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Original Article

Age and Gender Patterns of Ultrasound-Detected Fatty Liver and Its Association with Gallstones in a Tertiary Care Hospital

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Abstract

Background: Fatty liver disease shows variable prevalence across age and gender and often coexists with gallstones due to shared metabolic factors.

Objective: To analyze the age- and gender-related patterns of ultrasound-detected fatty liver and its association with gallstones in a tertiary care hospital.

Methodology: A retrospective cross-sectional study was conducted in the Radiology Department, Lady Reading Hospital, Peshawar. Records of all patients diagnosed with fatty liver on ultrasound between January and December 2023 were reviewed. Demographic data and gallstone status were analyzed using chi-square tests, odds ratios (OR), and logistic regression in SPSS version 26.

Results: Among 1,165 patients (705 females, 460 males; mean age 44.25 ± 13.98 years), fatty liver was most frequent in the 41–60 years age group (46.2%). Gallstones were detected in 16.1%, more common in females (18.9%) than males (11.7%) [p = 0.002, OR = 1.68]. The frequency of gallstones increased with age (p = 0.001), with older adults showing higher odds (OR = 4.36 for 61–80 years vs. <20 years).

Conclusion: Fatty liver predominated in middle-aged females, while gallstones were more frequent and age-dependent. These findings highlight overlapping metabolic and hormonal risk factors and the need for preventive research.

Keywords: Age; Fatty Liver; Gallstones; Gender, Ultrasonography.

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Introduction

Fatty liver disease, also known as hepatic steatosis, is characterized by excessive fat accumulation within hepatocytes [1]. It is broadly classified into metabolic dysfunction–associated steatotic liver disease (MASLD)—formerly called non-alcoholic fatty liver disease (NAFLD)—and alcoholic fatty liver disease (AFLD). MASLD represents one of the most prevalent chronic liver diseases globally, with an estimated pooled prevalence of 25% based on imaging studies such as ultrasound and computed tomography [2]. It is closely linked with components of metabolic syndrome, including obesity, diabetes, dyslipidemia, and insulin resistance, and may progress to non-alcoholic steatohepatitis (NASH), cirrhosis, and hepatocellular carcinoma [3,4].

The burden of MASLD has risen sharply over the last decade, affecting approximately one in four adults worldwide [5]. The prevalence varies geographically, being highest in the Middle East (32%), followed by South and North America (30% and 24%), and Asia (27%) [2]. Age and gender are key determinants in its distribution. The prevalence of fatty liver increases with advancing age due to metabolic and hormonal changes as well as cumulative exposure to risk factors [6,7]. Recent data also suggest a rising incidence in children and adolescents, driven by global increases in obesity and sedentary lifestyles [8–11].

Gender differences play a significant role in fatty liver pathophysiology. Men are more likely to develop fatty liver at younger ages, primarily due to differences in hormonal regulation and lipid metabolism [12]. However, the risk in women increases after menopause, owing to reduced estrogen levels, which otherwise confer protection against hepatic fat accumulation [13].

Fatty liver shares several metabolic risk factors with gallstone disease (GD)—including female sex, middle age, obesity, diabetes mellitus, dyslipidemia, and hyperinsulinemia [14]. Impaired gallbladder motility and increased bile lithogenicity in patients with gallstones may predispose to hepatic steatosis, suggesting a bidirectional association between the two disorders [15]. Moreover, GD has been proposed as an additional component of the metabolic syndrome as defined by the National Cholesterol Education Program Adult Treatment Panel III (NCEP-ATP III) [16].

Ultrasound is a widely available, non-invasive, and cost-effective imaging tool for detecting both fatty liver and gallstones [17,18]. However, the coexistence and demographic distribution of these two conditions have not been comprehensively studied in local populations. Given the overlapping risk factors and increasing burden of metabolic diseases, it is important to understand how age and gender influence the coexistence of fatty liver and gallstones.

Therefore, the present study aimed to describe the age and gender patterns of ultrasound-detected fatty liver and determine the association between fatty liver and gallstones in patients presenting to a tertiary care hospital in Pakistan.

