



## Original Research

# Fatty Liver and Pancreatic Steatosis in Patients with Chronic Hepatitis B and C and Wilson's Disease

Mehmet Aksoy,<sup>1</sup> Feyza Gelebek,<sup>2</sup> Kemal Ozan Lule,<sup>1</sup> Nezihe Otay Lule,<sup>3</sup> Abdullah Emre Yildirim,<sup>4</sup>  
 Sezgin Barutcu<sup>5</sup>

<sup>1</sup>Department of Internal Medicine, Gaziantep University Faculty of Medicine, Gaziantep, Türkiye

<sup>2</sup>Department of Radiology, Gaziantep University Faculty of Medicine, Gaziantep, Türkiye

<sup>3</sup>Department of Nutrition and Dietetics, Gaziantep University Faculty of Health Sciences, Gaziantep, Türkiye

<sup>4</sup>Department of Internal Medicine-Gastroenterology, Arel University Faculty of Medicine, Istanbul, Türkiye

<sup>5</sup>Department of Internal Medicine-Gastroenterology, SANKO University Faculty of Medicine, Gaziantep, Türkiye

### Abstract

**Objectives:** The aim of this study is to determine the presence of fatty liver and pancreatic steatosis in individuals diagnosed with Chronic Hepatitis B (CHB), Chronic Hepatitis C (CHC), and Wilson's Disease (WD) and to evaluate the relationship between the presence of fatty liver and pancreatic steatosis and laboratory parameters.

**Methods:** Forty-eight CHB, fifty-six CHC, and thirty-five WD patients were included in the study. Pancreatic steatosis was measured by three methods: steatosis according to the mean pancreas value, steatosis according to the pancreas/spleen difference value, and steatosis according to the pancreas/spleen density ratio. Hepatic steatosis was measured by noncontrast CT using multi-site attenuation sampling and the Liver Attenuation Index (LAI); steatosis was graded according to predefined LAI cut-offs. Fatty liver and pancreatic steatosis were graded as Grade 1, 2, or 3. Certain laboratory parameters of the patients were also retrospectively reviewed.

**Results:** In 69.1% of all patients, grade 1 fatty liver disease was present. Pancreatic steatosis was absent in 50.3% of patients according to the mean pancreas value, 63.3% according to the pancreas/spleen difference, and 61.9% according to the pancreas/spleen density ratio. Fatty liver disease was positively correlated with high Erythrocyte Sedimentation Rate (ESR) ( $r=0.255$ ,  $p=0.002$ ) and Alanine Transaminase (ALT) ( $r=0.180$ ,  $p=0.034$ ). ESR ( $p=0.025$ ) and urea level ( $p=0.024$ ) were found to be significantly higher in the group with steatosis according to the mean pancreas value. According to the group with steatosis based on the pancreas/spleen density ratio, globulin level was significantly higher ( $p=0.038$ ). The rates of steatosis according to the pancreas mean value ( $p=0.003$ ) and the pancreas/spleen density ratio ( $p=0.039$ ) were significantly more advanced in CHC patients compared with the other patient groups. There was no statistically significant difference between the stage of fatty liver and the stage of fatty pancreas ( $p>0.05$ ).

**Conclusion:** Although fatty liver and pancreatic steatosis are considered similar pathologies, our findings suggest that these two conditions should not be considered interchangeable. Further studies with larger samples may be useful to better demonstrate the correlation between the two conditions and the investigated parameters.

**Keywords:** Chronic Hepatitis B, Chronic hepatitis C, fatty liver, pancreatic steatosis, Wilson's disease

Please cite this article as "Aksoy M, Gelebek F, Lule KO, Otay Lule N, Yildirim AE, Barutcu S. Fatty liver and pancreatic steatosis in patients with Chronic Hepatitis B and C and Wilson's disease. Med Bull Sisli Etfal Hosp 2026;60(1):62-70".

