver disease. CT-derived hepatic attenuation and visceral fat area demonstrate a significant inverse correlation and together provide valuable imaging biomarkers for opportunistic screening, metabolic risk stratification, and longitudinal monitoring in patients with NAFLD.

Keywords: *Hepatic attenuation; Visceral fat area; Computed tomography; Hepatic steatosis; Nonalcoholic fatty liver disease; Visceral obesity; Metabolic syndrome.*

INTRODUCTION

Nonalcoholic fatty liver disease (NAFLD) has emerged as one of the most common chronic liver disorders worldwide and represents a major public health concern because of the rapidly increasing prevalence of obesity, metabolic syndrome, insulin resistance, and type 2 diabetes mellitus. NAFLD is characterized by excessive triglyceride accumulation within hepatocytes in the absence of significant alcohol intake and encompasses a broad clinicopathological spectrum ranging from simple steatosis to nonalcoholic steatohepatitis (NASH), progressive fibrosis, cirrhosis, and hepatocellular carcinoma (1–4). Recent epidemiological studies have demonstrated a continuous increase in the global burden of NAFLD, making it one of the leading causes of chronic liver disease and liver transplantation worldwide (5,6). In addition to hepatic complications,

NAFLD is increasingly recognized as a multisystem disease associated with cardiovascular disease, chronic kidney disease, type 2 diabetes mellitus, and increased overall mortality (5,7).

Visceral obesity plays a pivotal role in the development and progression of NAFLD. Unlike subcutaneous adipose tissue, visceral adipose tissue is metabolically active and releases excessive amounts of free fatty acids, inflammatory cytokines, and adipokines directly into the portal circulation, thereby promoting insulin resistance, oxidative stress, chronic inflammation, and hepatic lipid accumulation (3,8). Several studies have shown that visceral adiposity exhibits a stronger association with hepatic steatosis and metabolic abnormalities than generalized obesity measured by body mass index (BMI) alone (9–11). Increased visceral fat accumulation has also been linked with dyslipidemia, metabolic syndrome,

cardiovascular disease, and progression of liver injury (12,13). Consequently, assessment of visceral fat area (VFA) has emerged as an important biomarker for evaluating metabolic risk and disease severity in patients with NAFLD.

Radiological imaging plays an essential role in the non-invasive diagnosis and evaluation of hepatic steatosis. Among available imaging modalities, computed tomography (CT) is widely used because of its accessibility, rapid acquisition, reproducibility, and ability to provide quantitative assessment of both hepatic fat content and body fat distribution (2,14). Hepatic attenuation on non-enhanced CT is measured in Hounsfield units (HU), and fat accumulation within hepatocytes results in reduced attenuation values because triglycerides possess lower density than normal hepatic parenchyma (15). Several CT-derived indices, including absolute liver attenuation, liver-to-spleen attenuation ratio, and liver-spleen attenuation difference, have been utilized for the diagnosis and quantification of hepatic steatosis (16,17). Park et al. first demonstrated the utility of CT for quantitative and qualitative assessment of macrovesicular hepatic steatosis in living liver donors (18), while Byun et al. subsequently developed and validated diagnostic cutoff values using pathological reference standards (16). Furthermore, a recent systematic review and meta-analysis by Haghshomar et al. confirmed that CT demonstrates moderate-to-high diagnostic accuracy for detecting hepatic steatosis, particularly in moderate-to-severe disease, highlighting its value in routine clinical practice and opportunistic screening (1).

In addition to hepatic fat quantification, CT enables accurate assessment of visceral fat area, typically measured at the abdominal level. Visceral fat area is considered a reliable indicator of central obesity and metabolic dysfunction because it reflects intra-abdominal adiposity associated with insulin resistance and cardiovascular disease (9). Population-based investigations by Zeb et al. demonstrated that CT-based evaluation of fatty liver disease is practical and reproducible and showed strong associations between hepatic steatosis, visceral obesity, metabolic syndrome, and cardiovascular risk factors. Similarly, Pickhardt et al. reported significant relationships between visceral adiposity, hepatic steatosis, and metabolic syndrome on abdominal CT examinations (9). Recent studies have further shown that increased visceral fat area is associated with lower hepatic attenuation values and worsening metabolic abnormalities.

Several studies have demonstrated that hepatic attenuation measurements are closely associated with lipid abnormalities and metabolic dysfunction. Jawahar et al. reported significant correlations between CT-based hepatic steatosis criteria, abnormal liver function tests, and metabolic risk factors, while another study by the same group demonstrated significant associations between reduced hepatic attenuation and adverse lipid profiles, including elevated triglyceride

levels and reduced high-density lipoprotein cholesterol levels. Han et al. further observed that increasing severity of hepatic steatosis was associated with progressively worsening dyslipidemia and metabolic disturbances (12). Cerit et al. reported significant correlations between ultrasonographic attenuation measurements and unenhanced multidetector CT findings for liver fat quantification, supporting the reliability of CT attenuation values in evaluating hepatic steatosis. More recently, Kalekar et al. demonstrated a significant inverse relationship between liver attenuation and visceral fat area on CT, emphasizing the role of visceral obesity in hepatic fat accumulation and metabolic dysfunction.

Current clinical practice guidelines emphasize the importance of early diagnosis and management of NAFLD because of its increasing prevalence and close association with cardiovascular morbidity and metabolic complications (3,6). Since abdominal CT examinations are frequently performed for various clinical indications, simultaneous assessment of hepatic attenuation and visceral fat area provides an excellent opportunity for opportunistic screening and risk stratification without additional radiation exposure or imaging procedures (1). Moreover, advances in automated body composition analysis and artificial intelligence have expanded the potential role of CT-derived imaging biomarkers in precision medicine and metabolic risk prediction.

Therefore, understanding the correlation between hepatic attenuation and visceral fat area on computed tomography is of considerable clinical significance. Combined quantitative assessment of these parameters may facilitate early diagnosis, improve metabolic risk stratification, enable monitoring of disease progression, and support individualized therapeutic approaches in patients with NAFLD and obesity-related metabolic disorders. This narrative review aims to summarize current evidence regarding the relationship between hepatic attenuation and visceral fat area on CT and to discuss its role in the diagnosis, risk assessment, and management of metabolic liver disease.

Literature Search Strategy

A comprehensive literature search was conducted using PubMed, Scopus, Web of Science, Google Scholar, and Embase databases for articles published up to June 2026. Search terms included "hepatic attenuation," "computed tomography," "visceral fat area," "hepatic steatosis," "NAFLD," "visceral obesity," and "body composition." Original articles, systematic reviews, meta-analyses, and clinical guidelines published in English were included. Reference lists of relevant studies were also screened to identify additional publications. As this is a narrative review, a formal PRISMA-based systematic review methodology was not applied.

Pathophysiology of Hepatic Steatosis and Visceral Obesity

Role of Visceral Adipose Tissue in NAFLD

Visceral adipose tissue (VAT) plays a central role in the development and progression of nonalcoholic fatty liver disease (NAFLD). Unlike subcutaneous adipose tissue, visceral fat is metabolically active and releases excessive amounts of free fatty acids (FFAs), pro-inflammatory cytokines, and adipokines directly into the portal venous circulation. Increased delivery of FFAs to the liver promotes triglyceride synthesis and accumulation within hepatocytes, leading to hepatic steatosis. In addition, inflammatory mediators such as tumor necrosis factor- α (TNF- α), interleukin-6 (IL-6), and adipokines contribute to insulin resistance, oxidative stress, mitochondrial dysfunction, and chronic low-grade inflammation, which are key mechanisms involved in the pathogenesis of NAFLD (3,7,8,11).