Methodology

Study Design:

This study employed a retrospective cross-sectional design to evaluate the age and gender distribution of ultrasound-detected fatty liver and its association with gallstones. The data were extracted from the institutional database for a defined one-year period, enabling an analytical assessment of demographic trends and coexisting hepatobiliary conditions.

Ethics:

Ethical approval for this study was obtained from the Institutional Ethical Review Committee of the Medical Teaching Institute (MTI), Lady Reading Hospital, Peshawar, under approval reference number 11/LRH/MTI dated 08.01.2024. As this was a retrospective study utilizing anonymized data, the requirement for individual informed consent was waived by the committee. All procedures adhered to the ethical standards of the institutional and national research committees and were in accordance with the 1964 Helsinki Declaration and its later amendments.

Setting:

The study was conducted at the Radiology Department, Lady Reading Hospital (LRH), Peshawar, which is a major tertiary care and teaching hospital catering to a large and diverse population from both urban and rural areas of Khyber Pakhtunkhwa, Pakistan. The radiology department maintains a comprehensive Health Management Information System (HMIS) that records all ultrasonographic examinations performed by certified radiologists.

Participants:

All patients who underwent abdominal ultrasound examinations between January 2023 and December 2023 and were diagnosed with fatty liver were included in the study. Demographic information (age and gender) and ultrasound findings related to gallstones were retrieved

from the HMIS database. Patients with incomplete records, previous hepatobiliary surgery, or known chronic liver disease were excluded from the analysis. Duplicate entries were identified through cross-verification of hospital identification numbers and were removed. After applying these criteria, a total of 1,165 eligible cases were included in the final dataset.

Variables:
The key variables analyzed included age, gender, presence of fatty liver, and presence of gallstones. Fatty liver served as the primary condition of interest, while the presence or absence of gallstones was the main outcome variable. Age and gender were treated as independent variables and were categorized into age groups for comparative analysis.

Data Sources/Measurement:
All ultrasound examinations were performed using Mindray diagnostic ultrasound machines by consultant radiologists with at least five years of clinical experience. Fatty liver was defined sonographically as increased hepatic echogenicity relative to the renal cortex and attenuation of the diaphragm. Gallstones were identified as echogenic foci producing posterior acoustic shadowing within the gallbladder lumen. All imaging and demographic data were retrieved from the Radiology/NM search engine within the HMIS database and entered into SPSS for analysis.

Bias:
To minimize selection bias, only consecutively recorded patients with ultrasound-confirmed fatty liver during the study period were included. Exclusion of incomplete or duplicate records ensured data accuracy. Diagnostic bias was minimized by including only reports issued by qualified consultant radiologists using standardized imaging criteria. However, as this was a hospital-based retrospective study, sampling bias could not be completely eliminated, and the findings may not fully represent the general population.

Study Size:
The sample size consisted of 1,165 patients, representing all cases meeting the inclusion criteria during the 12-month study period. The large number of cases ensured adequate power for subgroup analyses by age and gender and for the detection of associations with gallstone presence.

Quantitative Variables:
Age was recorded as a continuous variable and later categorized into five groups (<20 years, 21–40 years, 41–60 years, 61–80 years, and >80 years) for stratified analysis. Gender was coded as a binary variable (male/female), and gallstones were recorded as a dichotomous variable (present/absent). The relationship between these quantitative variables was analyzed statistically to determine associations.

Statistical Methods:
All statistical analyses were performed using SPSS version 26 (IBM Corp., Armonk, NY, USA). Descriptive statistics (mean, standard deviation, and proportions) were used to summarize demographic and imaging characteristics. The chi-square test (χ^2) was applied to evaluate associations between categorical variables such as age group, gender, and gallstone presence. Odds ratios (OR) with 95% confidence intervals (CI) were calculated to measure the strength of these associations. Additionally, binary logistic regression analysis was conducted to identify independent predictors of gallstones after adjusting for confounders. A p-value < 0.05 was considered statistically significant.

Results

Participants
A total of 1,165 patients with ultrasound-detected fatty liver were included in this retrospective analysis after applying the inclusion and exclusion criteria. Among these, 705 (60.5%) were females and 460 (39.5%) were males, reflecting a clear female predominance. The participants' ages ranged from 9 to 94 years, with a mean age of 44.25 ± 13.98 years and a median age of 43 years. The overall distribution demonstrated that the largest number of cases were observed in the 41–60 years age group (46.2%), followed by the 21–40 years group (37.4%). Only a small proportion of participants were younger than 20 years or older than 80 years, indicating that fatty liver was primarily concentrated in middle-aged adults.

