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FREQUENCY OF FATTY LIVER DETECTED ON ULTRASONOGRAPHY IN PATIENTS PRESENTING TO MMC MARDAN

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Abstract

Fatty liver is a common liver condition, often incidentally diagnosed by ultrasonography. It is strongly linked with metabolic risk factors, such as obesity, diabetes, and hypertension, and has emerged as a significant public health issue.

Aim: To establish the prevalence of fatty liver detected on ultrasonography among patients presenting to MMC Mardan, and to investigate its associations with a number of demographic, clinical and sonographic factors.

Methodology: In this cross-sectional study, 382 patients who presented at MMC Mardan and had abdominal ultrasound were evaluated. Information was recorded regarding age, gender, height, weight, body mass index (BMI), diabetes, hypertension, dyslipidemia, use of hepatotoxic drugs, liver size, echogenicity, grade of fatty liver, and hepatomegaly. Body mass index (BMI) was calculated based on the height and weight. The data were presented in frequencies and percentages, and cross tabulation was done to find the association of fatty liver with different variables. Chi-square test was used and p-value of ≤0.05 was taken as statistically significant.

Results: A total of 107 (28.0%) patients had fatty liver on ultrasound and 275 (72.0%) did not have fatty liver. Of the 107 patients with fatty liver, 91 (23.8%) had Grade I and 16 (4.2%) had Grade II, but none had Grade III. Females were 55.5% and males 44.5% of the total patients. The majority of them were between 21-40 years (47.6%). Most patients were overweight (41.9%) or obese (30.6%) according to BMI. The prevalence of fatty liver was higher in males (32.4%) compared to females (24.5%), but was not significant (p = 0.115). Fatty liver was not significantly associated with age group (p = 0.057). But BMI category was significantly associated (p = 0.006), with an increase in frequency from 15.4% in normal weight to 35.0% in obese patients. Diabetes

(71.7% vs 22.0%, p < 0.001), hypertension (58.8% vs 21.3%, p < 0.001), hepatomegaly (85.2% vs 23.7%, p < 0.001), enlarged liver size (85.2% vs 23.9%, p < 0.001), and increased echogenicity (98.1% vs 0.4%, p < 0.001) were all significantly associated with fatty liver.

Conclusion: Fatty liver was frequently detected by ultrasonography in patients at MMC Mardan with an overall prevalence of 28.0%. It was significantly found to be associated with higher BMI, diabetes, hypertension, hepatomegaly, enlarged liver size and high echogenicity. Early diagnosis by ultrasound and prompt intervention to address metabolic risk factors may help minimise disease burden and progression to severe liver disease.

INTRODUCTION

Fatty liver disease is a common hepatic disease encountered in clinical practice and has become a major health issue globally. It refers to the accumulation of fat (mostly triglycerides) in hepatocytes and is classified into alcoholic fatty liver disease and non-alcoholic fatty liver disease based on the cause. Recently, non-alcoholic fatty liver disease has attracted more attention due to its close links with obesity, diabetes, hyperlipidemia, and metabolic syndrome, which are all on the rise in developed as well as developing nations. (1)

Non-alcoholic fatty liver disease is now recognised as the hepatic component of metabolic syndrome and represents a spectrum from simple steatosis to non-alcoholic steatohepatitis, fibrosis, cirrhosis and, in some cases, hepatocellular carcinoma. While simple steatosis is usually considered to be benign, growing evidence indicates that the condition may silently progress and play an important role in liver disease morbidity and mortality. Moreover, fatty liver is not only a hepatic disease, but also it can lead to cardiovascular disease and metabolic dysfunction. (2)

The incidence of fatty liver disease has been rapidly increasing worldwide over the past few decades as a result of a sedentary lifestyle, unhealthy dietary habits, and the epidemic of obesity and type 2 diabetes. The frequency of fatty liver varies between population studies, depending on ethnicity, age, gender, diagnostic criteria and study design. The prevalence of fatty liver seems to be rising rapidly in many Asian populations, including South Asians, even in those with lower body mass index (BMI) compared to the West. (3)

