

# Correlation of steatosis severity (ultrasound grade) with liver fibrosis stage (shear wave elastography) in patients with non-alcoholic fatty liver disease

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## ABSTRACT

**Background and Aim:** This study aimed to analyze the correlation between fatty liver grading based on ultrasonography and fibrosis staging using two-dimensional shear wave elastography (2D-SWE) in patients with Non-Alcoholic Fatty Liver Disease (NAFLD).

**Methods:** A cross-sectional study was conducted in the Radiology Department of our hospital from July to October 2025. A total of 52 NAFLD patients who underwent conventional abdominal ultrasonography and 2D-SWE were included. Fatty liver grading was categorized into four groups (grade 0–3) based on echogenicity and visualization of intrahepatic vascular structures. Fibrosis staging was assessed using 2D-SWE according to the Metavir classification (F0–F4). Patient demographic characteristics were recorded from the electronic medical record (EMR). Statistical analyses included descriptive analysis, Chi-square tests to evaluate associations between categorical variables, and Spearman correlation analysis to assess the relationship between steatosis and fibrosis severity. Significance was defined as  $p < 0.05$ .

**Results:** Of the 52 patients, most were female (55.8%) and aged <46 years (57.7%). Grade 1 steatosis was the most common ultrasonography finding (71.2%), whereas F0–F1 fibrosis predominated on SWE (67.3%). No statistically significant association was observed between fatty liver grading and gender ( $p = 0.613$ ) or age



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( $p = 0.944$ ). Similarly, fibrosis staging showed no association with gender ( $p = 0.371$ ) or age ( $p = 0.687$ ). However, a very strong positive correlation was found between ultrasonography-based steatosis grading and SWE-based fibrosis staging ( $p < 0.001$ ,  $r = 0.875$ ), indicating that increasing steatosis levels paralleled increasing fibrosis severity.

**Conclusions:** Fatty liver grading based on ultrasonography demonstrates a very strong correlation with fibrosis staging assessed by 2D-SWE, confirming the clinical relevance of combined ultrasound-based assessment in NAFLD imaging. While age and gender did not influence steatosis or fibrosis severity, direct fibrosis evaluation remains crucial for early risk stratification. ([www.actabiomedica.it](http://www.actabiomedica.it))

**Key words:** non-alcoholic fatty liver disease, ultrasound, shear wave elastography, liver fibrosis, fatty liver grading

## Introduction

Non-alcoholic fatty liver disease (NAFLD) has become one of the most common causes of chronic liver disease globally. It represents a spectrum of disorders characterized by hepatic steatosis in the absence of secondary causes of fat accumulation, such as excessive alcohol intake. NAFLD involves excessive macrovesicular fat deposition in more than 5% of hepatocytes due to dysregulation of hepatic lipid synthesis and utilization. Clinically, NAFLD ranges from non-alcoholic fatty liver (NAFL), the milder form, to non-alcoholic steatohepatitis (NASH), the more severe form that may progress to fibrosis and cirrhosis in advanced stages (1,2). The incidence and prevalence of NAFLD continue to rise, affecting approximately 32% of the global adult population, with an estimated worldwide incidence of 47 cases per 1,000 individuals annually, consistently higher in men compared to women. In Asia, NAFLD affects roughly 30% of the population, with reported prevalence rates varying widely across countries, including 12.5–38% in mainland China, 23–26% in Japan, 27% in Korea, 12–51% in Taiwan, 28% in Hong Kong, 9–32% in India, and 5–30% across South and Southeast Asia, including Sri Lanka, Malaysia, and Indonesia (2,3). Early diagnosis plays a critical role in identifying asymptomatic individuals at risk of progressive liver disease. Confirmation of NAFLD requires the detection of hepatic steatosis via imaging or histology in the absence of significant alcohol intake (<30 g/day for men and <20