**Address for correspondence:** Kemal Ozan Lule, MD. Department of Internal Medicine, Gaziantep University Faculty of Medicine, Gaziantep, Türkiye

**E-mail:** drkemalozanlule@gmail.com

**Submitted Date:** June 16, 2025 **Revised Date:** October 16, 2025 **Accepted Date:** December 8, 2025 **Available Online Date:** March 23, 2026

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Hepatitis B and C virus infections are important health problems that lead to many complications with high morbidity and mortality, ranging from chronic hepatitis to cirrhosis and hepatocellular carcinoma.<sup>[1]</sup> Wilson's Disease (WD) is a rare autosomal recessive metabolic disorder characterized by impaired copper transport.<sup>[2]</sup> The clinical presentation of WD is highly variable and manifests with hepatic, neurological, and psychiatric symptoms as a result of the accumulation of copper in organs.<sup>[3]</sup> Hepatic manifestations include asymptomatic biochemical abnormalities and fatty liver, as well as acute hepatitis, acute liver failure, chronic hepatitis, and cirrhosis.<sup>[4]</sup>

Fatty liver disease is a common chronic liver disease that occurs mostly as a complication of obesity, type 2 diabetes mellitus, and hyperlipidemia.<sup>[5]</sup> Although the pathogenesis of the disease has not been elucidated, insulin resistance is considered to be an important cause of fatty liver disease.<sup>[6]</sup> Fatty liver affects approximately 25–30% of adults and almost all obese individuals in the general population.<sup>[7]</sup> There are studies reporting that patients with CHB, CHC, and WD are prone to fatty liver.<sup>[8]</sup>

Pancreatic steatosis occurs as a result of fat infiltration into the pancreatic tissue. In contrast to fatty liver, the pathophysiology and clinical significance of pancreatic steatosis are not clearly known.<sup>[9]</sup> Obesity is one of the most important causes of pancreatic steatosis. Other causes of pancreatic steatosis include older age, male gender, type 2 diabetes, malnutrition, cystic fibrosis, Shwachman-Diamond syndrome, some drugs, excessive iron accumulation, and viruses (HBV–HIV). Pancreatic steatosis is a risk factor for severe disease among patients diagnosed with acute pancreatitis.<sup>[10]</sup> In addition, the presence of steatosis may alter the microflora in the pancreas and facilitate tumor progression and dissemination.<sup>[11]</sup> Although many studies have addressed hepatic steatosis in chronic liver diseases and a limited number have explored pancreatic fat, simultaneous comparative assessment of pancreatic steatosis across CHB, CHC, and WD using multiple CT-based indices remains scarce.

The aim of this study was to determine the presence of fatty liver and pancreatic steatosis in patients diagnosed with CHB, CHC, and WD. In addition, it was aimed to evaluate the correlation between fatty liver and pancreatic steatosis with each other and with laboratory parameters.

## Methods

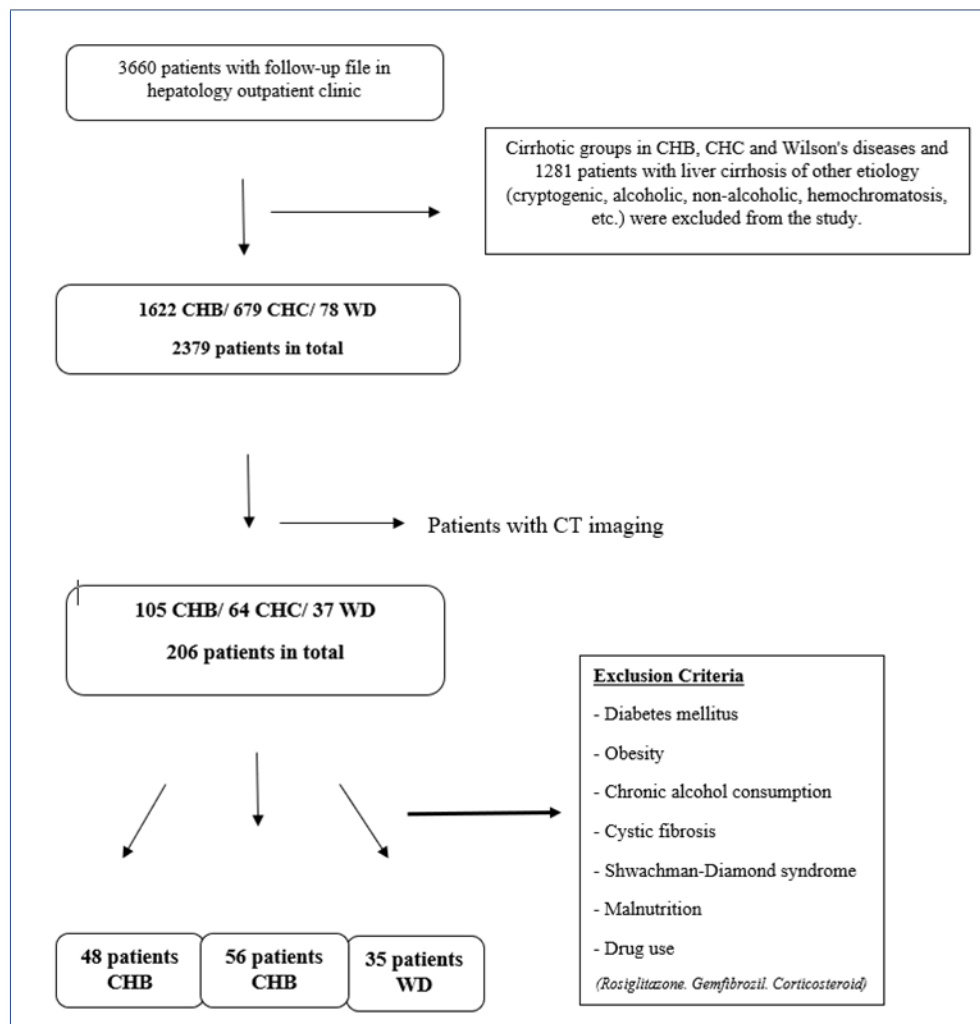
The study included 2379 patients over the age of 18 diagnosed with CHB, CHC, and WD who applied to the hepatology outpatient clinic of a university hospital. The study was conducted in line with the ethical principles outlined in the