The prevalence of fatty liver disease in Pakistan is likely to be high owing to a high prevalence of obesity, diabetes mellitus, hypertension **and dyslipidemia in the community. This rise is due to urbanization,** sedentary lifestyle, and a shift to a high-calorie diet. Although this is a burgeoning issue, there is a dearth of local hospital-based data, especially from smaller cities and district-based tertiary care hospitals. Thus, it is important to assess the prevalence of fatty liver in various clinical settings to understand the true burden of disease, and to plan screening and prevention measures. (4)

Fatty liver disease is often silent and may go unnoticed for many years. It is often asymptomatic, or patients present with non-specific symptoms, including fatigue, pain in the right upper quadrant of the abdomen or dyspepsia, or it is found incidentally during work-up for other disease. Biochemical evidence of mild to moderate elevations of liver enzymes may be present but these are not sensitive or specific. Therefore, imaging is crucial in the diagnosis of hepatic steatosis, particularly in clinical practice. (5)

Of the various imaging techniques ultrasonography is the most commonly used first-line imaging technique for the detection of fatty liver because it is non-invasive, cost-effective, safe, readily accessible, and does not involve exposure to ionizing radiation. This is particularly beneficial in areas where access to more sophisticated imaging modalities like CT, MRI, or liver biopsy may not be available for large-scale screening or routine evaluation. Ultrasonography identifies fatty liver based on the presence of increased echogenicity, blurring of the hepatic vessels, and increased attenuation of the ultrasound beam. (6)

While liver biopsy remains the definitive diagnostic and staging test for fatty liver disease, it is invasive, expensive and prone to procedure-related complications, and is generally not suitable for large-scale screening. Likewise, although MRI-based methods may offer better quantification of liver fat, their cost and availability limit their widespread use in many public hospitals. As a result, the use of ultrasonography remains the convenient and preferred means of detecting fatty liver in clinical practice, particularly in ambulatory and hospitalised patients. (7)

Sensitivity and specificity of ultrasonography for moderate to severe fatty liver in the literature are relatively high, suggesting it can be a useful diagnostic tool for epidemiological research and hospital-based prevalence surveys. But it may not perform as well in all situations, depending on the skill of the sonographer, the body shape of the patient and the severity of hepatic steatosis. Despite the potential shortcomings, ultrasonography is an accepted and valid technique for determining the prevalence of fatty liver disease in symptomatic and asymptomatic individuals. (8)

Several factors have been found to be associated with fatty liver disease, such as age, male sex in some populations, female sex in others, obesity, central obesity, insulin resistance, diabetes, hypertension, hyperlipidemia and physical inactivity. Ketoconazole, weight loss, malnutrition and endocrinopathies have also been shown to induce steatosis. Given the co-existence of these risk factors in the community, periodic evaluation of liver function is important, particularly in patients seen in tertiary-care facilities. (9)

Early diagnosis of fatty liver is important in clinical practice as early lifestyle changes and treatment of metabolic risk factors may prevent or even reverse disease. Lifestyle modification, weight loss, dietary interventions, regular exercise, blood glucose control and treatment of dyslipidemia have all been demonstrated to improve steatosis and prevent the progression to advanced liver disease. So early diagnosis of fatty liver by a simple imaging test like an ultrasound may provide an opportunity for intervention. (10)

PROBLEM STATEMENT

Despite the high global prevalence of fatty liver disease, there is limited local data regarding its frequency among patients in pakistan particularly in Mardan. Mardan Medical Complex (MMC) receives a large number of patients undergoing abdominal ultrasonography; however, the frequency of fatty liver detected in this population has not been adequately studied or documented. The absence of local epidemiological data limits the understanding of disease burden, delays early diagnosis, and restricts the development of targeted preventive strategies. Therefore, there is a need to determine the frequency of fatty liver detected on ultrasonography among patients presenting to MMC Mardan.

RESEARCH OBJECTIVES

- To assess the proportion of patients diagnosed with fatty liver on ultrasound
- To evaluate the distribution of fatty liver among different age groups
- To analyze gender-wise frequency of fatty liver.