g/day for women) and other causes of chronic liver disease. Among available modalities, transabdominal ultrasound remains the recommended first-line diagnostic tool due to its high sensitivity and accessibility (4). Steatosis on B-mode ultrasound is recognized by increased hepatic echogenicity relative to the renal cortex, resulting from intracellular fat accumulation. Transabdominal ultrasonography demonstrates high diagnostic performance in detecting moderate to severe steatosis, with sensitivity ranging from 62.5% to 100% and specificity ranging from 54% to 95% (5). Several risk factors contribute to NAFLD development and progression. Aging is associated with complex metabolic disturbances, including alterations in glucose, lipid, amino acid, and nucleotide metabolism (6). Platelets also play a significant role in NAFLD pathogenesis by promoting pro-inflammatory and pro-fibrotic pathways, with lipid toxicity triggering platelet activation, immune cell recruitment, and hepatic stellate cell activation (7). As fibrosis is a major determinant of NAFLD prognosis, non-invasive fibrosis assessment has become essential in clinical practice. Two-dimensional shear-wave elastography (2D-SWE) is an ultrasound-based technique that quantifies liver stiffness in real time by measuring shear wave speed or Young's modulus, providing an accurate biomarker of liver fibrosis severity (8). This topic was selected because it has not previously been investigated in Indonesia, particularly in Makassar, South Sulawesi. The application of conventional ultrasonography combined with shear wave elastography (SWE) in patients

with nonalcoholic fatty liver disease (NAFLD) offers substantial clinical value for assessing the relationship between hepatic steatosis severity and liver fibrosis stage. In many clinical settings in this region, liver biopsy, the current gold standard for fibrosis assessment is infrequently performed because of its invasive nature and limited availability. Consequently, ultrasound and SWE represent practical alternative modalities, particularly in remote or resource-limited areas, as they are noninvasive, easy to perform, cost-effective, and widely accessible. Given the clinical importance of both steatosis and fibrosis in NAFLD, establishing the association between ultrasound-based steatosis grading and 2D-SWE-based fibrosis staging may facilitate earlier identification of patients at risk for advanced disease; therefore, this study aims to evaluate the correlation between ultrasound-determined steatosis severity and liver fibrosis stage assessed by shear wave elastography in patients with NAFLD at our institution.

## Materials and methods

### Study design and patient selection

This research employed a cross-sectional design to evaluate the correlation between fatty liver grading based on ultrasound imaging and liver fibrosis staging based on shear wave elastography in patients diagnosed with Non-Alcoholic Fatty Liver Disease (NAFLD). The study was conducted in the Radiology Department of our hospital from July to October 2025. The study population consisted of patients diagnosed with NAFLD who underwent both abdominal ultrasound and two-dimensional shear wave elastography (2D-SWE) examinations. Patients were included if they met the following criteria: (1) a confirmed diagnosis of NAFLD supported by ultrasound and 2D-SWE imaging results, and (2) willingness to participate in the study. Patients were excluded if they had (1) liver nodules, (2) a history of hepatitis B and/or hepatitis C infection, or (3) incomplete ultrasound or 2D-SWE examination documentation. All relevant data were obtained from secondary sources recorded in the hospital's Electronic Medical Record (EMR) system.

### Ethical considerations

This study received approval from the Research Ethics Committee of the Faculty of Medicine, undertaken through the research and development unit of our university. Confidentiality and data protection were ensured throughout the study in accordance with institutional guidelines.

### Ultrasound-Based steatosis classification

Fatty liver severity was graded using standard transabdominal abdominal ultrasound criteria. Grade 0 represented normal liver echogenicity relative to the right renal cortex. Grade 1 indicated a slight and diffuse increase in hepatic parenchymal echogenicity while maintaining clear visualization of the diaphragm and intrahepatic vascular borders. Grade 2 corresponded to a moderate and diffuse increase in fine echoes with mildly impaired visualization of the diaphragm and intrahepatic vessels. Grade 3 represented a marked increase in hepatic echogenicity accompanied by poor or absent visualization of the intrahepatic vascular structures, diaphragm, and posterior right liver lobe.

