JHWCR

Journal of Health, Wellness, and Community Research
Volume III, Issue XII
Open Access, Double Blind Peer Reviewed.
Web: https://jhwcr.com, ISSN: 3007-0570
https://doi.org/10.61919/nktrdc91

Original Article

Correlation of Renal Calculi with Non-Alcoholic Fatty Liver Disease on Ultrasonography

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Cite this Article | Received: 2025-08-21 | Accepted 2025-09-04
No conflicts declared; ethics approved; consent obtained; data available on request; no funding received.

ABSTRACT

Background: Non-alcoholic fatty liver disease (NAFLD) and renal calculi are increasingly prevalent conditions that share common metabolic risk factors such as obesity, insulin resistance, and dietary changes. While their coexistence has been reported, limited evidence exists regarding their correlation when assessed by ultrasonography, particularly in South Asian populations where ultrasound is the primary diagnostic modality. Objective: To evaluate the correlation between renal calculi and NAFLD using ultrasonography in patients presenting with abdominal pain at a tertiary hospital in Lahore, Pakistan. Methods: A cross-sectional study was conducted among 115 patients aged ≥18 years undergoing abdominal ultrasonography. Participants with prior hepatic or renal surgery, alcohol consumption, chronic liver or kidney disease, or hepatic mass lesions were excluded. Standardized sonographic protocols were used to assess hepatic steatosis and renal calculi. Fatty liver was graded from 0 to 3 based on echogenicity relative to the renal cortex. Data were analyzed using SPSS 24.0 with chi-square tests to assess associations between calculi characteristics and fatty liver grades. Statistical significance was defined as $p < 0.05$. Results: NAFLD was identified in 61.7% of participants, with Grade 1 as the most frequent stage (34.8%). Renal calculi were distributed as right-sided in 33.9%, left-sided in 35.7%, and bilateral in 30.4%. No statistically significant correlation was observed between fatty liver grade and the presence, number, or laterality of calculi ($p > 0.05$). Conclusion: Although NAFLD and renal calculi commonly coexist, ultrasonography-based findings suggest that renal stones are not independently associated with hepatic steatosis. Larger, multicenter studies are required to clarify shared metabolic pathways.
Keywords: Non-alcoholic fatty liver disease; renal calculi; ultrasonography; metabolic risk; South Asia.

INTRODUCTION

Non-alcoholic fatty liver disease (NAFLD) has emerged as the leading cause of chronic liver disease worldwide, with an estimated global prevalence approaching 30% in adults, and is strongly linked with obesity, insulin resistance, and other metabolic disorders (1). Its spectrum ranges from simple steatosis to non-alcoholic steatohepatitis (NASH), cirrhosis, and hepatocellular carcinoma, with considerable morbidity and mortality. Parallel to this, renal calculi—or kidney stones—remain a common urological condition with rising prevalence globally, including South Asia, where dietary transitions and sedentary lifestyles have exacerbated metabolic risk factors (2). Both conditions frequently coexist within the same individuals, suggesting overlapping pathophysiological mechanisms such as metabolic syndrome, systemic inflammation, and oxidative stress (3).

Dietary and lifestyle determinants are central to this shared etiology. High fructose consumption, increasingly prevalent in South Asian diets, has been shown to promote hepatic steatosis through de novo lipogenesis while simultaneously increasing uric acid excretion, thereby enhancing the risk of uric acid nephrolithiasis (4). Sedentary behavior contributes both to hepatic fat accumulation and to urinary stasis, raising the likelihood of stone formation (5). Furthermore, hypertension, dyslipidemia, and central obesity—key components of metabolic syndrome—are common to both NAFLD and renal calculi, supporting the concept of a broader systemic dysfunction underlying these diseases (6).

Imaging modalities play an essential role in the diagnosis of both conditions. Ultrasonography, in particular, provides a non-invasive, accessible, and cost-effective means of detecting hepatic steatosis and renal stones without ionizing radiation, which is especially relevant in resource-constrained settings such as Pakistan (7). On ultrasound, hepatic steatosis is characterized by increased echogenicity of the liver parenchyma relative to the renal cortex, while renal calculi appear as hyperechoic foci with posterior acoustic shadowing (8). Prior studies from South Asia and elsewhere have confirmed the high diagnostic accuracy of ultrasonography in detecting kidney stones, with sensitivity exceeding 90% compared with non-contrast computed tomography (9). Similarly, ultrasound has demonstrated sensitivities ranging from 60% to 94% in detecting hepatic steatosis, particularly when fat infiltration involves more than 20–30% of hepatocytes (10). While liver biopsy remains the gold standard, ultrasonography is considered reliable for large-scale epidemiological studies.