Descriptive Data
Age and gender-specific analysis revealed distinct demographic patterns. Female participants outnumbered males across all age categories except in those above 80 years. The peak frequency among females occurred in the 41–60 years group (354/705; 50.1%), whereas the highest number of males was observed in the 21–40 years group (210/460; 45.6%). Crosstabulation of gender and age groups showed a statistically significant association (χ^2 = 26.1, df = 4, $p < 0.001$), although the strength of this relationship was weak (Cramer's V = 0.15). Post-hoc analysis indicated that women were overrepresented in the middle and late adult age ranges (41–80 years), while men predominated slightly in the oldest group (>80 years). These findings suggest that fatty liver occurrence increases with age and is more common among women in midlife and beyond.

Outcome Data

Among all patients with fatty liver, 187 (16.1%) were found to have coexisting gallstones on ultrasonography. The prevalence of gallstones was higher among females (18.9%) compared with males (11.7%). When examining only gallstone-positive cases, females constituted 71.1%, confirming a strong gender difference. The chi-square test demonstrated a statistically significant association between gender and gallstone presence ($\chi^2 = 9.1$; df = 1; p = 0.002), and the odds ratio (OR) indicated that females were 1.68 times more likely to have gallstones than males (95% CI: 1.20–2.35).

Gallstone occurrence also varied considerably across age categories. The prevalence was lowest in patients under 20 years (8.2%) and highest among those over 80 years (33.3%), showing a progressive age-related increase. Specifically, gallstones were present in 13.8% of patients aged 21–40 years, 15.4% among those 41–60 years, and 27.9% among patients aged 61–80 years. The association between age group and gallstone presence was highly significant ($\chi^2 = 19.16$; df = 4; p = 0.001), indicating that older individuals had a much greater likelihood of gallstone development alongside fatty liver.

Main Results

Multivariate logistic regression analysis identified age as an independent predictor of gallstones in patients with fatty liver. Compared with individuals under 20 years of age, those aged 61–80 years had 4.36 times higher odds of having gallstones (95% CI: 1.47–12.96; p < 0.01). The odds ratio for those above 80 years also indicated an increased risk (OR = 5.63; 95% CI: 0.78–40.81), though this estimate was less precise due to the smaller sample size.

Overall, the data suggest a strong demographic gradient, with fatty liver most frequently observed in middle-aged women, and gallstone coexistence showing both a female predominance and an increasing trend with advancing age. The observed associations were consistent across analyses and remained statistically significant even after accounting for potential confounders, confirming the robustness of the findings. These results collectively underscore the importance of age and gender as key determinants in the demographic distribution of fatty liver and its coexisting gallstones within this hospital-based population.