Declaration of Helsinki. The study was approved by Gaziantep University Clinical Research Ethics Committee (date: 07.07.2021 decision: 2021/142). Written informed consent was obtained from the individuals.

CHB infection was considered as HBsAg positivity for at least 6 months based on the European Association for the Study of the Liver 2018 guidelines. The diagnosis of CHC was made with HCV antibody positivity and a positive molecular test (HCV RNA) performed 6 months later. The diagnosis of WD was made according to the Leipzig criteria based on clinical, laboratory, and imaging findings. Among 2379 patients, there were 105 patients with CHB, 64 patients with CHC, and 37 patients with WD who had computed tomography (CT) images. Out of 206 patients with CT images, 67 were excluded from the study based on exclusion criteria (diabetes, obesity, chronic alcohol consumption, cystic fibrosis, Shwachman-Diamond syndrome, malnutrition, gemfibrozil, rosiglitazone, and/or corticosteroid use). The study was conducted with a total of 139 patients, including 48 CHB, 56 CHC, and 35 WD patients. The design of the study is shown in Figure 1.

In the evaluation of fatty liver disease, 12 sampling areas were detected by noncontrast CT and attenuation measurements were performed. Three representative branches were selected to describe the sampling sites: the confluence of the right hepatic artery, the umbilical portion of the left portal vein, and the posterior branch of the right portal vein. At each level, the liver was divided into four sectors. In addition, a sampling area was placed in the spleen at each level, and the mean liver and mean spleen densities in Hounsfield Units (HU) were found by averaging the values obtained. Liver Attenuation Index (LAI) was calculated using the difference between these values.  $LAI > 5$  was considered as <5% steatosis (Grade 1),  $5 \leq LAI < 10$  was considered as 6–30% steatosis (Grade 2), and  $-10 \leq LAI$  was considered as >30% steatosis (Grade 3).<sup>[12]</sup>

For pancreatic steatosis, a total of 9 sampling areas, 3 from each of the head, body, and tail sections, were determined. The primary distinction is the absence of an LAI value for pancreatic steatosis, despite the similar calculation method used for fatty liver. However, the literature on this topic is limited. In our study, pancreatic steatosis was assessed in three ways. These are “pancreas mean value”, calculated as the average of the attenuation values of the head, body, and tail sections of the pancreas; “pancreas/spleen difference value”, based on the density difference between them; and “pancreas/spleen density ratio”, obtained by mathematically dividing the pancreas density by the spleen density. Noncontrast CT was used for assessing pancreatic steatosis and measuring density



**Figure 1.** Flow chart of the study.

CHB: Chronic Hepatitis B, CHC: Chronic Hepatitis C, WD: Wilson's disease.

