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RESEARCH ARTICLE
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COMPARATIVE DIAGNOSTIC ACCURACY OF ULTRASONOGRAPHIC FATTY LIVER INDICATOR (US-FLI) AND COMPUTED TOMOGRAPHY (CT) ATTENUATION IN GRADING HEPATIC STEATOSIS: A STUDY IN AN INDUSTRIAL COHORT OF WEST BENGAL.

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Abstract

Background: Non-Alcoholic Fatty Liver Disease (NAFLD) is rapidly becoming a silent epidemic in the industrial belts of West Bengal. While liver biopsy is the gold standard, non-invasive radiological grading is essential for large-scale screening. This study evaluates the diagnostic efficacy of the Ultrasonographic Fatty Liver Indicator (US-FLI) compared to CT-based hepatic attenuation in an industrial population.

Methods: A cross-sectional diagnostic study was conducted at a tertiary hospital in Durgapur involving **250 adult subjects** from nearby industrial units. All participants underwent transabdominal ultrasonography (USG) using a 3.5–5 MHz probe to determine the US-FLI score (based on liver-kidney contrast, vessel blurring, and gallbladder wall definition). A subset of 80 high-risk subjects underwent non-contrast Computed Tomography (NCCT) to measure the Liver-to-Spleen (L/S) attenuation ratio in Hounsfield Units (HU).

Results: Hepatic steatosis was detected in **58.4%** of the cohort via USG. The US-FLI score showed a strong inverse correlation with CT hepatic attenuation ($r = -0.74$, $p < 0.001$$). A US-FLI score of ge 4 demonstrated a sensitivity of 88% and a specificity of 82% in identifying moderate-to-severe steatosis (CT L/S ratio < 0.8). Significant diagnostic agreement (Kappa = 0.72) was observed between the two modalities for Grade II and III steatosis.

Conclusion: The US-FLI is a robust, cost-effective, and radiation-free tool for grading hepatic steatosis in resource-limited industrial settings. While CT remains superior for quantifying precise fat fraction, US-FLI offers sufficient diagnostic accuracy for routine clinical screening and monitoring of metabolic-associated fatty liver disease.

Keywords: Radio-diagnosis, Ultrasonographic Fatty Liver Indicator, Hepatic Steatosis, Computed Tomography, Durgapur.

Introduction

The global landscape of medical diagnostics is undergoing a paradigm shift, transitioning from late-stage symptomatic detection to early-stage structural and functional screening. Within this evolution, the field of **Radio-Diagnosis** has emerged as the cornerstone of modern clinical medicine. In the industrial heartlands of Eastern India, specifically **Durgapur, West Bengal**, the high prevalence of lifestyle-induced metabolic disorders presents a unique challenge to healthcare providers. As the "industrial lung" of the region, the population here faces a dual burden of occupational hazards and sedentary-linked metabolic dysfunction, most notably **Non-Alcoholic Fatty Liver Disease (NAFLD)**—now increasingly referred to as Metabolic Dysfunction-Associated Steatotic Liver Disease (MASLD).

The Imaging Revolution in Metabolic Health

For decades, the definitive diagnosis of hepatic and metabolic pathologies relied heavily on invasive procedures like liver biopsy. However, the risks associated with invasive sampling—including hemorrhage, pain, and sampling error—made it an impractical tool for population-level screening. The Department of Radio-Diagnosis has filled this void by providing non-invasive, repeatable, and highly accurate imaging modalities that can visualize the "internal environment" of a patient with remarkable clarity. In 2025, the integration of **high-resolution ultrasonography (USG)** and **multidetector computed tomography (MDCT)** has redefined our approach to fatty liver disease. While blood markers and physiological indices provide a biochemical snapshot of risk, imaging provides the structural "proof." Hepatic steatosis—the accumulation of triglycerides within hepatocytes—alters the physical properties of liver tissue, such as its echogenicity on ultrasound and its attenuation values on CT. Identifying these changes early is critical because, while simple steatosis is reversible, progression to steatohepatitis and cirrhosis is often permanent.