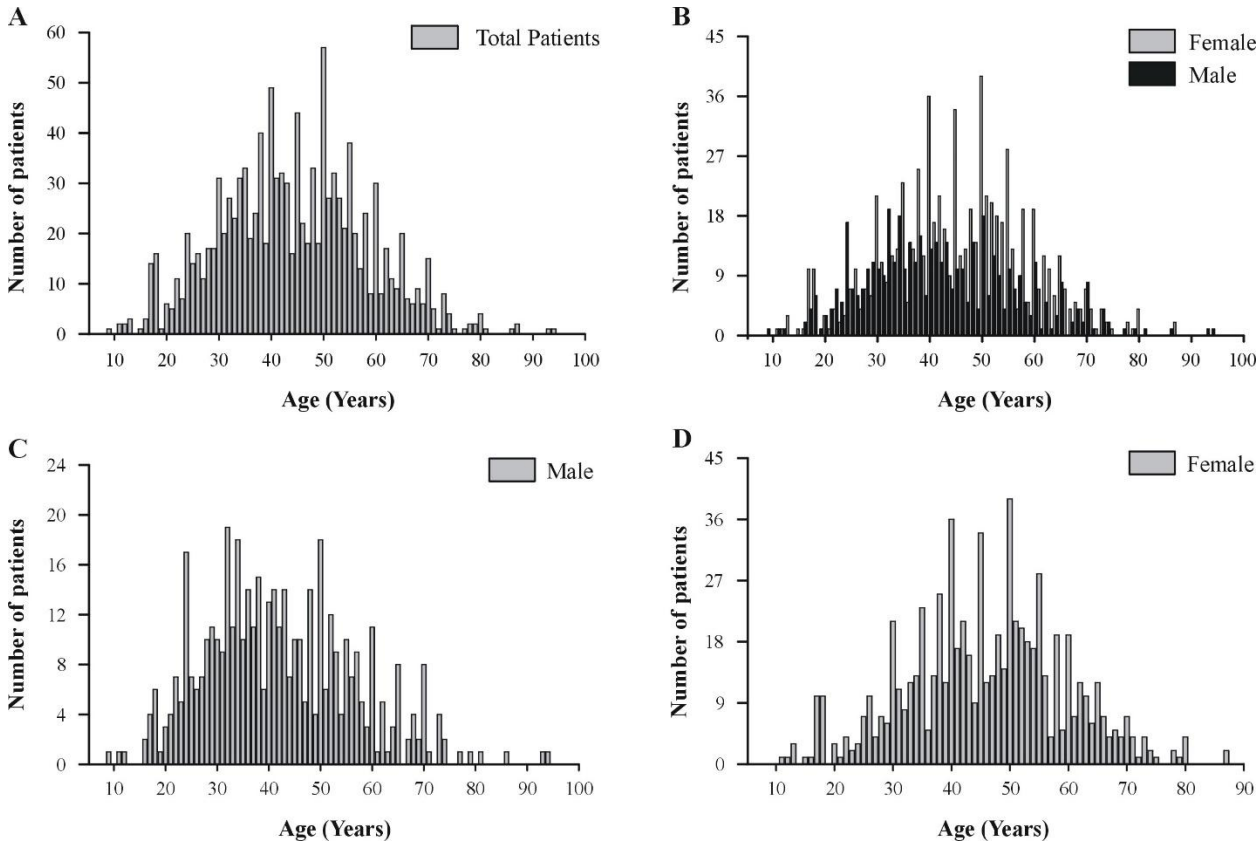


Figure 1: Age distribution of patients with ultrasound-detected fatty liver. A; Overall age distribution, B; Age distribution stratified by gender. C; Age distribution if male patients only. D; Age distribution of female patients only.