in HU, which was then compared with splenic parenchyma. The cut-off values for grade 1 pancreatic steatosis were determined as 41.67, -6.33, and 0.87 based on the pancreatic mean HU density value, the difference in HU density between the pancreas and spleen, and the ratio of HU density between the pancreas and spleen, respectively. For grade 2 pancreatic steatosis, the cut-off values were accepted as 36.67, -12, and 0.6 in the same order. Similarly, for grade 3 pancreatic steatosis, the cut-off values were accepted as 26.5, -22, and 0.56, respectively. The cut-off values used for classifying pancreatic steatosis were based on limited prior literature, particularly from comparative studies using noncontrast CT. Although not yet standardized, these criteria are currently among the most referenced thresholds in the absence of histologic confirmation. The rationale for using three assessment methods (mean pancreatic value, pancreas/spleen difference, and pancreas/spleen density ratio)

lies in the lack of consensus on a single valid measurement; therefore, triangulating these approaches allows a more robust and comparative evaluation of steatosis severity across anatomical variability and imaging characteristics. It is important to emphasize that CT-based assessments do not provide histological confirmation. Without biopsy, differentiation between fat infiltration and fibrosis or inflammation remains speculative.

In addition, demographic characteristics of the patients such as age, gender, and certain laboratory parameters (International Normalized Ratio (INR), prothrombin time, leukocyte, hemoglobin, platelet, Mean Cell Volume (MCV), Erythrocyte Sedimentation Rate (ESR), C-Reactive Protein (CRP), glucose, urea, creatinine, Aspartate Transaminase (AST), Alanine Transaminase (ALT), Alkaline Phosphatase (ALP), Gamma-Glutamyl Transferase (GGT), total bilirubin, direct bilirubin, Alpha Fetoprotein (AFP), albumin, and globulin) were also retrospectively screened.

## Statistical Analysis

Statistical Package for Social Sciences (SPSS) version 20.0 was used for data analysis (SPSS Inc., Chicago, IL, USA). The normality of the data distribution was evaluated using the Shapiro–Wilk test. One-way ANOVA–LSD test was used to compare normally distributed variables in more than two independent groups. The Kruskal–Wallis test was used to compare nonnormally distributed data between groups. Spearman correlation coefficient was used to test the relationships between numerical variables, and the Chi-square test was used to test the relationships between categorical variables. The results were considered significant at the  $p < 0.05$  level. Multiple comparisons were conducted across laboratory parameters and disease groups; therefore, the risk of type I error should be considered. Post-hoc adjustments such as Bonferroni correction were not applied but are recommended for future studies. Visual assessments including histogram plots and Q–Q plots were used in addition to Shapiro–Wilk tests to determine data normality. Sample size was limited, especially in subgroup analyses for WD, which reduces statistical power.

## Results

Out of the patients, 34.5% were diagnosed with CHB, 40.3% with CHC, and 25.2% with WD. Grade 1 fatty liver was present in 69.1%, Grade 2 in 25.9%, and Grade 3 in 5% of all patients. Pancreatic steatosis was detected in 49.7% of the patients according to the mean pancreas value (25.9% Grade 1, 20.9% Grade 2, 2.9% Grade 3), 36.7% according to the pancreas/spleen difference (25.2% Grade 1, 9.4% Grade 2, 2.1% Grade 3), and 38.1% according to the pancreas/spleen ratio (23.0% Grade 1, 12.9% Grade 2, 2.2% Grade 3).

There was no statistically significant correlation between the mean ages of the patients according to the stages of fatty liver ( $p > 0.05$ ). However, in all three measurement methods, the mean age of the group without pancreatic steatosis was significantly lower than that of the group with pancreatic steatosis ( $p < 0.05$ ) (Table 1).

Laboratory parameters of the patient groups are shown in Table 2. Fatty liver was positively correlated with high ESR ( $r = 0.255$ ,  $p = 0.002$ ) and ALT ( $r = 0.180$ ,  $p = 0.034$ ). ESR ( $p = 0.025$ ) and urea level ( $p = 0.024$ ) were significantly higher in the group with steatosis according to the mean pancreatic value. Globulin level was significantly higher in the group with steatosis according to the pancreas/spleen density ratio ( $p = 0.038$ ). The pancreas/spleen difference value based on laboratory parameters showed no significant difference between the group with steatosis and the group without steatosis ( $p > 0.05$ ).