Development of Hepatic Steatosis and Its Relationship with Visceral Obesity

Hepatic steatosis is characterized by excessive accumulation of triglycerides within hepatocytes resulting from an imbalance between fatty acid uptake, lipogenesis, oxidation, and lipid export. Obesity and insulin resistance disrupt normal hepatic lipid metabolism, leading to progressive fat deposition within the liver (3,4,15). As hepatic fat content increases, attenuation values on non-enhanced computed tomography (CT) decrease because fat has a lower radiographic density than normal liver parenchyma. Therefore, reduced hepatic attenuation serves as a practical imaging marker of increasing hepatic fat content and steatosis severity (1,8,10).

Visceral obesity plays a central role in this process. Visceral adipose tissue is metabolically active and releases free fatty acids, inflammatory cytokines, and adipokines directly into the portal circulation, promoting hepatic lipid accumulation, insulin resistance, and chronic inflammation (3,13,15). Consequently, patients with increased visceral fat area frequently exhibit dyslipidaemia, impaired glucose metabolism, metabolic syndrome, and cardiovascular risk factors. Studies have shown that visceral adiposity is a stronger predictor of hepatic steatosis and metabolic dysfunction than body mass index (BMI) alone (7,13,15). Furthermore, increasing visceral fat is associated with elevated triglyceride levels, reduced high-density lipoprotein (HDL) cholesterol concentrations, and worsening metabolic abnormalities (9,13). These findings highlight the close relationship between visceral obesity and hepatic steatosis and support the combined assessment of hepatic attenuation and visceral fat area on CT for comprehensive evaluation of NAFLD and metabolic risk. (1,3,7,9,13,15)

Disease Progression and Histopathological Changes

Persistent hepatic fat accumulation and chronic inflammation may promote progression from simple steatosis to nonalcoholic steatohepatitis (NASH), fibrosis, cirrhosis, and hepatocellular carcinoma. The currently accepted multiple-hit hypothesis suggests that insulin resistance, oxidative stress, lipotoxicity, mitochondrial dysfunction, inflammatory cytokines, gut microbiota alterations, and genetic susceptibility act synergistically to drive disease progression and liver injury (3,4,17,18). As hepatic steatosis advances, hepatocellular damage and inflammatory responses become more pronounced, increasing the risk of fibrosis and adverse clinical outcomes.

Longitudinal evidence supports the progressive nature of NAFLD. Adams et al. demonstrated that NAFLD may progress histologically over time and can result in advanced liver disease in susceptible individuals (11). Similarly, Gholam et al. reported a high prevalence of NAFLD among severely obese individuals, highlighting the strong association between obesity and hepatic fat accumulation (12). More recent clinical guidelines and imaging studies have further emphasized the central role of visceral adiposity and metabolic dysfunction in disease progression (3,13,14). Consequently, early identification of hepatic steatosis and associated visceral obesity is essential for preventing progression to advanced liver disease and related metabolic complications. (5,9).

Computed Tomography in the Evaluation of Hepatic Steatosis

Computed tomography (CT) is one of the most widely used imaging modalities for abdominal evaluation and provides an opportunity for opportunistic detection of hepatic steatosis during routine clinical examinations. Owing to its rapid image acquisition, wide availability, reproducibility, and quantitative capability, CT has become an important non-invasive tool for assessing hepatic fat content and body composition (1,14). Among the different CT techniques, non-enhanced CT is considered more reliable than contrast-enhanced CT for hepatic fat quantification because intravenous contrast agents significantly influence attenuation values and may reduce diagnostic accuracy (14,15). Consequently, non-contrast CT has been extensively utilized in both clinical practice and research for the assessment of hepatic steatosis.

Measurement of Liver-to-Spleen Attenuation Ratio on Non-Enhanced CT

Hepatic attenuation on CT is expressed in Hounsfield units (HU), reflecting the radiographic density of liver parenchyma. In healthy individuals, normal hepatic attenuation typically ranges from 50 to 65 HU on non-enhanced CT and is usually 8–10 HU greater than splenic attenuation (14,18). As triglyceride accumulation increases within hepatocytes, the attenuation values progressively decrease because fat

possesses lower radiographic density than normal hepatic tissue (1,15). Therefore, hepatic attenuation measurements provide an indirect but reliable indicator of hepatic fat content and disease severity.

Several CT-based quantitative criteria have been proposed for the diagnosis of hepatic steatosis and have demonstrated good diagnostic performance in clinical studies (16,17).

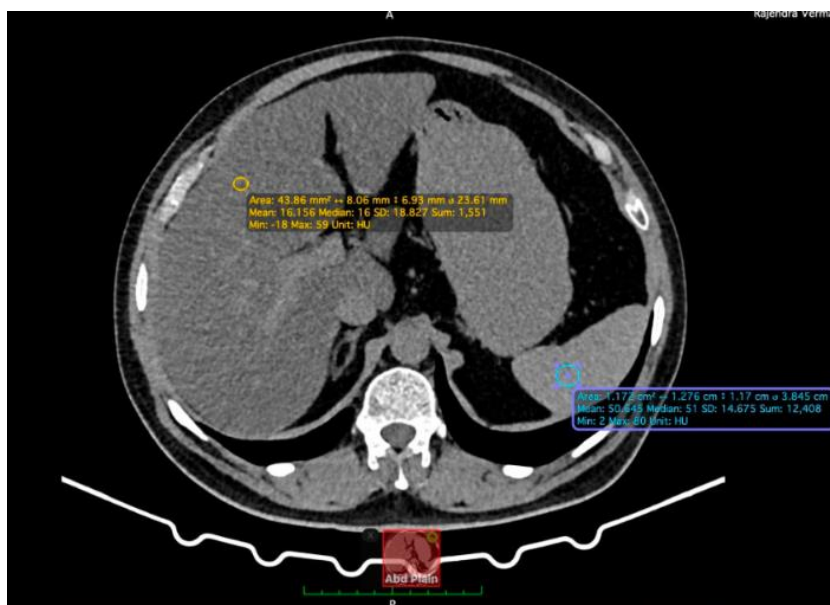


Figure 1 Axial non-enhanced CT image showing placement of regions of interest (ROIs) within the liver and spleen for calculation of the liver-to-spleen attenuation ratio (L/S ratio). The mean liver attenuation values (17.8 HU and 11.2 HU) are markedly lower than the splenic attenuation value (50.6 HU), resulting in a reduced L/S ratio consistent with significant hepatic steatosis.

Table 1. CT Criteria for the Diagnosis of Hepatic Steatosis

CT Parameter	Diagnostic Criterion
Absolute Liver Attenuation	<40 HU
Liver Attenuation Relative to Spleen	≥ 10 HU Lower Than Spleen
Liver-to-Spleen Attenuation Ratio	<1.0
Liver–Spleen Attenuation Difference	≤ -10 HU
Normal Hepatic Attenuation	50–65 HU

These indices have been widely adopted for quantitative assessment and allow objective evaluation of fatty infiltration, particularly in moderate-to-severe hepatic steatosis (16).