SIGNIFICANCE OF THE STUDY:

The burden of fatty liver disease is high globally, but there is a paucity of local data on the frequency of fatty liver in patients in pakistan, especially in Mardan. A significant number of patients undergo abdominal ultrasonography at Mardan Medical Complex (MMC) but the frequency of fatty liver among this patient population has not been well-studied or reported. The lack of epidemiological data on the frequency of fatty liver disease in this region hampers the assessment of disease burden, leads to delayed diagnosis and also hampers the development of prevention strategies. Hence, the need to establish the frequency of fatty liver detected on sonography in patients at MMC Mardan. This study will be significant because it will help determine the frequency of fatty liver among the patients who are referred for ultrasonography at MMC Mardan. This data will help health-care professionals to determine its local prevalence and facilitate its early diagnosis and treatment.

In addition, the study will:

- Help health workers establish risk factors

- Help inform prevention and educational programs
- Serve as a basis for future studies in the area
- Provide data to the national registry of fatty liver in Pakistan

MATERIALS AND METHODS

2.1 Study Design

This study was designed as a cross-sectional study to find the frequency of fatty liver on the basis of ultrasonography in patients.

2.2 Study Setting

This study was conducted in the Radiology Department of Mardan Medical Complex (MMC), Mardan, in which a high volume of abdominal ultrasound scans are performed.

2.3 Study Duration

The duration of the study was four months, 01 jan 2026 to 30 April 2026.

2.4 Sample Size

We have used EPI Info software to calculate sample size. We have included 382 patients who have had an abdominal ultrasound in the study period.
Sample size will be 382
Confidence level: 95%
Margin of error: 5%
Population proportion : 50%
Population size: 54264 (4522×12)

2.5 Sampling Technique

A non-probability convenience sampling technique was used to select patients.

2.6 Inclusion Criteria

- Patients with a request for abdominal ultrasonography
- Male and female patients
- Adults older than 18 years.
- Provide informed consent
- No chronic liver disease

2.7 Exclusion Criteria

- Known history of chronic liver disease (including cirrhosis and viral hepatitis)
- Patients with a history of alcohol abuse
- Cases of liver tumors or cancer
- When the ultrasound image was not clear
- Pregnancy (Physiology of liver)
- Use of hepatotoxic drug(methotrexate)

2.8 Data Collection Procedure

Data collection was performed after taking approval from the ASRB and ERB Boards of both institute and concerned Hospital. The patients who met the inclusion criteria were asked for consent. An experienced radiologist conducted the ultrasonography using a standard ultrasound machine. The liver was examined during sonography and its echogenicity compared to the echogenicity of the right kidney. Presence of fatty liver was determined based on ultrasound findings of increased hepatic echogenicity, poor visualization of intrahepatic vessels, and beam attenuation. If present, fatty liver disease was then graded as Grade I (mild), Grade II (moderate) or Grade III (severe). All the findings were documented on a pre-designed data collection sheet from the ultrasound reports..

Study Variables
We recorded the following for each patient
1) Age Gender Height
2) Weight BMI Hypertention
3) Liver size Dyslipidemia Hepatotoxicity
4) Echogenecity Presence or absence of fatty liver
5) Grade of fatty liver

2.9 Data Analysis
Data will be entered and analysed by Statistical Package for Social Sciences (SPSS). Descriptive statistics were calculated: Frequencies and percentages were calculated for categorical variables (gender, fatty liver) Mean and standard deviation were calculated for age groups Chi-square test will be used to determine the association between fatty liver and categorical variables (age groups and gender). P value: of <0.05 is considered statistically significant. We will then tabulate and graphically represent the data.

2.10 Ethical Considerations
The study was approved by the appropriate institutional and Hospital ASRB and ERB committees. Informed consent was obtained from all patients, who voluntarily participated in this study. The privacy of the patients was ensured and data were used only for research. Neither invasive procedures nor any risk was involved in this study.