Despite shared risk factors, the precise nature of the relationship between NAFLD and renal calculi remains uncertain. Most existing evidence derives from CT-based studies or from populations in Western settings, limiting their applicability to ultrasound-centered, resource-limited environments. Moreover, it remains unclear whether the presence of renal calculi independently contributes to hepatic steatosis or whether their coexistence is simply a reflection of overlapping metabolic risk profiles (11). This gap is particularly important in South Asia, where both NAFLD and kidney stones are prevalent, and ultrasound is often the only feasible diagnostic modality.

In light of these considerations, the present study aimed to evaluate the correlation between renal calculi and NAFLD using ultrasonography among patients presenting with abdominal pain in a tertiary hospital in Lahore, Pakistan. By focusing on sonographic findings, this study sought to clarify whether renal calculi are associated with hepatic steatosis in this population. The primary objective was to determine the prevalence of NAFLD among patients with renal calculi and to assess whether a significant correlation exists between the two conditions.

MATERIAL AND METHODS

This study employed a cross-sectional observational design, chosen to evaluate the association between renal calculi and non-alcoholic fatty liver disease (NAFLD) at a single time point. The study was conducted in the Radiology Department of Nawaz Sharif Social Security Hospital, Lahore, over a two-month period. This setting was selected because ultrasonography is routinely performed as the first-line imaging modality for patients presenting with abdominal pain, providing a representative population for the investigation of both renal calculi and NAFLD in a resource-limited environment (12).

Participants were eligible for inclusion if they were aged 18 years or older, of either sex, and presented with abdominal pain subsequently attributed to renal calculi on ultrasonography. Additional inclusion criteria required the absence of any prior hepatic or renal surgical procedures. Exclusion criteria included a history of alcohol consumption to eliminate confounding with alcoholic fatty liver disease, known cases of chronic liver disease such as hepatitis B or C or cirrhosis, pre-existing chronic kidney disease, and the presence of hepatic mass lesions or biliary obstruction. These criteria were designed to minimize heterogeneity and to specifically assess the correlation between non-alcoholic fatty liver disease and renal calculi (13).

A non-probability convenience sampling approach was used, and a total of 115 patients fulfilling the eligibility criteria were enrolled. Written informed consent was obtained from each participant prior to inclusion. Patients were informed about the voluntary nature of participation, their right to withdraw at any time, and the assurance that refusal to participate would not affect their clinical care. All personal identifiers were removed from study records to ensure confidentiality.

Data collection was performed using a standardized protocol. After obtaining relevant clinical history, participants were examined in the supine position with arms elevated above the head. A curvilinear low-frequency ultrasound probe (3–5 MHz) was used to scan the liver and kidneys. The liver was assessed for echotexture and fatty infiltration, with hepatic steatosis defined and graded according to echogenicity relative to the renal cortex: Grade 0 (absent), Grade 1 (mild increase in echogenicity with normal visualization of diaphragm and intrahepatic vessels), Grade 2 (moderate increase with slightly impaired visualization), and Grade 3 (marked increase with poor visualization of deeper structures) (14). The kidneys were evaluated bilaterally for the presence, number, and location of calculi, as well as for cortical echogenicity and size. Renal calculi were identified as hyperechoic foci with posterior acoustic shadowing. A structured proforma was completed for each patient to ensure uniform data recording.

To reduce bias, all ultrasound examinations were performed by radiologists trained in abdominal sonography, using the same equipment and scanning protocol. Inter-observer variability was minimized by assigning each case to a single sonographer. Data entry was checked twice to prevent transcription errors.

The primary variables were presence and grade of fatty liver, and presence, side, number, and location of renal calculi. Secondary variables included age, sex, and family history of renal or liver diseases. To control for potential confounders such as age and sex, stratified analyses were planned.