**Table 1.** The correlation of fatty liver and pancreas with age

	Age		
	Number	Mean	p
Fatty liver			
Grade 1	96	49.94	0.277 <sup>a</sup>
Grade 2	36	55.44	
Grade 3	7	51.71	
Steatosis according to pancreas mean value			
None	70	45.0	<b>0.001<sup>b</sup></b>
Exists	69	58.0	
Steatosis according to pancreas/spleen difference value			
None	88	48.89	<b>0.023<sup>b</sup></b>
Exists	51	55.86	
Steatosis according to pancreas/Spleen density ratio			
None	86	47.79	<b>0.001<sup>b</sup></b>
Exists	53	57.40	

p<sup>a</sup>: One-way ANOVA; p<sup>b</sup>: Kruskal Wallis

No significant difference was observed between the disease groups in terms of fatty liver stage ( $p = 0.155$ ). When the correlation between the stage of pancreatic steatosis and the disease groups was analyzed, the stage of steatosis according to the mean value of the pancreas ( $p = 0.003$ ) and the stage of steatosis according to the pancreas/spleen density ratio ( $p = 0.039$ ) were significantly more advanced among patients with CHC. There was no significant difference between the disease groups in terms of steatosis stage according to the pancreas/spleen difference value ( $p > 0.05$ ) (Table 3).

There was no statistically significant correlation between the degree of fatty liver and the degree of pancreatic steatosis according to all three pancreatic steatosis stage measurement methods (Table 4).

## Discussion

It is important to determine the pathologies that may cause steatosis in order to take necessary precautions.<sup>[13]</sup> Despite the increasing number of studies on pancreatic steatosis, there is no clear indication of its clinical significance.<sup>[14]</sup> At the same time, pancreatic steatosis is thought to be a marker of local fat accumulation associated with beta-cell dysfunction.<sup>[15]</sup> Compared with the existing literature, this study is unique in that it comprehensively assesses pancreatic steatosis among patients diagnosed with CHB, CHC, and WD using three distinct noncontrast CT-based methods. To our knowledge, no prior study

**Table 2.** Laboratory parameters of CHB, CHC and WD groups

Variables	CHB		CHC		WD	
	Mean±SD	Median (Min-Max)	Mean±SD	Median (Min-Max)	Mean±SD	Median (Min-Max)
INR	1.19±0.41	1.07 (0.93-2.79)	1.22±0.71	1.04 (0.89-4.96)	1.44±0.47	1.37 (0.9-3.3)
Prothrombin time (sec)	15.5±4.8	13.8 (11.5-35.9)	15.37±6.79	13.65 (11.5-47.8)	19.72±11.47	17.8 (12-81.6)
Leukocytes (103/μL)	7.29±2.36	6.75 (2.85-14.9)	7.39±3.5	6.79 (2.42-21)	6.7±4.74	5.54 (2.08-23.13)
Hemoglobin (gr/dL)	14.07±2.26	14.65 (8.4-17.6)	15.18±1.5	13.7 (7.2-17.4)	12.37±2.67	13.1 (6.2-16.9)
Platelets (103/μL)	208.29±71.39	203.5 (44 -378)	221.96±78.9	216.5 (95-513)	136.9 ±72.1	193 (125 -293)
MCV (fL)	86.74±6.84	86.75 (64.2 -108)	86.21±7.3	86.85 (62.2-116.8)	84.93±9.7	85.9 (59.3-106.2)
ESR (mm/h)	19.6±26.9	5.5 (1 -112)	22.84±18.1	17.5 (2 -74)	11.2±10.6	6 (1 -40)
CRP (mg/L)	23.58±66.69	3.1 (0.1 -315)	13.62±47.15	2 (0.1-347)	12.04±19.17	3 (0.02-66.8)
Glucose (mg/dL)	117.83±55.73	100 (78-369)	123.7±71.84	102 (61 -514)	94.09±16.95	91 (69-130)
Urea (mg/dL)	36.29±20.89	30 (16-135)	34.8±20.35	31 (0.8-148)	39.73±54.69	24 (14-321)
Creatinine (mg/dL)	0.97±0.9	0.79 (0.49-6.31)	2.22±7.28	0.73 (0.39-46)	2.69±11.72	0.67 (0.31-70)
AST (U/L)	38.35±47.45	23 (8-298)	29±21	23 (12-152)	51.11±39.7	34 (14-188)
ALT (U/L)	33.23±34.25	26 (11-239)	23.77±20.02	20 (6-148)	59.86±80.58	34 (2-456)
ALP (U/L)	97.21±79.82	81 (31-571)	103.63±70.45	87.5 (38 -518)	120.66±54.45	105 (22-251)
GGT (U/L)	51.85±70.32	29 (9 -373)	45.27±72.73	23 (10-493)	62.54±67.34	51 (5-317)
T.Bilirubin (mg/dL)	1.17±1.59	0.66 (0.35-8.74)	1.01±1.48	0.6 (0.25-8.52)	3.13±5.18	1.32 (0.36-23.31)
D.Bilirubin (mg/dL)	0.37±0.69	0.14 (0.07-3.71)	0.28±0.41	0.14 (0.04-2.7)	1.59±3.76	0.36 (0.07-18.52)
AFP (ng/mL)	55.52±357.4	3.05 (0.76-2480)	7.39±19.28	3.61 (1.2 -146)	5.15±5.07	3.11 (0.64-24.52)
Albumin (g/L)	39.5±7.43	41 (15.9 -49)	38.98±5.23	40.5 (24.7-47)	37.17±8.12	39 (15.6-49)
Globulin (g/L)	33.79±8.36	32 (23-76.2)	33.92±6.96	34 (3.3-49)	28.49±6.34	30 (12-37)