RESULTS
Descriptive statistics of the 382 patients revealed that there were slightly more female patients in the study group, with 212 (55.5%) patients, while males numbered 170 (44.5%). The majority of patients belonged to the 21–40 years age group, comprising 182 (47.6%) cases, followed by 41–60 years with 135 (35.3%) patients, whereas only 33 (8.6%) were aged ≤20 years and 32 (8.4%) were older than 60 years. According to body mass index, the majority of the patients were overweight and obese, with 160 (41.9%) and 117 (30.6%) patients, respectively, followed by normal weight of 104 (27.2%) patients, and only 1 (0.3%) patient was underweight. A total of 46 (12.0%) patients had diabetes while the rest, 336 (88.0%) patients, did not. Likewise, 68 (17.8%) had hypertension and 314 (82.2%) were without hypertension. None of the study patients reported having dyslipidemia or a history of hepatotoxic drugs, with all 382 (100.0%) patients being assigned "No" for these variables.

Table 3.1 Distribution of frequency and percentage of demographic, obesity and clinical factors (n = 382)

Variable	Category	Frequency (n)	Percentage (%)
Gender	Male	170	44.5
	Female	212	55.5
Age group	≤20 years	33	8.6
	21–40 years	182	47.6
	41–60 years	135	35.3
	>60 years	32	8.4
BMI category	Underweight	1	0.3
	Normal	104	27.2
	Overweight	160	41.9
	Obese	117	30.6
Diabetes	Yes	46	12.0
	No	336	88.0
Hypertension	Yes	68	17.8
	No	314	82.2
Dyslipidemia	Yes	0	0.0

	No	382	100.0
Hepatotoxic drugs	Yes	0	0.0
	No	382	100.0

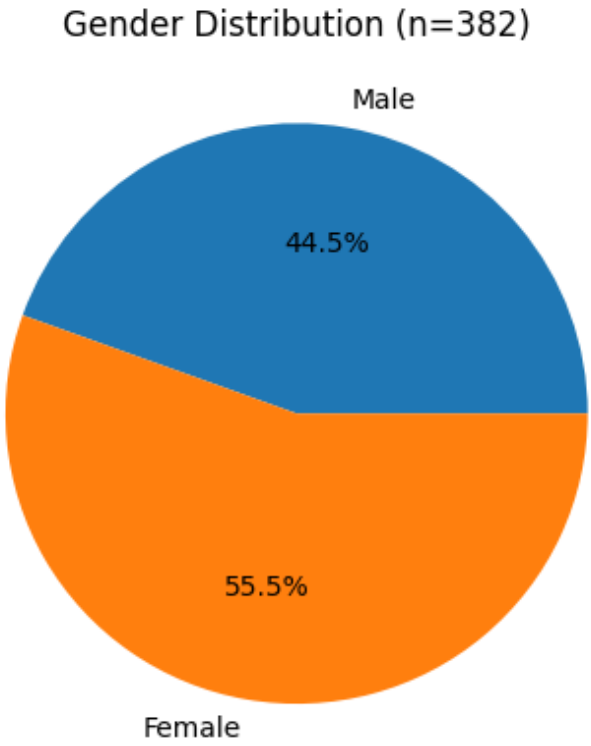


Figure 3.1. Gender Distribution

Most patients had normal liver size in 352 (92.1%) cases, with 23 (6.0%) cases having enlarged liver size and just 3 (0.8%) cases having decreased liver size. In terms of liver echogenicity, 273 (71.5%) patients were found to have normal echogenicity, while 108 (28.3%) had increased echo and 1 (0.3%) had reduced echo. Regarding the grade of fatty liver changes, most of the patients had Grade 0 (275, 72.0%) or no fatty liver, 91 (23.8%) had Grade I and 16 (4.2%) had Grade II fatty liver; no one was found to have Grade III. In terms of hepatomegaly, 27 (7.1%) had hepatomegaly and 355 (92.9%) did not.