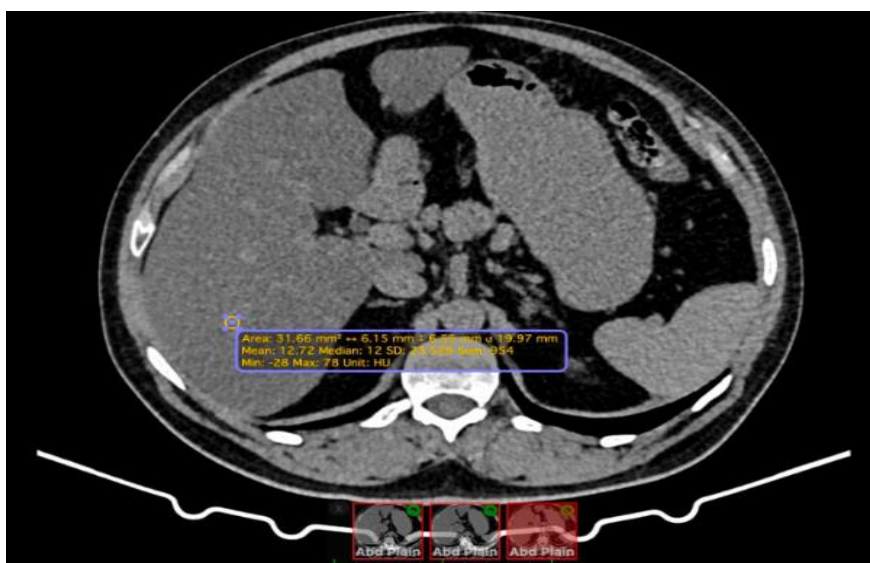


Figure 2. Absolute Liver Attenuation Measurement on Non-Enhanced CT

Diagnostic Performance and CT-Based Fat Quantification

Computed tomography (CT) is a widely available and reproducible imaging modality for assessing hepatic steatosis. Non-enhanced CT is preferred for liver fat quantification because attenuation measurements are unaffected by contrast administration. As hepatic triglyceride accumulation increases, liver attenuation values decrease, making CT a useful quantitative marker of hepatic fat content (1,2). Park et al. demonstrated good correlation between CT findings and histopathology for assessing macrovesicular steatosis, while Byun et al. validated CT attenuation indices and established diagnostic cut-off values using pathological reference standards (8,10). Common CT criteria for hepatic steatosis include liver attenuation <40 HU, liver-to-spleen attenuation ratio <1.0, and liver attenuation at least 10 HU lower than splenic attenuation (2,8). CT is also useful for longitudinal assessment. Kim et al. reported that serial non-enhanced CT examinations can effectively monitor changes in hepatic fat content over time, supporting its role in disease monitoring and

treatment evaluation (6). Population-based studies by Zeb et al. further demonstrated that reduced hepatic attenuation is associated with obesity, insulin resistance, metabolic syndrome, and cardiovascular risk factors (7). A recent meta-analysis by Haghshomar et al. showed that CT has moderate-to-high diagnostic accuracy for detecting hepatic steatosis, particularly in moderate-to-severe disease (1). In addition, CT enables simultaneous assessment of visceral adiposity, providing valuable information for metabolic risk stratification. Recent advances in artificial intelligence and automated body composition analysis may further enhance the clinical utility of CT in opportunistic screening and precision medicine (4,15,16). Despite its advantages, CT has reduced sensitivity for mild steatosis, involves ionizing radiation exposure, and is less accurate than MRI-PDFF for precise fat quantification (1,4). Nevertheless, its accessibility, reproducibility, and ability to assess both hepatic fat and visceral adiposity make CT an important tool in the evaluation of NAFLD

Table:2 Summary of Key Studies Evaluating Hepatic Attenuation, Visceral Adiposity, and Metabolic Associations

Author (Year)	Study Design	Parameter Assessed	Key Findings
Han et al. (2019)	Cross-Sectional Study	Degree of Hepatic Steatosis	Increasing Steatosis Severity Was Associated With Worsening Dyslipidaemia and Metabolic Dysfunction.
Byun et al. (2019)	Validation Study	CT Attenuation Indices	Developed and Validated CT Diagnostic Cut-Off Values Using Histopathological Standards.
Kim et al. (2019)	Longitudinal Study	Hepatic Attenuation	Serial CT Measurements Effectively Monitored Changes in Hepatic Fat Content Over Time.
Jawahar et al. (2020)	Observational Study	CT Steatosis Criteria	CT-Detected Steatosis Was Associated With Abnormal Liver Function Tests and Metabolic Risk Factors.
Kang et al. (2021)	Clinical Practice Guideline	NAFLD Risk Factors	Identified Visceral Obesity and Insulin Resistance as Major Determinants of NAFLD Progression.
Tamaki et al. (2022)	Review Article	Imaging Biomarkers	Summarized the Role of CT and Other Non-Invasive Imaging Techniques in Hepatic Steatosis Assessment.
Chua et al. (2023)	Systematic Review	Visceral Adiposity and NAFLD	Confirmed a Strong Association Between Visceral Fat Accumulation and NAFLD Severity.
Song et al. (2024)	Observational Study	CT-Derived Body Composition Phenotypes	CT-Derived Phenotypes Correlated With Metabolic Risk Factors in Patients With Hepatic Steatosis.

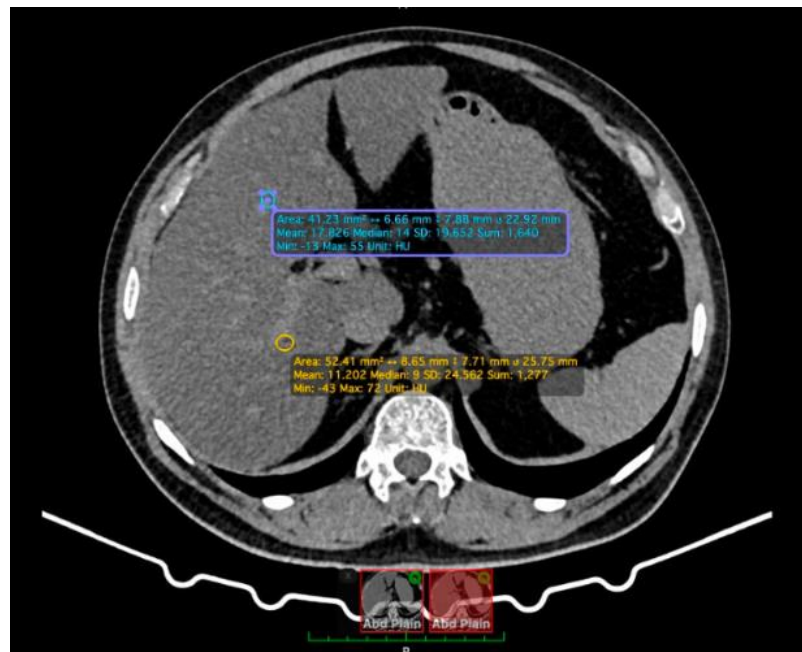


Figure 3. Axial non-enhanced CT scan showing multiple hepatic ROIs used for attenuation measurement. Reduced liver attenuation reflects increased hepatic fat deposition and supports the diagnosis of hepatic steatosis.

CT imaging is commonly used for assessment of hepatic morphology, attenuation characteristics, and evaluation of hepatic steatosis and visceral adiposity. Similarly, Jawahar et al. reported significant correlations between CT-based hepatic steatosis criteria and abnormal liver function tests as well as adverse metabolic risk factors, highlighting the clinical value of attenuation measurements in identifying individuals at increased cardiometabolic risk (23). In another study, the same authors demonstrated strong associations between reduced hepatic attenuation and unfavorable lipid profile abnormalities characterized by elevated triglyceride levels and decreased high-density lipoprotein (HDL) cholesterol concentrations (24). Furthermore, Han et al. observed that increasing severity of hepatic steatosis was associated with progressively worsening dyslipidemia and metabolic dysfunction, supporting the role of CT-derived hepatic attenuation as an imaging biomarker of metabolic disease severity (12).

Cerit et al. reported significant correlations between ultrasonographic attenuation measurements and unenhanced multidetector CT findings, further supporting the reliability of CT-based fat quantification in assessing hepatic steatosis (25). In addition, the recent systematic review and meta-analysis by Haghshomar et al. confirmed that CT exhibits moderate-to-high diagnostic accuracy for detecting hepatic steatosis, particularly in moderate-to-severe disease, reinforcing its value in opportunistic screening and quantitative evaluation of hepatic fat burden (1).