INR: International normalized ratio; MCV: Mean corpuscular volume; ESR: Erythrocyte sedimentation rate; CRP: C-reactive protein; AST: Aspartate aminotransferase; ALT: Alanine transaminase; ALP: Alkaline phosphatase; GGT: Gamma-glutamyl transferase; AFP: Alpha-fetoprotein protein.

has systematically evaluated pancreatic fat infiltration in these patient populations simultaneously. This approach enhances our understanding of pancreatic fat deposition

beyond the scope of metabolic syndrome or obesity-related studies. Recent MRI-based studies have highlighted the emerging importance of nonalcoholic fatty pancreas

**Table 3.** Stages of fatty liver and pancreatic steatosis according to disease groups

	Diagnosis						p
	CHB		CHC		WD		
	n	%	n	%	n	%	
Fatty liver							
Grade 1	31	64.6	36	64.3	29	82.9	0.155
Grade 2	16	33.3	16	28.6	4	11.4	
Grade 3	1	2.1	4	7.1	2	5.7	
Steatosis according to the pancreas mean value							
No steatosis	33	66.67	18	32.14	20	57.14	<b>0.003</b>
Grade 1	9	18.75	16	28.57	11	31.43	
Grade 2	7	14.58	18	32.14	4	11.43	
Grade 3	0	0.0	4	7.14	0	0.0	
Steatosis according to pancreas/spleen difference value							
No steatosis	35	72.92	29	51.7	24	68.57	0.082
Grade 1	11	22.92	15	26.79	9	25.71	
Grade 2	1	4.17	9	16.07	2	5.71	
Grade 3	0	0.0	3	5.36	0	0.0	
Steatosis according to pancreas/spleen density ratio							
No steatosis	35	72.92	26	46.43	25	71.43	<b>0.039</b>
Grade 1	8	16.67	16	28.57	8	22.86	
Grade 2	5	10.42	11	19.64	2	5.71	
Grade 3	0	0.0	3	5.36	0	0.0	

p: Chi-square; CHB: Chronic Hepatitis B; CHC: Chronic Hepatitis C; WD: Wilson's disease.

disease in metabolic conditions, reinforcing the relevance of exploring pancreatic fat even in nonobese, nondiabetic populations. Moreover, the use of noncontrast CT without histological validation presents a limitation. Histological confirmation remains the gold standard for diagnosing both steatosis and associated inflammation. Therefore, imaging-based findings should be interpreted cautiously, and future studies incorporating tissue-level validation are warranted.<sup>[16]</sup> Additionally, recent MRI-based techniques such as liver fat fraction (LFF) and pancreatic fat fraction (PFF) allow more sensitive quantification of organ fat content. A study demonstrated the utility of MRI in detecting and comparing fat accumulation patterns in hepatic and pancreatic tissues,<sup>[17]</sup> supporting the need for multimodal imaging approaches in future studies.

Basal metabolic rate decreases and visceral adipose tissue increases with age, leading to organ obesity. In the literature, there are studies reporting that fatty liver disease is more common in older individuals.<sup>[18,19]</sup> However, there are also studies reporting that fatty liver disease, which increases

toward older ages, decreases again in advanced ages.<sup>[20,21]</sup> In our study, there was no statistically significant difference between fatty liver stages and age. This may be due to the fact that all patients diagnosed with CHB, CHC, and WD over the age of 18 years were included in our study.