### 2D-SWE-Based liver fibrosis staging

Liver fibrosis staging was determined from 2D-SWE measurements and classified using the Metavir scoring system. Liver stiffness values of <7 kPa indicated F0–F1 (no or mild fibrosis), 7.0–9.0 kPa indicated F2 (moderate fibrosis), 9.0–12.5 kPa indicated F3 (severe fibrosis), and >12.5 kPa indicated F4 (cirrhosis). Measurements were documented in kilopascals (kPa) and interpreted by experienced radiologists.

### Statistical analysis

Univariate analysis was performed to describe demographic and clinical characteristics of the study population, including mean, minimum, and maximum values as well as standard deviation for quantitative and semi-quantitative variables. Frequency and percentage distributions were calculated for categorical variables. Bivariate analysis was used to determine the relationship between ultrasound-based fatty liver grading and shear wave elastography-based fibrosis staging.

Chi-square test was applied to assess the significance of associations between the two variables. Spearman correlation test was used to measure the degree of association between two variables. Statistical analyses were conducted using the Statistical Package for the Social Sciences (SPSS) version 25.0, with statistical significance set at  $p < 0.05$ .

## Results

A total of 52 patients met the inclusion and exclusion criteria and were included in the final analysis. The demographic and clinical characteristics of the study population are presented in Table 1. The majority of patients were female (55.8%), and most were aged <46 years (57.7%). Based on ultrasonographic evaluation, fatty liver grade 1 was the most common category (71.2%), whereas grade 3 was the least common (5.8%). According to shear wave elastography findings, most patients were classified as F0–F1 (67.3%), and only 1.9% were classified as F3.

Evaluation of fatty liver grading by gender is shown in Table 2. Grade 1 steatosis was most frequently observed in women (59.5%), grade 2 occurred equally in men and women (50%), and grade 3 was predominantly found in women (66.7%). Statistical

analysis demonstrated no significant association between fatty liver grading and gender among NAFLD patients ( $p = 0.613$ ). Analysis by age demonstrated that grade 1 steatosis was most frequent among patients aged <46 years (56.8%), grade 2 was most frequent in the <46-year group (58.3%), and grade 3 was equally distributed, with 66.7% occurring in patients aged <46 years. No statistically significant association was found between fatty liver grading and age ( $p = 0.944$ ).

Fibrosis grading assessed through shear wave elastography by gender is summarized in Table 3. F0–F1 fibrosis was most frequent in women (60%), F2 fibrosis was more common in men (56.4%), and F3

**Table 2.** Relationship between sample gender and fatty liver grading based on ultrasound images

Variables	Fatty liver grade based on ultrasound, n (%)			P value
	Grade 1 (n=37)	Grade 2 (n=12)	Grade 3 (n=3)	
<b>Gender</b>				
Male	15 (40.5)	6 (50.0)	2 (66.7)	0.613*
Female	22 (59.5)	6 (50.0)	1 (33.3)	
<b>Age</b>				
< 46 years	21 (56.8)	7 (58.3)	2 (66.7)	0.944*
≥ 46 years	16 (43.2)	5 (41.7)	1 (33.3)	

\*Chi-square test

**Table 1.** Study characteristics

Variables	n (%)
<b>Gender</b>	
Male	23 (44.2)
Female	29 (55.8)
<b>Age</b>	
<46 years	30 (57.7)
≥46 years	22 (42.3)
<b>Fatty liver grade based on ultrasound</b>	
Grade 1	37 (71.2)
Grade 2	12 (23.1)
Grade 3	3 (5.8)
<b>Liver fibrosis stage based on shear wave elastography</b>	
F0-F1	35 (67.3)
F2	16 (30.8)
F3	1 (1.9)

**Table 3.** Relationship between sample characteristics and fibrosis staging based on shear wave elastography

Variables	Liver fibrosis stage based on shear wave elastography, n (%)			P value
	F0-F1 (n=35)	F2 (n=16)	F3 (n=1)	
<b>Gender</b>				
Male	14 (40.0)	9 (56.4)	0 (0)	0.371*
Female	21 (60.0)	7 (43.8)	1 (100)	
<b>Age</b>				
< 46 years	20 (57.1)	9 (56.2%)	1 (100)	0.687*
≥ 46 years	15 (42.9)	7 (43.8%)	0 (0)	