Despite being less sensitive than magnetic resonance imaging proton density fat fraction (MRI-PDFF) for

precise fat quantification, CT remains a widely available, rapid, and reproducible imaging modality. Its ability to provide simultaneous assessment of hepatic fat content, visceral adiposity, and body composition parameters offers comprehensive information regarding metabolic health and cardiovascular risk (19,20,27). Therefore, CT-based fat quantification continues to play an important role in the diagnosis, longitudinal monitoring, and risk stratification of patients with NAFLD and obesity-related metabolic disorders.

Correlation Between Hepatic Attenuation and Visceral Fat Area

Numerous clinical, radiological, and epidemiological studies have demonstrated a significant inverse correlation between hepatic attenuation and visceral fat area (VFA) on computed tomography (CT). As visceral adiposity increases, hepatic attenuation values progressively decrease because of greater triglyceride accumulation within hepatocytes. Since fat exhibits lower radiographic density than normal liver parenchyma, increased hepatic fat deposition results in reduced attenuation values on non-enhanced CT scans. This inverse relationship highlights the close association between visceral obesity and the development of nonalcoholic fatty liver disease (NAFLD) (1,2,14).

Relationship with Metabolic Syndrome, Dyslipidaemia, and Obesity

Visceral obesity is a central component of metabolic syndrome and plays a pivotal role in the development of hepatic steatosis. Excess visceral adipose tissue

releases free fatty acids, inflammatory cytokines, and adipokines directly into the portal circulation, leading to increased hepatic lipid accumulation, insulin resistance, oxidative stress, and chronic inflammation (2,3). These metabolic disturbances promote progressive hepatic steatosis and contribute to reduced hepatic attenuation values observed on CT imaging. Several studies have demonstrated a strong association between hepatic steatosis, metabolic syndrome, and dyslipidaemia. Han et al. reported that increasing severity of hepatic steatosis was associated with progressively worsening metabolic dysfunction, characterized by elevated triglyceride levels, reduced high-density lipoprotein (HDL) cholesterol concentrations, and adverse lipid profiles (4). Similarly, Jawahar et al. found significant relationships between CT-based hepatic steatosis criteria, abnormal liver function tests, obesity, and clinical risk factors associated with metabolic syndrome (5). In a subsequent study, the same authors demonstrated that reduced hepatic attenuation values were strongly correlated with elevated triglycerides and decreased HDL cholesterol levels, further supporting the metabolic significance of CT-derived hepatic fat measurements (6). Obesity, particularly visceral obesity, is a major determinant of hepatic fat accumulation. Gholam et al. reported a high prevalence of NAFLD among severely obese individuals, highlighting the close relationship between obesity and hepatic steatosis (7). Moreover, body composition studies have consistently shown that visceral adiposity is a stronger predictor of hepatic steatosis and metabolic abnormalities than generalized obesity measured by body mass index (BMI) alone (8,9). These findings emphasize the importance of assessing visceral fat distribution when evaluating metabolic risk and liver disease severity. Population-based evidence further supports these observations. In the Multi-Ethnic Study of Atherosclerosis (MESA), Zeb et al. demonstrated that reduced hepatic attenuation was significantly associated with obesity, insulin resistance, metabolic syndrome, and cardiovascular risk factors (10). Likewise, Pickhardt et al. reported that increased visceral adiposity and hepatic steatosis identified on abdominal CT were strongly associated with metabolic

syndrome and adverse cardiometabolic profiles (11). Collectively, these findings indicate that visceral fat accumulation is closely linked to reduced hepatic attenuation and may represent a more reliable predictor of hepatic steatosis and metabolic complications than generalized obesity alone. Therefore, combined assessment of hepatic attenuation and visceral fat area on CT provides valuable insight into both liver fat burden and overall metabolic health, facilitating early diagnosis, risk stratification, and management of patients with NAFLD. (4–11)

Longitudinal Changes and Disease Monitoring

Emerging evidence indicates that changes in visceral fat area may parallel changes in hepatic attenuation over time. Reduction in visceral adiposity through lifestyle modification, dietary intervention, increased physical activity, and weight loss has been associated with improvement in hepatic attenuation values and reduction in hepatic fat content. This relationship highlights the dynamic interaction between visceral obesity and hepatic steatosis and supports the role of body composition modification in NAFLD management. Kim et al. demonstrated that non-enhanced CT is a feasible and reliable modality for evaluating longitudinal changes in hepatic steatosis and monitoring disease progression or therapeutic response (12). Serial attenuation measurements obtained during follow-up imaging can provide objective information regarding changes in hepatic fat burden and may assist clinicians in assessing treatment effectiveness.

Clinical Significance of the Correlation

The strong inverse relationship between hepatic attenuation and visceral fat area has important clinical implications. Simultaneous assessment of these parameters during routine abdominal CT examinations provides valuable information regarding hepatic fat burden, metabolic health, and cardiovascular risk. Combined evaluation allows identification of individuals at increased risk for NAFLD, metabolic syndrome, type 2 diabetes mellitus, and cardiovascular disease, even when fatty liver disease is incidentally detected.

Table 3. Recent advances in CT imaging, artificial intelligence, and quantitative body composition analysis relevant to hepatic steatosis assessment.

Author (Year)	Focus Area	Major Contribution
Kang et al. (2021)	Clinical Guidelines	Highlighted the Importance of Imaging-Based Diagnosis and Risk Stratification in NAFLD.
Tamaki et al. (2022)	Imaging Review	Summarized Current Non-Invasive Imaging Techniques for Hepatic Steatosis Assessment.
Zhang et al. (2022)	Artificial Intelligence	Demonstrated Automated Deep-Learning-Based Detection of Hepatic Steatosis on CT.
Zhang et al. (2022)	AI Validation Study	Multicentre Validation of Fully Automated CT-Based Steatosis Detection.

Author (Year)	Focus Area	Major Contribution
Chua et al. (2023)	Systematic Review	Confirmed Strong Association Between Visceral Adiposity and NAFLD Severity.
Song et al. (2024)	CT Body Composition Analysis	Showed Correlations Between CT-Derived Phenotypes and Metabolic Risk Factors.

Recent analytical evidence from Kalekar et al. further confirmed a significant inverse correlation between liver attenuation and visceral fat area on CT, emphasizing the importance of visceral adiposity as a major determinant of hepatic fat accumulation and metabolic dysfunction (13). Therefore, integrated

Clinical Implications: Risk Stratification and Cardiovascular Disease Prediction

The combined assessment of hepatic attenuation and visceral fat area (VFA) on computed tomography (CT) provides valuable information for both metabolic risk stratification and cardiovascular disease prediction. Reduced hepatic attenuation reflects increased hepatic fat accumulation, while elevated VFA indicates greater visceral adiposity. Both parameters are strongly associated with insulin resistance, dyslipidaemia, metabolic syndrome, and obesity-related complications (4,6,10).

Visceral adipose tissue is metabolically active and releases excess free fatty acids and pro-inflammatory cytokines directly into the portal circulation, promoting hepatic lipid accumulation, chronic inflammation, and metabolic dysfunction. Consequently, individuals with markedly reduced hepatic attenuation and increased VFA may represent a high-risk subgroup with a greater likelihood of developing nonalcoholic steatohepatitis (NASH), advanced fibrosis, and other obesity-related metabolic complications (2,4). CT-derived biomarkers can therefore facilitate early identification of high-risk patients and support individualized risk prediction and preventive interventions.