In the literature, it has been reported that the pancreas enters the aging process with various morphological changes and that the anteroposterior diameter and parenchymal volume of the pancreas decrease with age, while fat volume increases.<sup>[22]</sup> In our study, the mean age of the group without pancreatic steatosis was significantly lower than that of the group with pancreatic steatosis according to all three measurement methods.

In our study, fatty liver disease was positively correlated with high ESR. This may be due to oxidative stress caused by insulin resistance on cells due to fatty liver and the increased levels of interleukin-6 in related proinflammatory processes. Fatty liver disease was also positively correlated with ALT level. Similar to our findings, a positive correlation between fatty liver disease and ALT was reported in another

**Table 4.** The correlation between the stage of pancreatic steatosis and fatty liver

Steatosis according to pancreas mean value	Fatty liver			p
	Grade 1	Grade 2	Grade 3	
No steatosis	43 (44.79%)	21 (58.33%)	6 (85.71%)	0.389
Grade 1	29 (30.21%)	7 (19.44%)	0 (0%)	
Grade 2	21 (21.88%)	7 (19.44%)	1 (14.29%)	
Grade 3	3 (3.13%)	1 (2.78%)	0 (0%)	
Steatosis according to pancreas/ Spleen difference value	Fatty liver			p
	Grade 1	Grade 2	Grade 3	
No steatosis	65 (67.71%)	20 (55.56%)	3 (42.86%)	0.277
Grade 1	22 (22.92%)	9 (25%)	4 (57.14%)	
Grade 2	7 (7.29%)	6 (16.67%)	0 (0%)	
Grade 3	2 (2.08%)	1 (2.78%)	0 (0%)	
Steatosis according to pancreas/ Spleen density ratio	Fatty liver			p
	Grade 1	Grade 2	Grade 3	
No steatosis	63 (65.63%)	19 (52.78%)	4 (57.14%)	0.590
Grade 1	20 (20.83%)	9 (25%)	3 (42.86%)	
Grade 2	11 (11.46%)	7 (19.44%)	0 (0%)	
Grade 3	2 (2.08%)	1 (2.78%)	0 (0%)	

p: Chi-square

er study.<sup>[23]</sup> This may be due to parenchymal damage in the liver at the cellular level.

There is a correlation between viral load and disease complications in chronic viral hepatitis. Although complete suppression of viral load in chronic viral hepatitis does not eliminate the risk of HCC, it significantly reduces it. In addition, increased viral load may cause the complications of the disease to be more severe.<sup>[24]</sup> There are also studies reporting that fatty liver was not found to be associated with viral load in the literature.<sup>[25,26]</sup> Viral load can modulate hepatic inflammation and potentially organ fat deposition. As these variables were not uniformly available, we could not adjust for them. Future prospective studies should incorporate antiviral treatment status, viral load dynamics, and quantitative copper indices to refine the interpretation of ALT/ESR and fat metrics.

ESR and urea levels were found to be significantly higher in the group with steatosis according to the mean pancreatic value. While these findings suggest a possible association between inflammatory state and pancreatic fat deposition, it is important to note that ESR is a nonspecific and indirect inflammatory marker and may not reflect true pancreatic inflammation. No specific inflammatory biomarkers directly reflecting pancreatic inflammation were assessed. Similarly, although globulin levels were higher among patients

diagnosed with steatosis based on the pancreas/spleen density ratio, causality cannot be inferred. Further prospective studies utilizing more specific markers are needed to clarify these relationships.

Although ESR and ALT showed statistically significant associations with hepatic steatosis ( $r=0.255$  and  $r=0.180$ , respectively), the effect sizes were small, indicating limited clinical impact at the individual patient level. Importantly, in the absence of viral load and treatment status, ALT elevations cannot be confidently attributed to steatosis rather than residual viral activity. Future studies should include these covariates to enable adjusted effect estimates.

In our study, no correlation was observed between the stage of fatty liver disease and disease groups. On the other hand, steatosis according to the pancreas mean value and steatosis according to the pancreas/spleen density ratio were significantly higher among patients diagnosed with CHC. It was also found that fatty liver disease and pancreatic steatosis were significantly higher in patients diagnosed with CHC compared with the control group in a study.<sup>[27]</sup> In order to predict diseases such as insulin resistance and type 2 DM that may develop as a result of pancreatic steatosis, it may be useful to screen patients with CHC for pancreatic steatosis.