\*Chi-square test

fibrosis was seen exclusively in women (100%). Statistical analysis revealed no significant relationship between fibrosis grading and gender ( $p = 0.371$ ). Based on age, F0–F1 fibrosis was predominantly observed in patients aged <46 years (57.1%), F2 was more common in the same age group (56.2%), and F3 was found entirely in patients aged <46 years. There was no statistically significant relationship between fibrosis grading and age ( $p = 0.687$ ).

The relationship between fatty liver grading based on ultrasound and fibrosis staging based on shear wave elastography is presented in Table 4. Most patients with absent or mild fibrosis (F0–F1) demonstrated grade 1 steatosis on ultrasound (100%). Moderate fibrosis (F2) was most frequently associated with grade 2 steatosis (75%), while severe fibrosis (F3) was predominantly associated with grade 1 steatosis (100%). Statistical testing demonstrated a significant correlation between ultrasound-based fatty liver grading and shear wave elastography-based fibrosis grading ( $p < 0.001$ ). The strength of the correlation was very strong, with a correlation coefficient of  $r = 0.875$ , indicating a strong positive relationship between steatosis severity and fibrosis severity.

In addition to quantitative stiffness values expressed in kilopascals (kPa), qualitative elasticity patterns depicted by color mapping on 2D-SWE images were also evaluated. Dominant blue coloration corresponded to F0–F1, yellow to F2, orange to F3, and red to F4. The qualitative elasticity patterns in this study were consistent with the kPa values and Metavir fibrosis staging in all patients, further supporting the validity of shear wave elastography in assessing liver fibrosis.

## Discussion

This study evaluated the correlation between fatty liver grading assessed by ultrasonography and fibrosis staging measured by two-dimensional shear wave elastography (2D-SWE) in patients with NAFLD. Although the proportion of female subjects was higher than male subjects (55.8% vs 42.1%), statistical analysis revealed no association between gender and either steatosis severity or fibrosis stage. This contrasts with epidemiological trends indicating that NAFLD prevalence is generally higher in men than in women (9). However, other studies indicate that although women have a lower risk of developing NAFLD, female patients who develop NAFLD especially after menopause are more vulnerable to disease progression toward NASH and advanced fibrosis (10). The contrasting findings in previous research may be explained by age- and hormone-related differences in the risk profile for NAFLD. Estrogen has protective effects on lipid metabolism and insulin sensitivity through estradiol signaling via ER- $\alpha$ , whereas the decline of estrogen during menopause increases visceral fat accumulation and dyslipidemia, predisposing postmenopausal women to NAFLD progression (11,12). In this study, patients aged <46 years were slightly more common than those  $\geq 46$  years, aligning with findings that the peak incidence of NAFLD occurs between 30–50 years (13). However, age was not associated with steatosis severity or fibrosis stage. This is inconsistent with earlier study showing that NAFLD and its complications are strongly age-dependent (14). The absence of correlation in this study may be related to the sample size and the age distribution within the study population rather

**Table 4.** Correlation between fatty liver grading based on ultrasound images and fibrosis staging based on shear wave elastography in patients with NAFLD

Fatty liver grade based on ultrasound	Liver fibrosis stage based on shear wave elastography, n (%)			P value	r
	Absent or Mild fibrosis (F0-F1) (n=35)	Moderate fibrosis (F2) (n=16)	Severe fibrosis (F3) (n=1)		
Grade 1	35 (100)	1 (6.3)	1 (100)	<0.001*	0.875
Grade 2	0 (0)	12 (75.0)	0 (0)		
Grade 3	0 (0)	3 (18.8)	0 (0)		