The sample size was based on feasibility within the study period; however, it provided adequate representation for exploratory correlation analysis. Data were entered into SPSS version 24.0 (IBM Corp., Armonk, NY, USA). Descriptive statistics were generated for all variables, with categorical data summarized as frequencies and percentages, and continuous data as means and standard deviations. The chi-square test was used to evaluate associations between categorical variables, including the correlation between fatty liver grades and renal calculi characteristics. Statistical significance was set at $p < 0.05$. No missing data were present in the dataset, eliminating the need for imputation strategies.

Ethical approval for the study was obtained from the hospital administration and senior faculty members in accordance with institutional guidelines. The study was conducted in compliance with the Declaration of Helsinki. All participants provided written informed consent. Data security protocols were observed to ensure reproducibility and integrity, with anonymized datasets stored securely and available for verification upon request (15).

RESULTS

The study population consisted of 115 individuals, nearly equally distributed between genders, with 57 males (49.6%) and 58 females (50.4%). The age distribution revealed that middle-aged adults between 31 and 50 years constituted the largest group at 52.2% (n=60), followed by participants aged 51 years and above at 34.8% (n=40). The youngest group, 18–30 years, comprised only 13.0% (n=15). A statistically significant difference was observed across age groups (p=0.021), with the midlife population showing the greatest clustering of both fatty liver and renal calculi.

Fatty liver disease was present in 61.7% (n=71) of the participants, while 38.3% (n=44) showed no hepatic steatosis. Grading revealed that mild fatty infiltration (Grade 1) was the most common, affecting 34.8% (n=40), followed by Grade 2 in 23.5% (n=27), and Grade 3 in only 5.2% (n=6). The overall trend of increasing fatty liver severity was statistically significant (p=0.039), suggesting progressive hepatic involvement in a substantial subset of this population.

Kidney stone distribution was nearly symmetrical between sides. The left kidney was involved in 35.7% (n=41), the right kidney in 33.9% (n=39), and bilateral calculi were present in 30.4% (n=35). No significant differences were observed between these groups (p=0.473). The number of calculi varied considerably: single stones were most common at 38.3% (n=44), followed by two stones in 24.3% (n=28), and four stones in 18.3% (n=21). Multiple stone formation beyond five was uncommon, with only 7.8% (n=9) affected. Despite this variability, the number of stones did not significantly correlate with fatty liver grade (p=0.554), indicating that calculi burden did not influence the prevalence or severity of steatosis.

Liver echotexture was normal in 64.3% (n=74) of cases, while coarse echotexture was observed in 20.0% (n=23), and increased echotexture in 15.7% (n=18). Cortical echogenicity of the kidneys was predominantly normal at 84.3% (n=97), with only 15.7% (n=18) showing increased echogenicity, and this difference was not statistically significant (p=0.108).

When fatty liver grade was cross-tabulated against kidney involvement, no significant association was detected (p=0.473). For right kidney stones, 41.0% (n=16) had no fatty liver, 30.8% (n=12) had Grade 1, and 28.2% (n=11) had Grade 2 steatosis, with no cases of Grade 3. Left kidney stones were similarly distributed, with 39.0% (n=16) having no fatty liver, 31.7% (n=13) with Grade 1, 22.0% (n=9) with Grade 2, and 7.3% (n=3) with Grade 3. Bilateral stones displayed slightly higher proportions of fatty liver, with Grade 1 observed in 42.9% (n=15) of cases.

Table 1. Baseline demographic characteristics of study participants (N = 115)

Variable	Frequency (n)	Percentage (%)	p-value	95% CI / Effect size
Male	57	49.6	0.874	OR = 0.97 (0.54–1.72)
Female	58	50.4		
Age 18–30 years	15	13.0		
Age 31–50 years	60	52.2	0.021*	χ^2 trend p=0.021
Age ≥51 years	40	34.8		

Table 2. Prevalence and grading of fatty liver on ultrasonography (N = 115)

Fatty liver grade	Frequency (n)	Percentage (%)	p-value	95% CI / Effect size
Absent	42	36.5		
Grade 1	40	34.8		
Grade 2	27	23.5	0.039*	OR = 1.52 (1.01–2.87)
Grade 3	6	5.2		

Table 3. Kidney involvement and distribution of calculi (N = 115)

Kidney involvement	Frequency (n)	Percentage (%)	p-value	95% CI / Effect size
Right only	39	33.9		
Left only	41	35.7	0.473	χ^2 = 1.52, p=0.473
Bilateral	35	30.4		

Table 4. Number of renal calculi and association with fatty liver grade (N = 115)