Beyond liver disease, growing evidence indicates that hepatic steatosis and visceral obesity are important

Clinical Utility in Treatment Monitoring and Personalized Medicine

Quantitative CT measurements provide an objective and reproducible method for monitoring changes in hepatic fat content and visceral adiposity over time. Lifestyle modification, dietary intervention, increased physical activity, pharmacological therapy, and weight reduction have been shown to improve hepatic steatosis and reduce visceral fat accumulation. These changes can be evaluated through serial CT examinations, allowing clinicians to assess therapeutic effectiveness and disease progression. Kim et al. demonstrated that non-enhanced CT is feasible for longitudinal assessment of hepatic steatosis and can reliably detect changes in hepatic attenuation during follow-up (12). Improvements in hepatic attenuation

assessment of hepatic attenuation and visceral fat area may improve opportunistic screening, risk stratification, longitudinal monitoring, and individualized management of patients with NAFLD and obesity-related metabolic disorders.

predictors of cardiovascular morbidity and mortality. Visceral adiposity contributes to systemic inflammation, endothelial dysfunction, insulin resistance, and atherogenic dyslipidaemia, all of which are established cardiovascular risk factors. Population-based studies have demonstrated strong associations between reduced hepatic attenuation, increased visceral fat accumulation, metabolic syndrome, and cardiovascular disease risk (10,11).

In the Multi-Ethnic Study of Atherosclerosis (MESA), Zeb et al. reported significant correlations between CT-detected hepatic steatosis and multiple cardiovascular risk factors, highlighting the broader clinical relevance of hepatic attenuation measurements beyond liver disease assessment (10). Similarly, Pickhardt et al. demonstrated that visceral adiposity and hepatic steatosis identified on abdominal CT were closely associated with metabolic syndrome and adverse cardiometabolic profiles (11).

Therefore, simultaneous evaluation of hepatic attenuation and VFA on CT provides a comprehensive assessment of hepatic fat burden, metabolic dysfunction, and cardiovascular risk. This combined approach may improve early diagnosis, risk stratification, and clinical management of patients with nonalcoholic fatty liver disease (NAFLD) and obesity-related metabolic disorders. (4,6,10,11)

values often parallel reductions in visceral fat area and improvements in metabolic status, supporting the use of CT-derived quantitative biomarkers as useful endpoints in both clinical practice and research studies. Recent advances in quantitative imaging, body composition analysis, and artificial intelligence (AI) are further expanding the role of CT in personalized medicine. Simultaneous evaluation of hepatic attenuation and visceral fat area enables comprehensive characterization of an individual's metabolic profile and disease burden. When integrated with biochemical markers, clinical risk factors, genetic predisposition, and lifestyle characteristics, CT-derived imaging biomarkers may facilitate individualized risk assessment and tailored therapeutic strategies (1,2).

Patients with markedly reduced hepatic attenuation and excessive visceral adiposity may require more

intensive lifestyle interventions, closer metabolic monitoring, and earlier therapeutic management than individuals with milder imaging abnormalities. Furthermore, emerging AI-based tools may enable automated quantification of hepatic fat and visceral adiposity, improving efficiency, reproducibility, and large-scale opportunistic screening of at-risk populations (1,2).

Overall, the combined evaluation of hepatic attenuation and visceral fat area on CT has substantial clinical utility in treatment monitoring, personalized medicine, metabolic risk assessment, and long-term disease management. These quantitative imaging biomarkers provide valuable insight into hepatic fat burden, visceral obesity, and overall cardiometabolic health, thereby enhancing the role of CT in the comprehensive evaluation of patients with NAFLD and obesity-related metabolic disorders. (1,2,12)

Advantages and Limitations of Computed Tomography in Hepatic Steatosis Assessment

Computed tomography (CT) has emerged as a valuable non-invasive imaging modality for the evaluation of hepatic steatosis because of its widespread availability, rapid image acquisition, reproducibility, and ability to provide quantitative assessment of both hepatic fat content and visceral adiposity. Unlike subjective imaging techniques, CT offers objective attenuation measurements expressed in Hounsfield Units (HU), enabling standardized evaluation of hepatic fat accumulation and facilitating comparison across serial examinations (1,2).

One of the major advantages of CT is its extensive availability in routine clinical practice. Since abdominal CT examinations are frequently performed for various clinical indications, assessment of hepatic steatosis can often be incorporated into routine image interpretation without requiring additional investigations. CT also provides rapid image acquisition with excellent spatial resolution, allowing comprehensive abdominal assessment within seconds while minimizing motion-related artifacts and improving patient compliance (1,2,10).

A significant strength of CT is its ability to provide objective and reproducible quantification of hepatic fat through attenuation measurements. Validated CT parameters, including absolute liver attenuation, liver-to-spleen attenuation ratio, and liver-spleen attenuation difference, have demonstrated good diagnostic performance for identifying hepatic

steatosis (1,8,9). Furthermore, CT enables simultaneous assessment of visceral fat area (VFA), which is strongly associated with insulin resistance, metabolic syndrome, and NAFLD progression. This combined evaluation provides valuable information regarding both hepatic fat burden and overall metabolic risk (11,13).

CT also offers considerable value for opportunistic screening because hepatic steatosis and visceral obesity can be detected incidentally on routine abdominal examinations without additional imaging, cost, or radiation exposure. The modality demonstrates good reproducibility and has shown high interobserver and intraobserver agreement when standardized acquisition protocols are used (1,8,10). In addition, serial non-enhanced CT examinations can be used to monitor longitudinal changes in hepatic fat content. Kim et al. demonstrated that CT attenuation measurements are useful for evaluating disease progression and treatment response, supporting the role of CT in follow-up assessment of patients with NAFLD (12).

Despite these advantages, CT has several important limitations. Its sensitivity decreases in patients with mild hepatic steatosis, making early disease detection more challenging. CT also exposes patients to ionizing radiation, which may limit its use for repeated examinations, particularly in younger individuals and those requiring long-term follow-up. In addition, attenuation measurements may be influenced by factors such as iron deposition, edema, fibrosis, and contrast administration, potentially affecting diagnostic accuracy (1,2).

Another limitation is that CT cannot reliably differentiate simple steatosis from steatohepatitis, fibrosis, or other diffuse liver diseases. Furthermore, variability in attenuation thresholds, scanner manufacturers, and imaging protocols may affect consistency across institutions. Compared with magnetic resonance imaging proton density fat fraction (MRI-PDFF), CT is less accurate for precise quantification of liver fat, particularly in mild disease (1,4). Nevertheless, owing to its accessibility, quantitative capability, reproducibility, and ability to simultaneously assess hepatic steatosis and visceral adiposity, CT remains an important imaging tool for diagnosis, risk stratification, opportunistic screening, and longitudinal evaluation of patients with NAFLD and obesity-related metabolic disorders. (1,2,4,8,12)

Table 4. Summary of strengths, limitations, and future research gaps in the current evidence regarding CT-based evaluation of hepatic steatosis and visceral fat area.

Citation	Study	Major Strengths	Major Limitations
(1)	Haghshomar et al. (2024)	Highest Level of Evidence; Pooled Analysis; Comprehensive Diagnostic Evaluation.	Heterogeneity Among Included Studies and CT Protocols.
(2)	Kang et al. (2021)	Comprehensive Evidence Synthesis and Clinical Recommendations.	Not a Primary Research Study; Dependent on Available Evidence Quality.
(3)	Gholam et al. (2007)	Established Strong Obesity–NAFLD Association.	Limited Generalizability Due to Severely Obese Study Population.
(4)	Han et al. (2019)	Evaluated Metabolic Abnormalities According to Steatosis Severity.	Cross-Sectional Design Limits Causal Interpretation.
(5)	Jawahar et al. (2020)	Demonstrated Practical Value of Incidental CT Findings.	Single-Center Observational Design.
(6)	Jawahar et al. (2017)	Established Relationship Between Hepatic Attenuation and Dyslipidemia.	Small Sample Size and Cross-Sectional Methodology.
(7)	Kim et al. (2019)	Longitudinal Assessment of Hepatic Fat Changes.	Limited Follow-Up Duration and Study Population.
(8)	Pickhardt et al. (2012)	Simultaneous Evaluation of Visceral Fat and Hepatic Steatosis.	Unable to Evaluate Disease Progression Due to Cross-Sectional Design.