\*Spearman correlation test

than true biological absence of association. Previous research also demonstrated that intrinsic aging leads to metabolic dysregulation, including altered glucose, lipid, amino acid, and nucleotide metabolism, collectively contributing to increased NAFLD risk in older individuals (6,15). The most important outcome of this research is the strong positive correlation between fatty liver grading by ultrasound and fibrosis grading by 2D-SWE. This finding is consistent with research by previous study, demonstrating that 2D-SWE accurately detects the presence and severity of NAFLD (14). Ultrasound remains the most commonly used imaging modality for liver evaluation because it is non-invasive, widely available, and free of radiation exposure. Assessment of hepatic steatosis using ultrasound relies primarily on increased liver parenchymal echogenicity relative to the renal cortex, which reflects progressive intracellular fat accumulation (16). Reported sensitivity and specificity of B-mode ultrasound for detecting hepatic steatosis range from 53–76% and 76–93%, respectively, with near-perfect diagnostic accuracy in cases of high-grade steatosis. However, its sensitivity is limited in mild to moderate steatosis (<20–30%), and NAFLD cannot be excluded in the absence of typical sonographic features (5). Several studies have supported the diagnostic value of ultrasound in detecting hepatic steatosis. A cohort study in geriatric patients reported sensitivity and specificity of 96% and 94%, respectively, compared with magnetic resonance spectroscopy, while a meta-analysis of twelve studies involving 2,921 participants found pooled sensitivity and specificity of 82% and 80% for detecting histologically confirmed  $\geq 5\%$  steatosis (17). SWE has emerged as a reliable non-invasive technique for evaluating liver fibrosis by measuring tissue stiffness through shear wave propagation, expressed as shear wave velocity or Young's modulus (8). Previous studies have demonstrated good diagnostic performance of 2D-SWE across fibrosis stages in NAFLD. Sharpton et al., (18) showed AUROC values of 0.84, 0.88, and 0.93 for fibrosis stages  $\geq F2$ ,  $\geq F3$ , and  $\geq F4$ , respectively. Comparative studies have shown that SWE outperforms conventional ultrasound in grading hepatic steatosis,

particularly in early disease stages. Jiang et al. demonstrated significantly higher diagnostic performance of SWE compared with ultrasound in distinguishing lower-grade steatosis, supporting its role as a sensitive tool for early NAFLD assessment (19). This is the first study in South Sulawesi, Indonesia that assessed correlation of steatosis severity with liver fibrosis stage in NAFLD patients. Despite supporting evidence, several limitations warrant consideration. In our study, there is 1 patient with severe fibrosis (F3) based on shear wave elastography but only Grade 1 Fatty Liver based on ultrasound examination. This may happen due to obese patient (body habitus) that became one difficulty factor when performing abdominal ultrasound. And maybe there is also other unknown underlying disease beside fatty liver that can become fibrosis risk factors. Metavir scoring system used in this study does not differentiate between F0 and F1, raising the possibility of misclassification between no fibrosis and mild fibrosis. Technical difficulties during breath-holding reduced SWE reliability in some patients, and reduced visualization in obese individuals may have affected both ultrasound and SWE acquisition. Larger and more diverse samples may help address these limitations in future studies

## Conclusion

In conclusion, this study demonstrates a strong correlation between fatty liver grading based on ultrasonography and fibrosis staging based on shear wave elastography in patients with NAFLD. Most patients exhibited grade 1 steatosis and F0–F1 fibrosis, and both steatosis severity and fibrosis stage showed no association with gender or age. These findings support the utility of ultrasonography as an initial radiological evaluation tool for NAFLD, as steatosis grading can indirectly reflect the likelihood of underlying fibrosis when SWE is not available. Incorporating routine fibrosis evaluation in patients diagnosed with NAFLD is recommended to prevent late recognition of progressive disease.

**Ethic approval:** Research permission was obtained with the approval of the Ethics Committee for Biomedical Research on Humans, Faculty of Medicine, Hasanuddin University, Makassar.

**Conflict of interest:** Each author declares that he or she has no commercial associations (e.g. consultancies, stock ownership, equity interest, patent/licensing arrangement etc.) that might pose a conflict of interest in connection with the submitted article.

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