Table 3.2 Ultrasonographic findings (n = 382)

Variable	**Category**	**Frequency (n)**	**Percentage (%)**
Liver size	Normal	352	92.1
	Enlarged	23	6.0
	Reduced	3	0.8
Echogenicity	Normal	273	71.5
	Increased	108	28.3
	Reduced	1	0.3
Fatty grade	Grade 0	275	72.0
	Grade I	91	23.8
	Grade II	16	4.2
	Grade III	0	0.0
Hepatomegaly	Yes	27	7.1
	No	355	92.9

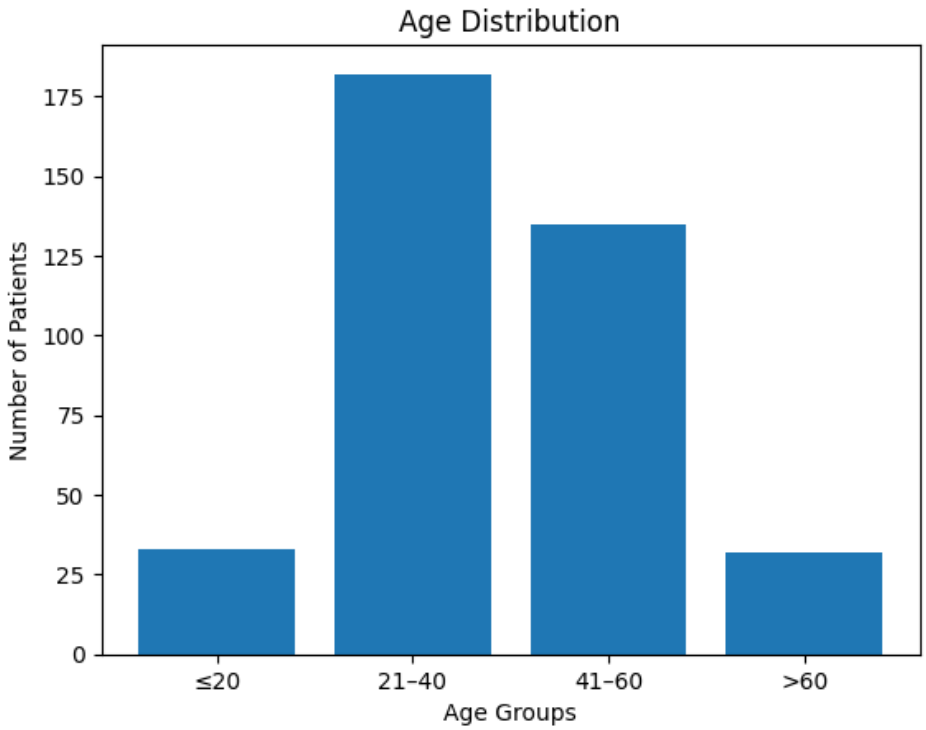


Figure 3.2. Age Distribution

These results indicate that of 382 patients, 107 (28.0%) had fatty liver on ultrasonography and 275 (72.0%) had no evidence of fatty liver. This suggests that almost one-third of the study population had fatty liver, while most patients had no fatty liver.

Table 3.3 Prevalence of fatty liver on ultrasonography (n = 382)

Finding	Frequency (n)	Percentage (%)
Fatty liver present (Grade I + Grade II + Grade III)	107	28.0
Fatty liver absent (Grade 0)	275	72.0