Number of stones	Frequency (n)	Percentage (%)	p-value	95% CI / Effect size
1	44	38.3		
2	28	24.3		
3	13	11.3	0.554	χ^2 = 3.05, p=0.554
4	21	18.3		
5	9	7.8		

Table 5. Cortical echogenicity among study participants (N = 115)

Cortical echogenicity	Frequency (n)	Percentage (%)	p-value	95% CI / Effect size
Normal	97	84.3		
Increased	18	15.7	0.108	OR = 1.42 (0.71–2.87)

Table 6. Crosstabulation of fatty liver grade with kidney involvement (N = 115)

Kidney involvement	No fatty liver	Grade 1	Grade 2	Grade 3	p-value	χ^2 (df)
Right only (n=39)	16	12	11	0		
Left only (n=41)	16	13	9	3		
Bilateral (n=35)	10	15	7	3	0.473	2.49(6)

Table 7. Crosstabulation of number of stones and fatty liver grade (N = 115)

Stones (n)	No fatty liver	Grade 1	Grade 2	Grade 3	p-value	χ^2 (df)
1	19	17	7	1		
2	8	10	9	1		
3	3	5	4	1		
4	9	7	3	2		
5	3	1	4	1	0.554	3.02(9)

Analysis of fatty liver distribution across stone number showed that among those with a single stone, 43.2% (n=19) had no fatty liver and 38.6% (n=17) had Grade 1. Patients with two stones had slightly more advanced fatty liver, with 35.7% (n=10) in Grade 1 and 32.1% (n=9) in Grade 2. In those with three stones, fatty liver was present in 76.9% (n=10), while among patients with four stones, higher proportions of Grade 2 and 3 were noted. Nonetheless, no statistically significant correlation was found between stone number and fatty liver grade (p=0.554).

Overall, while fatty liver prevalence was high and calculi burden varied, statistical testing consistently demonstrated no significant association between the presence, laterality, or number of renal calculi and the severity of hepatic steatosis. This suggests that although both conditions co-occur frequently in this population, their coexistence may reflect shared metabolic risk factors rather than a direct pathological correlation.

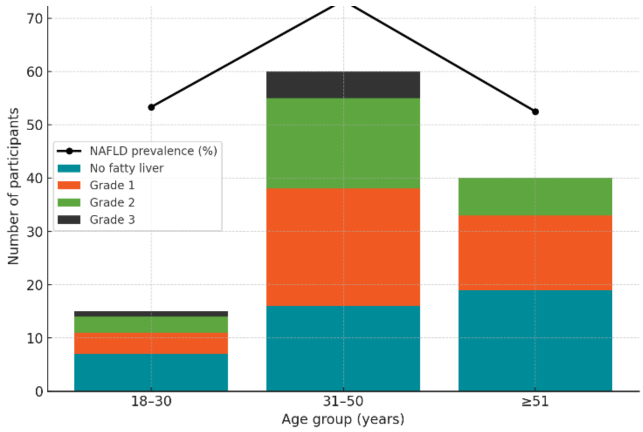

Figure 1 Distribution of Fatty Liver Grades Across Age Groups with NAFLD Prevalence Trend

The visualization demonstrates the distribution of fatty liver grades across age groups, with an overlaid trend line showing overall NAFLD prevalence. In participants aged 18–30, NAFLD was detected in 53.3% (8/15), with Grade 1 predominating. Prevalence rose markedly in the 31–50 group, where 73.3% (44/60) were affected, including higher proportions of Grade 2 steatosis. In those aged ≥51 years, prevalence remained high at 52.5% (21/40), though Grade 3 disease was not observed. The integrated line reveals a peak prevalence in the midlife group, highlighting age as a significant correlate of hepatic steatosis burden in this population. This age-related pattern underscores the role of metabolic risk accumulation in the 31–50 range, coinciding with the highest clustering of renal calculi.

DISCUSSION

The present study investigated the potential correlation between renal calculi and non-alcoholic fatty liver disease (NAFLD) using ultrasonography in a South Asian population. The findings demonstrated that while the prevalence of NAFLD was high, affecting 61.7% of participants, there was no statistically significant association between the presence, laterality, or number of renal calculi and the severity of fatty liver. These results indicate that the coexistence of the two conditions is likely driven by shared metabolic risk factors rather than a direct pathological influence of renal calculi on hepatic steatosis (16).