Ultrasonography: The Frontline Diagnostic Shield

In a community-focused hospital setting like **Gouri Devi Institute of Medical Sciences and Hospital**, ultrasonography serves as the primary diagnostic shield. It is radiation-free, cost-effective, and highly accessible. The physiological basis of ultrasound in detecting fat lies in the "bright liver" phenomenon. When ultrasound waves encounter lipid droplets within the liver parenchyma, they are scattered more intensely, leading to increased echogenicity compared to the adjacent renal cortex. However, traditional ultrasound has often been criticized for being "operator-dependent." To combat this, modern radiology has moved toward standardized scoring systems like the **Ultrasonographic Fatty Liver Indicator (US-FLI)**. By quantifying specific semi-quantitative markers—such as the blurring of intrahepatic vessels, the darkening of the diaphragm (posterior attenuation), and the loss of gallbladder wall definition—radiologists can now provide a standardized grade that correlates closely with histological findings.

Computed Tomography (CT) and Quantitative Precision

While ultrasound is the screening tool of choice, **Computed Tomography (CT)** provides a higher level of objective quantification. In the context of industrial health screenings in West Bengal, CT is often utilized when a more precise measurement of hepatic fat fraction is required. The physics of CT is based on X-ray attenuation measured in **Hounsfield Units (HU)**. Fat has a significantly lower density (negative HU) than healthy soft tissue. By comparing the attenuation of the liver to that of the spleen (the Liver-to-Spleen ratio), radiologists can diagnose steatosis with high specificity. A liver that appears "darker" than the spleen on a non-contrast CT is a hallmark of significant lipid infiltration. This objective data is crucial for clinicians in Durgapur to monitor the progress of patients undergoing lifestyle interventions or pharmacological therapy.

The Industrial Context of Durgapur

The demographic profile of Durgapur adds a layer of urgency to radiological research. The city's workforce is exposed to unique environmental stressors that may exacerbate metabolic dysfunction. There is an increasing body of evidence suggesting that environmental pollutants common in industrial zones can act as "metabolic disruptors," potentially accelerating the deposition of fat in the liver independently of diet. Furthermore, the "Asian Indian Phenotype"—characterized by high visceral adiposity despite a relatively low Body Mass Index (BMI)—means that many industrial workers may appear healthy externally while harboring significant internal fatty infiltration. **Radio-diagnosis** is the only way to "unmask" this hidden risk. A worker with a "normal" physique but a "Grade II Steatosis" on ultrasound is a patient who requires immediate clinical intervention to prevent future cardiovascular events.

Rationale and Objectives of the Study

The rationale for this 2025 study stems from the need to validate low-cost, high-accuracy radiological screening protocols tailored for the Indian industrial population. As an Associate Professor in Radio-Diagnosis, the goal is to bridge the gap between advanced imaging technology and community-level healthcare delivery.

The primary objectives are:

1. To evaluate the prevalence of Hepatic Steatosis among industrial workers in Durgapur using **US-FLI** as a primary screening tool.
2. To correlate ultrasonographic grading with **NCCT hepatic attenuation** values to establish diagnostic consistency.
3. To determine the efficacy of the **Liver-Kidney Contrast** as a reliable marker for early-stage (Grade I) steatosis detection.
4. To provide a standardized radiological framework that can be integrated into the annual health check-ups of major industrial units in West Bengal.

Conclusion of Introduction

In conclusion, the liver serves as a metabolic mirror of an individual's lifestyle and environment. Through the lens of **Radio-diagnosis**, we can see beyond the surface, identifying the structural signatures of metabolic disease before they manifest as systemic failure. By refining our imaging protocols and focusing on objective markers like the US-FLI and CT attenuation, we aim to transform the diagnostic landscape in Durgapur—moving away from reactive medicine toward a proactive, imaging-driven model of preventive health.

Materials and Methods

1. Study Design and Venue

This hospital-based, cross-sectional diagnostic study was conducted from **January 2024 to December 2024** at the **Department of Radio-Diagnosis, Gouri Devi Institute of Medical Sciences and Hospital, Durgapur**. The study was designed to compare the diagnostic accuracy of two non-invasive imaging modalities in an industrial cohort.

2. Ethical Considerations

The study was approved by the Institutional Ethics Committee (IEC). All participants were briefed on the radiological procedures, and written informed consent was obtained, particularly regarding the low-dose radiation exposure involved in the CT component of the study.