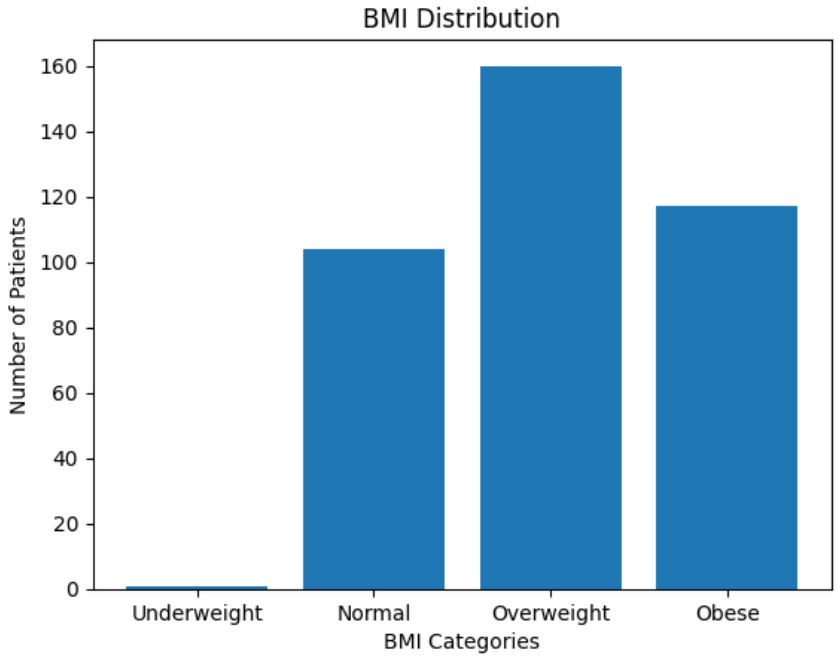


Figure 3.3 BMI Category Distribution

From the cross-tabulation, fatty liver was more prevalent in males (32.4%) than females (24.5%) although this was not statistically significant. As for age, fatty liver was the least frequent in patients aged ≤20 years (9.1%), to the highest in 21-40 years (30.8%) and 41-60 years (30.4%) patients and then in over 60 years (21.9%) patients. There was a progressive increase in prevalence in relation to BMI, as none of the underweight patients had fatty liver, and the prevalence was 15.4% in normal weight, 31.2% in overweight and 35.0% in obese patients. Fatty liver was significantly more prevalent among patients with diabetes (71.7% vs 22.0%) and hypertension (58.8% vs 21.3%) compared to those without diabetes and hypertension, respectively. Likewise, hepatomegaly was strongly associated with fatty liver, as 85.2% of patients with hepatomegaly had fatty liver, while only 23.7% of those who did not have hepatomegaly had fatty liver. The same was observed with liver size, with 85.2% of patients with increased liver size having fatty liver, while none of the patients with decreased liver size had fatty liver. The strongest association was shown with echogenicity, where 98.1% of patients with increased echogenicity had fatty liver, while only 0.4% of patients with normal echogenicity had fatty liver. Fatty liver grade also correlated with disease status, where all patients with Grade I and Grade II had the presence of fatty liver and all patients with Grade 0 had the absence of fatty liver.

Table 3.4 Cross-tabulation of different variables with fatty liver on ultrasound (n = 382)

Variable	Category	Fatty liver absent n (%)	Fatty liver present n (%)	Total (n)	Prevalence of fatty liver (%)
Gender	Male	115 (67.6)	55 (32.4)	170	32.4
	Female	160 (75.5)	52 (24.5)	212	24.5
Age group	≤20 years	30 (90.9)	3 (9.1)	33	9.1
	21–40 years	126 (69.2)	56 (30.8)	182	30.8
	41–60 years	94 (69.6)	41 (30.4)	135	30.4
	>60 years	25 (78.1)	7 (21.9)	32	21.9
BMI category	Underweight	1 (100.0)	0 (0.0)	1	0.0
	Normal	88 (84.6)	16 (15.4)	104	15.4
	Overweight	110 (68.8)	50 (31.2)	160	31.2
	Obese	76 (65.0)	41 (35.0)	117	35.0
Diabetes	Yes	13 (28.3)	33 (71.7)	46	71.7
	No	262 (78.0)	74 (22.0)	336	22.0
Hypertension	Yes	28 (41.2)	40 (58.8)	68	58.8
	No	247 (78.7)	67 (21.3)	314	21.3
Hepatomegaly	Yes	4 (14.8)	23 (85.2)	27	85.2
	No	271 (76.3)	84 (23.7)	355	23.7
Liver size	Enlarged	4 (14.8)	23 (85.2)	27	85.2
	Normal	268 (76.1)	84 (23.9)	352	23.9
	Reduced	3 (100.0)	0 (0.0)	3	0.0
Echogenicity	Increased	2 (1.9)	106 (98.1)	108	98.1
	Normal	272 (99.6)	1 (0.4)	273	0.4
	Reduced	1 (100.0)	0 (0.0)	1	0.0
Fatty liver grade	Grade 0	275 (100.0)	0 (0.0)	275	0.0
	Grade I	0 (0.0)	91 (100.0)	91	100.0
	Grade II	0 (0.0)	16 (100.0)	16	100.0
	Grade III	0 (0.0)	0 (0.0)	0	0.0