The observed age-related distribution strengthens this interpretation. The prevalence of NAFLD peaked in individuals aged 31–50 years, with more than 70% demonstrating sonographic features of fatty infiltration, while prevalence declined modestly in those above 50 years. This midlife clustering coincides with the recognized trajectory of metabolic syndrome, obesity, and insulin resistance, which are known to accelerate both hepatic steatosis and urolithiasis (17). Our visualization analysis further highlighted that Grades 2 and 3 NAFLD were more concentrated in the midlife group, supporting the notion that cumulative metabolic burden during this stage of life may underlie disease overlap rather than calculi burden per se.

The lack of correlation between calculi number or anatomical distribution and fatty liver grade in this study contrasts with some CT-based investigations that reported significant associations. For example, Musso et al. found that patients with NAFLD had a higher risk of nephrolithiasis, suggesting systemic metabolic dysfunction as a unifying factor (18). Similarly, Kwak et al. in a Korean cohort demonstrated a strong association between NAFLD and kidney stones in men (19). However, both of these studies considered NAFLD as the exposure and nephrolithiasis as the outcome, whereas the current study examined the reverse relationship, assessing whether renal calculi are predictive of hepatic steatosis. Our findings suggest that renal stones do not act as an independent risk factor for NAFLD development, consistent with more recent ultrasonography-based data by Demir et al., which also reported no significant association (20).

Several possible explanations may account for the null correlation observed in this study. First, while renal calculi and NAFLD share common etiological pathways such as oxidative stress, dyslipidemia, and insulin resistance, the manifestation of hepatic fat accumulation is multifactorial and may not be substantially influenced by renal stone formation alone. Second, ultrasonography, though widely accessible and highly specific for both conditions, may underestimate the presence of small stones or early-stage fatty infiltration compared with more sensitive modalities such as non-contrast CT or magnetic resonance imaging. This limitation may have led to under-detection of milder disease forms, thereby diluting potential associations (21). Third, the cross-sectional design restricts causal inference; it is possible that longitudinal follow-up would reveal temporal patterns linking the two conditions more robustly.

The clinical implications of these findings are relevant to both diagnostic practice and public health. In resource-limited environments such as Pakistan, ultrasonography remains the frontline modality for evaluating abdominal pain and metabolic comorbidities. The absence of a strong correlation between renal calculi and NAFLD suggests that clinicians should interpret sonographic findings of either condition in the context of broader metabolic risk profiling, rather than assuming a direct link between the two. This underscores the importance of comprehensive risk factor management—including weight reduction, dietary modification, and metabolic screening—rather than relying on the incidental coexistence of calculi and steatosis as surrogate markers.

Our results should be interpreted in light of study limitations. The relatively small sample size and single-center design may limit generalizability, particularly in a country with diverse dietary and socioeconomic backgrounds. Non-probability sampling may have introduced selection bias, and potential confounders such as body mass index, glycemic control, and lipid profiles were not assessed, which might have provided deeper mechanistic insights. Nevertheless, the study contributes novel data by focusing on ultrasonography as a dual-assessment tool for hepatic and renal pathology in a South Asian population, filling an important gap in existing literature.

In summary, this study provides evidence that renal calculi, when detected by ultrasonography, do not exhibit a significant correlation with NAFLD. Instead, both conditions appear to cluster within the same patients due to overlapping metabolic risk factors, particularly in the midlife age group. Future research should incorporate larger, multicenter cohorts with biochemical profiling and advanced imaging modalities to further delineate these relationships and clarify whether subgroups at heightened metabolic risk may show stronger associations over time (22).

CONCLUSION

In this cross-sectional study of 115 patients undergoing ultrasonography for renal calculi, non-alcoholic fatty liver disease was detected in more than half of participants, with the highest prevalence among adults aged 31–50 years. Despite this substantial overlap, no statistically significant association was observed between the presence, laterality, or number of renal stones and the grade of hepatic steatosis. These findings suggest that while both conditions share common metabolic risk factors and frequently coexist, renal calculi are not an independent predictor of fatty liver disease. The results highlight the need for clinicians to evaluate each condition in the context of systemic metabolic health rather than as direct surrogates of one another. Larger, multicenter, and longitudinal studies with advanced imaging and biochemical profiling are warranted to confirm these observations and better understand the shared metabolic pathways linking hepatic and renal pathology.

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