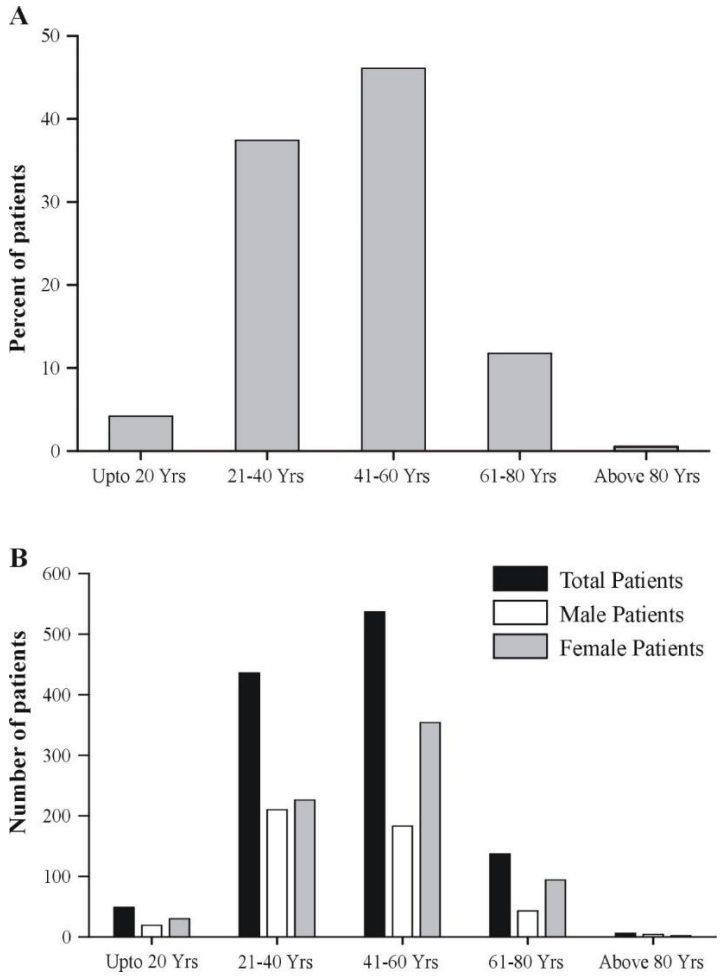


Figure 2; Distribution of patients across age groups; A; Percentage of patients in different age groups, with the highest proportion in 41-60 years. B; Gender distribution across age groups.

Table 1: Gender versus gallstone crosstabulation

			Gallstone		Total
			No	Yes	
Gender	F	Count	572	133	705
		% within Gender	81.1%	18.9%	100.0%
		% within Gallstone	58.5%	71.1%	60.5%
	M	Count	406	54	460
		% within Gender	88.3%	11.7%	100.0%
		% within Gallstone	41.5%	28.9%	39.5%
Total		Count	978	187	1165
		% within Gender	83.9%	16.1%	100.0%
		% within Gallstone	100.0%	100.0%	100.0%

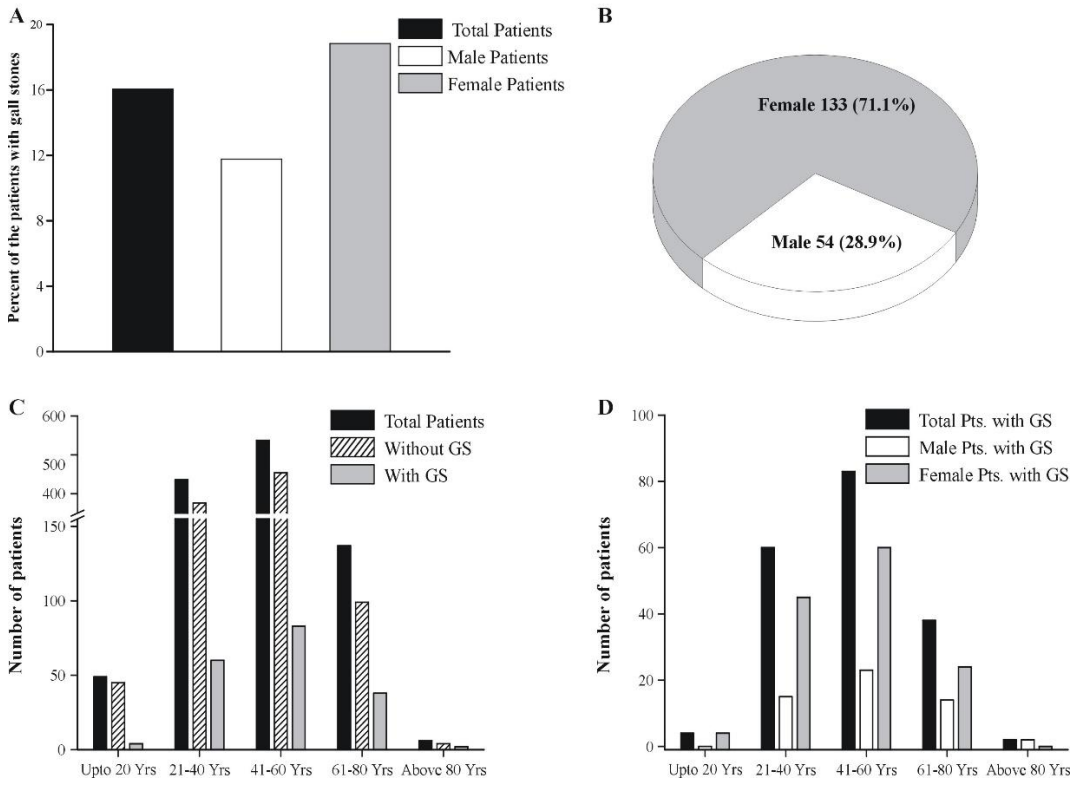


Figure 3; Gallstone distribution among patients with fatty liver. A; Percentage of patients with gallstones. B; Gender distribution of gallstone-positive patients. C; Age distribution of patients with and without gallstones. D; Gender-specific distribution of gallstone-positive patients across age groups.