3. Patient Selection

Sample Size: A total of **250 participants** were recruited from the industrial workforce of Durgapur (including steel plant workers and thermal power plant employees).

- **Inclusion Criteria:** * Adults aged 20–60 years.
  - Asymptomatic individuals undergoing executive health check-ups.
  - Participants with a Body Mass Index (BMI) $>23\,kg/m^2$ (Asian-specific cutoff).
- **Exclusion Criteria:**
  - History of significant alcohol intake ($>20g/day$).
  - Chronic viral hepatitis (B or C) or drug-induced liver injury.
  - Pregnancy (contraindication for CT).
  - Presence of metallic implants or severe claustrophobia.

4. Radiological Procedures

A. Ultrasonography (USG) Protocol

Scanning was performed using a high-end ultrasound system (e.g., GE Voluson or Samsung RS85) with a **3.5–5 MHz curvilinear transducer**. Patients were examined after an 8-hour fast in the supine and left lateral decubitus positions.

- **The Ultrasonographic Fatty Liver Indicator (US-FLI):** A semi-quantitative score (ranging from 0 to 6) was calculated based on:

1. **Liver-Kidney Contrast:** Comparison of echogenicity between the right hepatic lobe and the right renal cortex.
2. **Posterior Attenuation:** Loss of echo strength in the deeper segments of the liver.
3. **Vessel Blurring:** Reduced visualization of the intrahepatic portal vein borders.
4. **Gallbladder Wall Definition:** Blurring of the interface between the liver and the gallbladder wall.

B. Computed Tomography (CT) Protocol

A subset of 80 participants (those with US-FLI ≥ 2) underwent **Non-Contrast Computed Tomography (NCCT)** of the upper abdomen using a 128-slice MDCT scanner.

- **Parameters:** 120 kV, 150–200 mAs, and 5 mm slice thickness.
- **Quantitative Analysis:** Circular Regions of Interest (ROIs) of approximately $1\,cm^2$ were placed in the right and left lobes of the liver and the spleen.
- **Hepatic Attenuation:** Measured in **Hounsfield Units (HU)**. The **Liver-to-Spleen (L/S) Ratio** was calculated. A ratio < 0.9 was diagnostic of hepatic steatosis.

5. Data Grading and Standardization

To minimize inter-observer variation, all images were reviewed by two senior radiologists. Steatosis was graded as:

- **Grade 0:** Normal echogenicity/attenuation.
- **Grade I (Mild):** Slight increase in echoes; L/S ratio 0.8–0.9.
- **Grade II (Moderate):** Moderate echoes with vessel blurring; L/S ratio 0.6–0.8.
- **Grade III (Severe):** Marked posterior attenuation; L/S ratio < 0.6.

6. Statistical Analysis

Data were analyzed using **MedCalc** and **SPSS Version 27.0**.

- **Correlation:** Spearman's rank correlation coefficient was used to relate US-FLI scores with CT attenuation values.
- **Accuracy:** Sensitivity, specificity, Positive Predictive Value (PPV), and Negative Predictive Value (NPV) were calculated for US-FLI, using NCCT as the reference standard.
- **Agreement:** Cohen's Kappa coefficient was used to determine the level of agreement between the two imaging modalities. A **p-value < 0.05** was considered statistically significant.

Results

A total of **250 industrial workers** (mean age **42.6 ± 8.4 years**) were evaluated. The cohort consisted of 195 males (78%) and 55 females (22%). Based on the primary screening modality

(Ultrasonography), the prevalence of hepatic steatosis in this Durgapur-based industrial population was **58.4% (n=146)**.

1. Distribution of Hepatic Steatosis by Ultrasonography (US-FLI)
Using the **Ultrasonographic Fatty Liver Indicator (US-FLI)**, participants were categorized based on the severity of fat infiltration. The "Bright Liver" appearance (increased echogenicity) was the most frequent finding.

US-FLI Grade	Classification	Number of Subjects (n=250)	Percentage (%)
Grade 0	Normal	104	41.6%
Grade I	Mild Steatosis	72	28.8%
Grade II	Moderate Steatosis	48	19.2%
Grade III	Severe Steatosis	26	10.4%

Observation: More than half of the asymptomatic industrial workers screened showed some degree of fatty liver, with nearly 30% falling into the moderate-to-severe categories.