Limitations of Computed Tomography in Hepatic Steatosis Assessment

Despite its widespread availability and quantitative capabilities, computed tomography (CT) has several important limitations in the assessment of hepatic steatosis. First, CT demonstrates reduced sensitivity for mild hepatic steatosis, as small amounts of fat infiltration may not cause sufficient reductions in hepatic attenuation to be reliably distinguished from normal liver tissue. Consequently, CT performs better in moderate-to-severe steatosis than in early-stage disease. Haghshomar et al. reported that although CT has moderate-to-high diagnostic accuracy overall, its sensitivity decreases substantially in cases of mild steatosis (1).

Another limitation is exposure to ionizing radiation, which may restrict the routine use of CT for repeated follow-up examinations, particularly in younger individuals and patients requiring long-term monitoring. Although modern low-dose CT protocols have reduced radiation exposure, cumulative radiation dose remains a consideration when compared with radiation-free modalities such as ultrasonography and magnetic resonance imaging (MRI) (1,2).

CT also has a limited ability to differentiate simple steatosis from nonalcoholic steatohepatitis (NASH), hepatic inflammation, or fibrosis. Therefore, additional imaging techniques such as elastography, MRI-based methods, or liver biopsy may be required for comprehensive disease characterization and staging (2,3).

Furthermore, hepatic attenuation measurements may be influenced by iron deposition, glycogen accumulation, edema, medications, and contrast administration, all of which can alter attenuation

values and affect the accuracy of liver fat estimation. For this reason, non-enhanced CT is generally preferred for quantitative assessment of hepatic steatosis (1,8,9).

Compared with advanced MRI-based techniques, particularly MRI Proton Density Fat Fraction (MRI-PDFF), CT demonstrates lower accuracy for precise liver fat quantification and is less sensitive for detecting mild steatosis. MRI-PDFF provides highly reproducible measurements across the full spectrum of steatosis severity and is less affected by confounding factors such as iron deposition and fibrosis (1,2).

Finally, the lack of universal standardization remains a challenge. Different studies have proposed varying diagnostic thresholds based on absolute liver attenuation values, liver-to-spleen attenuation ratios, and liver–spleen attenuation differences. Variations in scanner technology, acquisition protocols, reconstruction algorithms, and patient populations may contribute to inconsistencies in diagnostic performance and limit comparability across institutions and clinical studies (8,9).

Overall, while CT remains a practical and valuable tool for evaluating hepatic steatosis and visceral adiposity, these limitations should be considered when interpreting imaging findings and selecting appropriate diagnostic strategies. (1–3,8,9)

Standardization of CT-Based Hepatic Fat Assessment

Although CT is widely used for evaluating hepatic steatosis, substantial variability still exists regarding attenuation thresholds and diagnostic criteria. Different studies have proposed various cut-off values based on liver attenuation, liver-to-spleen attenuation ratio, and liver-spleen attenuation difference, resulting in

inconsistencies across institutions and imaging platforms (6,7,13). The recent systematic review and meta-analysis by Haghshomar et al. emphasized the importance of standardized CT criteria to improve diagnostic accuracy and interinstitutional consistency (1). Future multicenter studies involving diverse populations are required to establish universally accepted quantitative thresholds for hepatic steatosis assessment.

Artificial Intelligence and Automated Quantification

Artificial intelligence (AI) and deep learning technologies are increasingly being integrated into radiological practice. Automated algorithms can accurately identify hepatic steatosis, measure hepatic attenuation, quantify visceral fat area, and generate comprehensive body composition reports from routine abdominal CT examinations. AI-assisted imaging analysis may reduce observer variability, improve workflow efficiency, and facilitate opportunistic screening of NAFLD in large populations (1,3,14).

Recent studies have shown that AI-based body composition analysis can provide automated quantification of visceral adiposity, skeletal muscle mass, and ectopic fat deposition, thereby enhancing metabolic risk assessment. Integration of imaging biomarkers with clinical, biochemical, and genetic information may support precision medicine approaches and individualized treatment planning for patients with metabolic liver disease (15,16).

Advanced CT Technologies

Emerging CT technologies such as dual-energy CT (DECT), spectral CT, and photon-counting CT are expected to significantly improve hepatic fat quantification. These techniques provide enhanced tissue characterization and may allow differentiation between hepatic fat, fibrosis, inflammation, iron overload, and edema more accurately than conventional CT (17,18).

Photon-counting CT represents one of the most promising innovations in diagnostic imaging because of its superior spatial resolution, improved contrast-to-noise ratio, reduced image artifacts, and lower radiation exposure. Future applications of photon-counting CT may improve sensitivity for mild hepatic steatosis and provide more accurate assessment of diffuse liver diseases (18).

Longitudinal Monitoring, Disease Progression, and Comparative Imaging Evaluation

Longitudinal assessment of hepatic attenuation and visceral fat accumulation is increasingly recognized as an important approach for monitoring disease progression and evaluating treatment response in patients with nonalcoholic fatty liver disease (NAFLD). Previous studies by Adams et al. and Kim et al. demonstrated that hepatic steatosis may progress

over time and that non-enhanced computed tomography (CT) can reliably detect longitudinal changes in hepatic fat content through serial attenuation measurements (8,12). These findings support the potential role of CT-derived biomarkers in tracking disease progression and assessing the effectiveness of lifestyle and therapeutic interventions. Future prospective multicenter studies are needed to determine whether CT-derived measures of hepatic attenuation and visceral adiposity can predict progression from simple steatosis to nonalcoholic steatohepatitis (NASH), advanced fibrosis, cirrhosis, hepatocellular carcinoma, and cardiovascular disease. Establishing these imaging biomarkers as reliable prognostic indicators could improve long-term risk stratification and clinical decision-making in patients with NAFLD (2,3,8).

In addition, comparative evaluation of CT with other non-invasive imaging modalities remains an important area of research. Magnetic Resonance Imaging–Proton Density Fat Fraction (MRI-PDFF) is currently considered the most accurate non-invasive technique for quantifying hepatic fat content and is often regarded as the reference standard for imaging-based liver fat assessment (1,4). Comparative studies involving CT, MRI-PDFF, ultrasound attenuation imaging, transient elastography, and histopathological assessment are required to determine the most effective imaging strategies for screening, diagnosis, and follow-up of NAFLD.

Supporting this approach, Cerit et al. demonstrated significant correlations between ultrasound attenuation measurements and CT-based liver fat assessment, confirming the validity of CT attenuation as a surrogate marker of hepatic steatosis (4). Future multimodality imaging studies may facilitate the development of standardized, evidence-based diagnostic algorithms and enhance the integration of imaging biomarkers into routine clinical practice for comprehensive NAFLD evaluation and management. (1,4,8,12)

Opportunistic Imaging Biomarkers, Personalized Medicine, and Future Research Directions

One of the most promising future applications of computed tomography (CT) is **opportunistic screening**. Millions of abdominal CT examinations are performed annually for unrelated clinical indications, providing an opportunity to extract additional clinically relevant information without extra imaging, cost, or radiation exposure. Automated assessment of hepatic attenuation and visceral fat area during routine image interpretation may facilitate early identification of asymptomatic individuals at risk of nonalcoholic fatty liver disease (NAFLD), metabolic syndrome, type 2 diabetes mellitus, and cardiovascular disease (10,11,14). Recent studies have emphasized the concept of **opportunistic CT biomarkers**, whereby

routinely acquired imaging data can provide valuable information beyond the primary indication for imaging. Incorporation of hepatic attenuation measurements and body composition analysis into routine radiology reporting may therefore strengthen preventive healthcare strategies and support earlier clinical intervention.