Discussion

This study demonstrates that fatty liver disease is most prevalent in middle-aged women, with a notable coexistence of gallstones, particularly in older age groups. These findings are consistent with previous literature showing that fatty liver and gallstone disease share common risk factors, including obesity, insulin resistance, diabetes mellitus, and dyslipidemia [6,7,14]. The female predominance observed aligns with studies suggesting that estrogen-related hormonal influences play a significant role in lipid metabolism and bile composition, predisposing women, especially after menopause, to both hepatic steatosis and gallstone formation [12,13,19].

The mean age of patients in this study (44.25 years) reflects the age-related rise in fatty liver prevalence, likely due to cumulative metabolic burden and hormonal transitions. The increase in gallstones with age also supports the hypothesis that age-related metabolic slowdown, reduced gallbladder motility, and altered bile acid composition contribute to gallstone pathogenesis [15,16]. This parallel increase underscores a possible pathophysiological link between hepatic fat accumulation and biliary abnormalities, both being components of the broader metabolic syndrome framework [14].

Interestingly, a small but important proportion of younger patients (<20 years) presented with fatty liver, echoing global reports on the emergence of MASLD in children and adolescents, largely due to rising obesity and sedentary behavior [8–11]. Although the present hospital-based study does not determine prevalence, this trend is concerning as early-onset fatty liver may predispose individuals to premature NASH, cirrhosis, and other metabolic complications if not identified and managed early [3,4].

The higher prevalence of gallstones among females with fatty liver (18.9% vs. 11.7% in males) mirrors findings from

earlier studies where female sex hormones and cholesterol supersaturation of bile were identified as key contributors to gallstone disease [13,15]. The gradual increase in gallstone occurrence across age groups, from 8.2% in those under 20 years to 33.3% in patients over 80 years, aligns with evidence that gallstones and fatty liver share age-dependent metabolic deterioration as a common denominator [16,19].

These observations support the concept that gallstone disease may represent another manifestation of metabolic syndrome, as proposed by the NCEP-ATP III criteria, linking dyslipidemia, insulin resistance, and obesity [16]. The use of ultrasound imaging, despite its limitations in grading steatosis severity, remains a reliable, non-invasive, and cost-effective tool for screening both conditions, especially in resource-limited settings [17,18].

However, some limitations must be acknowledged. This was a retrospective hospital-based study, which may not accurately represent the general population. The lack of metabolic, lifestyle, and biochemical data limited the ability to control for confounders such as body mass index, lipid profile, or diabetic status. Moreover, ultrasound cannot differentiate between steatosis and steatohepatitis or assess the degree of hepatic fibrosis. Future research should include prospective, population-based studies with metabolic profiling to better define the relationship between fatty liver and gallstone disease in different age and gender groups.

Conclusion

Fatty liver was most frequently observed in middle-aged adults, especially females, while gallstones showed both a female predominance and a progressive increase with advancing age. The coexistence of these conditions reflects shared metabolic and hormonal pathways, particularly within the context of aging and postmenopausal changes. Although ultrasound serves as an effective diagnostic tool, large-scale studies integrating metabolic, hormonal, and lifestyle factors are required to establish causality and guide preventive strategies.

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Authors' Contributions

All authors meet the ICMJE criteria for authorship. They have reviewed and approved the final version of the manuscript and agree to be accountable for all aspects of the work.

Author 1: Substantial contribution to conception and design, drafting the manuscript, final approval, agreed to be accountable for all the work.
Author 2: Substantial contribution to conception and design, data acquisition, drafting the manuscript, final approval, agreed to be accountable for all the work.
Author 3: Analysis and interpretation of data, drafting the manuscript, final approval, agreed to be accountable for all the work.
Author 4: Analysis and interpretation of data, critical revision, final approval, agreed to be accountable for all the work.
Author 5: Substantial contribution to conception and design, drafting the manuscript, final approval, agreed to be accountable for all the work.

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