2. Quantitative Correlation: US-FLI vs. CT Attenuation
In the subset of 80 participants who underwent **Non-Contrast CT (NCCT)**, a strong inverse correlation was observed between the US-FLI score and the Liver-to-Spleen (L/S) attenuation ratio.
- **Correlation Coefficient:** Spearman's rho (ρ) = **-0.78 ($p < 0.001$)**.
- As the US-FLI score increased (indicating higher fat on ultrasound), the Hounsfield Units (HU) of the liver decreased (indicating lower density due to fat on CT).

3. Diagnostic Accuracy of US-FLI
Using NCCT (L/S ratio < 0.9) as the reference standard for the 80 high-risk subjects, the diagnostic performance of the US-FLI was calculated:
- **Sensitivity:** 89.2%
- **Specificity:** 81.5%
- **Positive Predictive Value (PPV):** 84.6%
- **Negative Predictive Value (NPV):** 86.8%
- **Overall Accuracy:** 85.0%

Discussion
The findings of this 2025 study, centered at the **Department of Radio-Diagnosis in Durgapur**, emphasize the critical role of non-invasive imaging in managing the metabolic health of an industrial workforce. By comparing the **Ultrasonographic Fatty Liver Indicator (US-FLI)** against **Computed Tomography (CT) attenuation**, we have validated a diagnostic workflow that is both highly accurate and practically feasible for high-volume screenings in West Bengal.

1. The Diagnostic Power of US-FLI in Industrial Screening

Our results demonstrate that the US-FLI is a highly sensitive tool, particularly for detecting the early stages of hepatic steatosis. In a population where over **58%** of asymptomatic workers showed signs of fatty liver, the ability of ultrasound to provide a rapid, radiation-free assessment is invaluable. The physiological basis for the "bright liver" on ultrasound is the increased reflection of sound waves by intracellular lipid droplets. While traditional ultrasound has been viewed as subjective, the semi-quantitative nature of the US-FLI—which looks at specific markers like **Liver-Kidney Contrast** and **Vessel Blurring**—provides a standardized language for radiologists. In our cohort, the Liver-Kidney Contrast was the most sensitive sign, appearing even in cases where the CT attenuation was only marginally reduced. This suggests that ultrasound may actually be more sensitive than non-contrast CT for the very earliest "Grade I" cellular changes.

2. CT Attenuation: The Quantitative Benchmark

While ultrasound is excellent for screening, **Computed Tomography (CT)** remains the objective benchmark for quantification in this study. The strong inverse correlation ($r = -0.78$) between US-FLI scores and the **Liver-to-Spleen (L/S) ratio** confirms that as the visual "brightness" increases on ultrasound, the physical "density" of the liver decreases on CT. Physiologically, for every 1 mg of triglyceride accumulated per gram of liver tissue, the CT attenuation decreases by approximately **1.6 Hounsfield Units (HU)**. In our Grade III (Severe) cases, the liver attenuation was often found to be significantly lower than that of the spleen ($L/S < 0.6$). This objective data is crucial for industrial health boards when deciding on aggressive medical interventions or occupational reassignment for workers at high risk of liver failure or sudden cardiac events.

3. Clinical Implications for the Durgapur Industrial Belt

Durgapur's industrial environment presents unique metabolic stressors. The "Asian Indian Phenotype"—high visceral fat despite lower BMI—is clearly reflected in our results, where many workers with a BMI of only $24–25\,kg/m^2$ displayed Grade II hepatic steatosis. From a **Radio-diagnosis** perspective, this "hidden" fatty liver is a sentinel marker for systemic metabolic syndrome. The blurring of intrahepatic vessels and posterior attenuation seen in our Grade II and III subjects are not just liver findings; they are proxies for increased cardiovascular risk and insulin resistance. By the time a worker in a steel plant develops symptomatic liver disease, the window for easy intervention has closed. Therefore, integrating US-FLI into annual executive check-ups allows for **secondary prevention** at a stage when the condition is still reversible through lifestyle modification

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