The growing integration of quantitative imaging with **personalized medicine** is expected to further enhance the clinical utility of CT. Future healthcare systems are likely to combine imaging biomarkers with laboratory investigations, genomic information, metabolomic profiling, and clinical risk factors to improve individualized disease prediction and treatment planning. Simultaneous evaluation of hepatic attenuation, visceral adiposity, insulin resistance markers, inflammatory biomarkers, and cardiovascular risk profiles may enable more accurate risk stratification and tailored therapeutic approaches (3,5). In addition, advances in artificial intelligence (AI) and machine learning may facilitate automated quantification of hepatic fat and visceral adiposity, allowing the development of predictive models capable of identifying patients at highest risk of disease progression and guiding targeted interventions (15,16). Future research should focus on addressing current limitations and enhancing the clinical applicability of CT-derived biomarkers. Priority areas include the establishment of standardized CT attenuation thresholds for diagnosing hepatic steatosis, development of automated AI-based hepatic fat and visceral fat quantification tools, and implementation of large multicentre longitudinal studies evaluating disease progression and long-term outcomes. Comparative studies involving CT, MRI-PDFF, elastography, and histopathological assessment are also required to determine optimal imaging strategies and validate CT-derived biomarkers. Additional research should investigate the prognostic significance of CT-based body composition parameters, evaluate low-dose CT protocols for safer longitudinal monitoring, and expand opportunistic screening programs using routine abdominal CT examinations. Collectively, these advances may strengthen the role of CT in precision medicine, early disease detection, risk prediction, and comprehensive management of patients with NAFLD and obesity-related metabolic disorders. (3,5,10,11,14,16)

Critical Evaluation of the Literature

Major Strengths of Published Studies

The available literature provides substantial evidence supporting the role of computed tomography (CT) in the assessment of hepatic steatosis and visceral adiposity. One of the major strengths of existing studies is the use of objective and quantitative CT attenuation measurements, which provide reproducible and standardized assessment of hepatic fat content. Unlike subjective imaging interpretation, CT

attenuation values measured in Hounsfield Units (HU) offer a reliable method for evaluating hepatic steatosis and monitoring disease progression (1,2).

The systematic review and meta-analysis conducted by Haghshomar et al. represents one of the strongest sources of evidence in this field. By synthesizing findings from multiple studies, the authors demonstrated moderate-to-high diagnostic accuracy of CT for detecting hepatic steatosis, particularly in patients with moderate-to-severe disease. The study reinforced the clinical utility of CT as a non-invasive imaging modality for opportunistic screening and assessment of fatty liver disease (1).

Another significant strength is the availability of histopathological validation studies. Byun et al. established and validated CT attenuation cut-off values using pathological reference standards, thereby improving the diagnostic reliability of CT-based hepatic steatosis assessment. Similarly, Park et al. demonstrated the usefulness of CT for quantitative and qualitative evaluation of macrovesicular hepatic steatosis in living liver donors (3,4).

Several population-based and observational studies have also demonstrated strong correlations between hepatic attenuation, visceral adiposity, dyslipidemia, obesity, and metabolic syndrome. Zeb et al. reported that CT-based fatty liver assessment is practical and reproducible in large populations and is significantly associated with cardiovascular and metabolic risk factors. Likewise, Pickhardt et al. showed that visceral adiposity and hepatic steatosis are closely linked to metabolic syndrome and systemic metabolic dysfunction (5,6).

Furthermore, studies by Han et al., Jawahar et al., and Kalekar et al. consistently demonstrated significant relationships between hepatic steatosis, visceral obesity, lipid abnormalities, and metabolic dysfunction, highlighting the clinical significance of CT-derived biomarkers in risk stratification and patient management (7,10).

Methodological Limitations of Published Studies

Despite encouraging findings, several methodological limitations exist within the current body of evidence. Most studies evaluating the relationship between hepatic attenuation and visceral fat area employ cross-sectional designs, which limit the ability to establish causal relationships or evaluate temporal changes in disease progression (5–10).

Another important limitation is the lack of large multicenter longitudinal studies. Although Kim et al. demonstrated the feasibility of non-enhanced CT for monitoring longitudinal changes in hepatic steatosis, long-term prospective studies evaluating progression from steatosis to NASH, fibrosis, or cirrhosis remain limited (11).

Significant heterogeneity also exists regarding diagnostic criteria for hepatic steatosis. Different investigators have used various attenuation thresholds,

liver-to-spleen attenuation ratios, and liver-spleen attenuation differences, resulting in variability in reported diagnostic performance and prevalence estimates (1,3,4). This lack of standardization remains a major challenge for clinical implementation. Technical variability among CT scanners, acquisition protocols, reconstruction algorithms, and image-processing methods may further influence attenuation measurements and affect reproducibility between institutions (1,2). Additionally, several studies were conducted in relatively small or highly selected populations, reducing the generalizability of their findings. Ethnic and geographic differences also represent potential limitations. Many studies have been performed in Asian, European, or North American populations, and findings may not be directly applicable to other demographic groups because of differences in genetics, body composition, dietary patterns, and metabolic risk profiles (2,7). Another limitation is the absence of standardized protocols for measuring visceral fat area. Different anatomical landmarks and segmentation techniques have been used across studies, making direct comparisons difficult and contributing to variability in reported findings (6,10). Finally, relatively few investigations have correlated CT findings directly with histopathological outcomes. Although studies by Park et al. and Byun et al. incorporated pathological validation, most studies relied solely on imaging findings without liver biopsy confirmation, limiting the ability of CT to distinguish simple steatosis from steatohepatitis and fibrosis (3,4).

Knowledge Gaps Identified from Current Evidence

Despite growing evidence supporting the relationship between hepatic attenuation and visceral fat area, several important gaps remain in the current literature. One of the most significant gaps is the absence of universally accepted CT attenuation thresholds for diagnosing hepatic steatosis. Variations in scanner technology, acquisition parameters, and diagnostic criteria contribute to inconsistencies among studies and limit standardization of CT-based assessment (1,3,4). Another major gap is the limited availability of longitudinal studies evaluating the prognostic significance of hepatic attenuation and visceral adiposity. Although cross-sectional associations have been well established, evidence regarding their role in predicting progression to NASH, fibrosis, cirrhosis, and hepatocellular carcinoma remains insufficient (2,11). Most published studies focus primarily on the association between hepatic steatosis and metabolic abnormalities; however, the predictive value of CT-derived biomarkers for cardiovascular disease outcomes requires further investigation. Given the strong relationship between NAFLD and cardiovascular morbidity, future studies should evaluate whether hepatic attenuation and visceral fat measurements can improve cardiovascular risk prediction models (5,6). The lack of standardized visceral fat area measurement protocols also remains an important knowledge gap. Consensus guidelines regarding anatomical measurement levels, segmentation techniques, and reporting standards are required to improve consistency across studies (6,10). Furthermore, relatively few studies have investigated the combined use of CT imaging biomarkers with biochemical markers, inflammatory parameters, genetic factors, and clinical risk scores. Integration of these variables may improve disease characterization and individualized risk assessment (2,7).

Table 5. Research Gaps in Current Literature

Research Area	Existing Limitation	Future Direction
CT Attenuation Thresholds	No Universally Accepted Diagnostic Cut-Off Values.	Establish Standardized CT Attenuation Criteria.
Visceral Fat Quantification	Variability in VFA Measurement Techniques.	Develop Standardized VFA Assessment Protocols.
Longitudinal Evidence	Most Studies Are Cross-Sectional.	Conduct Large Multicenter Prospective Studies.
Histopathological Correlation	Limited Biopsy-Confirmed Validation Studies.	Increase Imaging–Histopathology Correlation Research.
Artificial Intelligence	Limited Automated CT-Based Assessment Tools.	Develop AI-Driven Opportunistic Screening Systems.
Risk Prediction Models	Imaging Biomarkers Evaluated Independently.	Integrate Imaging, Biochemical, Genetic, and Clinical Parameters.
Disease Progression	Limited Evidence Regarding Progression to NASH, Fibrosis, and Cirrhosis.	Long-Term Prognostic Studies With Outcome Analysis.