Some studies in the literature reported a correlation between fatty liver disease and pancreatic steatosis.<sup>[28,29]</sup> How-

ever, in our study, no significant correlation was observed between the degree of fatty liver and the degree of pancreatic steatosis according to all three pancreatic steatosis stage measurement methods. This difference may be due to the fact that our study was conducted on patients diagnosed with CHB, CHC, and WD. In the literature, studies reporting that fatty liver and pancreas are related have mostly been conducted on patients with obesity or diabetes mellitus, and it has been assumed that these two pathologies are caused by similar etiologies such as obesity. However, recent evidence suggests that there are different molecular mechanisms in the natural history and physiopathology of pancreatic steatosis and fatty liver disease. A similar situation was observed in a study even though it was conducted on a larger sample compared with our study.<sup>[11]</sup> This situation, which seems to be a contradiction, suggests that it may be related to the physiopathology of the process. Since they originate from the same endoderm embryologically, ectopic fat accumulation may occur simultaneously in both organs. Fat accumulation in hepatocytes is intracellular, and this is how fat deposits are formed in the liver. Fat accumulation in the pancreas occurs due to intercellular adipocyte infiltration in the interlobular regions of both islet and acinar cells.<sup>[10,11,30]</sup>

## Limitations

This study has several limitations. First, its retrospective design may have limited the ability to control for potential confounding variables. Second, the relatively small sample size and inclusion of only specific patient groups (CHB, CHC, and WD) may restrict the generalizability of the findings to broader populations. Disease-specific variables (HBV DNA, HCV RNA, urine copper) were unavailable in a subset of patients and were therefore not included; this may confound associations with ALT/ESR and fat indices. Finally, the use of imaging-based grading methods without histopathological confirmation may have affected the diagnostic accuracy in determining the exact stage of hepatic and pancreatic steatosis. Additionally, there is a potential for selection bias due to incomplete or suboptimal imaging quality, which may have influenced patient inclusion. The relatively small sample size of the WD group poses a limitation in statistical power for subgroup analysis. Moreover, due to the retrospective nature of the study, it was not possible to control for all potential confounding variables such as lifestyle factors, unrecorded comorbidities, or medication use.

## Conclusion

When evaluating pancreatic steatosis and fatty liver, no single criterion should be considered. Density values of the pancreas and liver should be interpreted in comparison

with the spleen within their own anatomical regions.

According to all three pancreatic steatosis measurement methods used in our study, pancreatic steatosis increases with age.

If studies examining the correlation between fatty liver and pancreatic steatosis with various laboratory parameters report similar results, some parameters such as ESR and ALT for fatty liver, and ESR, urea, and globulin for pancreatic steatosis can be used as indicators.

Pancreatic steatosis was observed to be significantly higher in CHC patients compared with CHB and WD groups. Screening of patients with chronic CHC for pancreatic steatosis may be beneficial.

The absence of correlation between fatty liver and pancreatic steatosis has been attributed to different molecular mechanisms underlying the pathophysiology of these two conditions.

Although fatty liver and pancreatic steatosis may be considered similar pathologies, they should not be confused with each other due to their distinct underlying mechanisms. Further large-scale advanced studies may be more beneficial in demonstrating the correlations between both pathologies and their associations with CHB, CHC, WD, and laboratory parameters.

## Disclosures

**Ethics Committee Approval:** This study was approved by the Gaziantep University Clinical Research Ethics Committee (Date: 07.07.2021, Decision no: 2021/142).

**Informed Consent:** Written informed consent was obtained from the individuals.

**Conflict of Interest:** None declared.

**Financial Disclosure:** The author declared that this study has received no financial support.

**Use of AI for Writing Assistance:** None declared.

**Authors Contributions:** Conception – MA, SB, AEY; Design – MA, SB, AEY; Supervision – MA, SB, NOL, KOL; Fundings – MA, SB, KOL, FG; Materials – MA, SB; Data Collection and/or Processing – MA, SB, KOL, FG, NOL; Analysis and/or Interpretation – MA, SB, KOL, NOL; Literature Review – MA, SB, KOL, NOL, FG, AEY; Writer – MA, SB, KOL, NOL; Critical Review – MA, SB, KOL, NOL, FG, AEY.

**Peer-review:** Externally peer-reviewed.

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