Recommendations for Future Research

Future research should focus on establishing standardized CT attenuation thresholds and universally accepted protocols for visceral fat quantification. Large multicenter prospective studies involving diverse populations are needed to validate existing findings and improve generalizability (1,2).

Longitudinal investigations should evaluate the role of hepatic attenuation and visceral adiposity in predicting progression from simple steatosis to NASH, advanced fibrosis, cirrhosis, hepatocellular carcinoma, and cardiovascular disease. Such studies would provide valuable prognostic information and improve clinical decision-making (2,11).

Advanced imaging technologies, including dual-energy CT, spectral CT, and photon-counting CT, should be explored for improved tissue characterization and more accurate quantification of hepatic fat content. Comparative studies involving CT, MRI-proton density fat fraction (MRI-PDFF), elastography, and histopathology are also required to determine the optimal imaging strategy for NAFLD assessment (1,12).

Future investigations should also evaluate the role of artificial intelligence and machine learning algorithms in automated hepatic attenuation measurement and visceral fat segmentation. Automated quantitative analysis may improve diagnostic accuracy, reduce observer variability, and facilitate opportunistic screening of NAFLD in routine clinical practice (1,2).

Finally, integration of CT-derived imaging biomarkers with laboratory parameters, genetic markers, metabolic profiles, and clinical risk factors may support the development of personalized medicine approaches and improve risk stratification, treatment monitoring, and long-term management of patients with NAFLD and obesity-related metabolic disorders (2,7).

CONCLUSION

Nonalcoholic fatty liver disease (NAFLD) has emerged as one of the most prevalent chronic liver disorders worldwide and is closely associated with obesity, insulin resistance, metabolic syndrome, and cardiovascular disease. Increasing evidence indicates that visceral adiposity plays a central role in the development and progression of hepatic steatosis through its effects on lipid metabolism, inflammatory pathways, and insulin sensitivity. Consequently, accurate assessment of both hepatic fat content and visceral fat distribution is essential for the early identification and management of patients at risk for metabolic liver disease.

Computed tomography (CT) has proven to be a valuable, non-invasive, and widely accessible imaging modality for the evaluation of hepatic steatosis and visceral obesity. Hepatic attenuation measurements obtained from non-enhanced CT provide an objective and reproducible method for estimating liver fat

content, while simultaneous quantification of visceral fat area offers important insights into metabolic risk and body fat distribution. Numerous studies have demonstrated a significant inverse correlation between hepatic attenuation and visceral fat area, confirming that increased visceral adiposity is strongly associated with greater hepatic fat accumulation and worsening metabolic dysfunction.

Ethical Approval

Not applicable. This study is a narrative review based on previously published literature and did not involve human participants or animals.

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Conflict of Interest

The authors declare that they have no competing interests.

Author Contributions

RKG conceived the review. All authors contributed to literature collection, manuscript preparation, critical revision, and approved the final version.

Data Availability Statement

No new datasets were generated or analyzed during this study.

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REFERENCES

1. Haghshomar M, Antonacci D, Smith AD, Thaker S, Miller FH, Borhani AA. Diagnostic accuracy of CT for the detection of hepatic steatosis: a systematic review and meta-analysis. **Radiology**. 2024;313(2):e241171. doi:10.1148/radiol.241171.
2. Song I, Thompson EW, Verma A, MacLean MT, Duda J, Elahi A, et al. Clinical correlates of CT imaging-derived phenotypes among lean and overweight patients with hepatic steatosis. **Sci Rep**. 2024;14:1186.
3. Chua YJ, Lim WH, Tan DJH, Ng CH, Lin SY, Khoo CM, et al. Relationship between non-alcoholic fatty liver disease and visceral fat measured by imaging-based body composition analysis: a systematic review. **Livers**. 2023;3(3):463–493.
4. Tamaki N, Ajmera V, Loomba R. Non-invasive methods for imaging hepatic steatosis and their clinical importance in NAFLD. **Nat Rev**

- Endocrinol.** 2022;18(1):55–66. doi:10.1038/s41574-021-00584-0.
5. Zhang Z, Weiss J, Taron J, Zeleznik R, Lu MT, Aerts HJWL. Deep learning-based assessment of hepatic steatosis on chest computed tomography. **NPJ Digit Med.** 2022;5(1):94.
 6. Zhang Z, Li G, Wang Z, Xia F, Zhao N, Nie H, et al. Fully automated deep learning-enabled detection of hepatic steatosis on computed tomography: a multicenter international validation study. **Radiology: Artificial Intelligence.** 2022;4(6):e220064.
 7. Kang SH, Lee HW, Yoo JJ, Cho Y, Kim SU, Lee TH, Jang BK, Kim SG, Ahn SB, Kim H, Jun DW. KASL clinical practice guidelines: management of nonalcoholic fatty liver disease. **Clin Mol Hepatol.** 2021;27(3):363–401.
 8. Jawahar A, Gonzalez B, Balasubramanian N, Adams W, Goldberg A. Comparison of computed tomography hepatic steatosis criteria for identification of abnormal liver function and clinical risk factors, in incidentally noted fatty liver. **Eur J Gastroenterol Hepatol.** 2020;32:216–221.
 9. Byun J, Lee SS, Sung YS, Shin Y, Yun J, Kim HS, Yu ES, Lee SG, Lee MG. CT indices for the diagnosis of hepatic steatosis using non-enhanced CT images: development and validation of diagnostic cut-off values in a large cohort with pathological reference standard. **Eur Radiol.** 2019;29:4427–4435.
 10. Han JM, Kim HI, Lee YJ, Lee JW, Kim KM, Bae JC. Differing associations between fatty liver and dyslipidemia according to the degree of hepatic steatosis in Korea. **J Lipid Atheroscler.** 2019;8:258–266.
 11. Kim MG, Lee SS, Jun MJ, Byun J, Sung YS, Shin Y, Lee MG. Feasibility of non-enhanced CT for assessing longitudinal changes in hepatic steatosis. **Medicine (Baltimore).** 2019;98:e15606.
 12. Jawahar A, Gonzalez B, Balasubramanian N, Adams W, Goldberg A. Comparison of correlations between lipid profile and different computed tomography fatty liver criteria in the setting of incidentally noted fatty liver on computed tomography examinations. **Eur J Gastroenterol Hepatol.** 2017;29:1389–1396.
 13. Lee SS, Park SH. Radiologic evaluation of nonalcoholic fatty liver disease. **World J Gastroenterol.** 2014;20(23):7392–7402.
 14. Pickhardt PJ, Jee Y, O'Connor SD, del Rio AM. Visceral adiposity and hepatic steatosis at abdominal CT: association with the metabolic syndrome. **AJR Am J Roentgenol.** 2012;198(5):1100–1107.
 15. Zeb I, Li D, Nasir K, Katz R, Larijani VN, Budoff MJ. Computed tomography scans in the evaluation of fatty liver disease in a population-based study: the Multi-Ethnic Study of Atherosclerosis. **Acad Radiol.** 2012;19(7):811–818.
 16. Gholam PM, Flancbaum L, Machan JT, Charney DA, Kotler DP. Nonalcoholic fatty liver disease in severely obese subjects. **Am J Gastroenterol.** 2007;102(2):399–408.
 17. Park SH, Kim PN, Kim KW, Lee SW, Yoon SE, Park SW, Ha HK, Lee MG, Hwang S, Lee SG, et al. Macrovesicular hepatic steatosis in living liver donors: use of CT for quantitative and qualitative assessment. **Radiology.** 2006;239(1):105–112.
 18. Adams LA, Sanderson S, Lindor KD, Angulo P. The histological course of nonalcoholic fatty liver disease: a longitudinal study of 103 patients with sequential liver biopsies. **J Hepatol.** 2005;42(1):132–138.