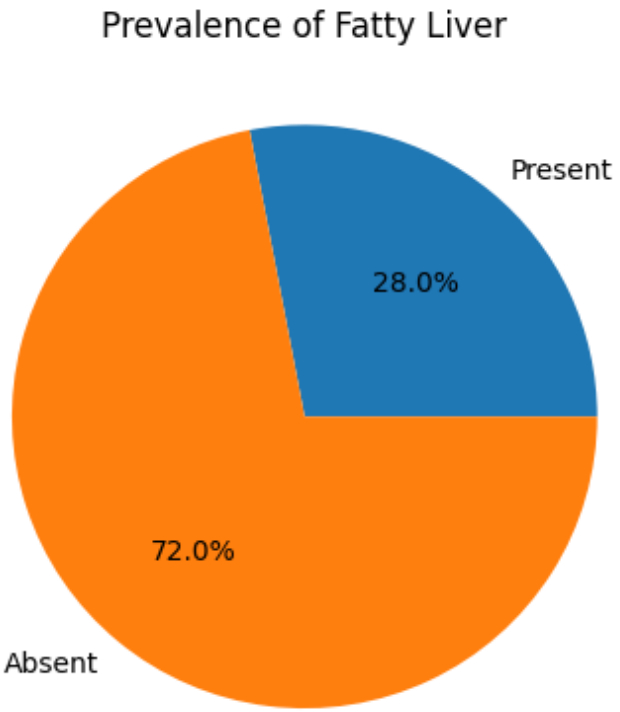


Figure 3.4. Prevalence of fatty liver

Cross-tabulation revealed that fatty liver was more frequent in males than females at rates of 32.4% and 24.5% respectively, but this was not significant ($p = 0.115$). There was no significant association between age group and fatty liver ($p = 0.057$), although prevalence was highest in patients 21-40 (30.8%) and 41-60 (30.4%) years and lowest in those ≤20 years old (9.1%). However, BMI category was significantly associated with fatty liver ($p = 0.006$), with a progressive increase from 15.4% of normal weight patients to 31.2% of overweight and 35.0% of obese patients. There was also a highly significant association between diabetes and fatty liver, with 71.7% of diabetics and 22.0% of non-diabetics having fatty liver ($p < 0.001$). Similarly, hypertension was also highly significantly associated with fatty liver: 58.8% of patients with hypertension had fatty liver compared with 21.3% of those without hypertension ($p < 0.001$). Similarly, hepatomegaly was significantly associated with fatty liver as 85.2% of patients with hepatomegaly had fatty liver while 23.7% of those without hepatomegaly had fatty liver ($p < 0.001$). There was also a significant association with liver size, with 85.2% of patients with increased liver size having fatty liver, while 0% of patients with decreased liver size had fatty liver ($p < 0.001$). The highest level of association was observed for echogenicity, with 98.1% of patients with increased echogenicity having fatty liver compared with 0.4% of those with normal echogenicity ($p < 0.001$).

Table 3.5 Cross-tabulation of fatty liver with study variables (n = 382)

Variable	Category	Fatty liver absent n (%)	Fatty liver present n (%)	Total	p-value
Gender	Male	115 (67.6)	55 (32.4)	170	0.115
	Female	160 (75.5)	52 (24.5)	212	
Age group	≤20 years	30 (90.9)	3 (9.1)	33	0.057
	21–40 years	126 (69.2)	56 (30.8)	182	
	41–60 years	94 (69.6)	41 (30.4)	135	
	>60 years	25 (78.1)	7 (21.9)	32	
BMI category	Underweight	1 (100.0)	0 (0.0)	1	0.006
	Normal	88 (84.6)	16 (15.4)	104	

	Overweight	110 (68.8)	50 (31.2)	160	
	Obese	76 (65.0)	41 (35.0)	117	
Diabetes	Yes	13 (28.3)	33 (71.7)	46	<0.001
	No	262 (78.0)	74 (22.0)	336	
Hypertension	Yes	28 (41.2)	40 (58.8)	68	<0.001
	No	247 (78.7)	67 (21.3)	314	
Hepatomegaly	Yes	4 (14.8)	23 (85.2)	27	<0.001
	No	271 (76.3)	84 (23.7)	355	
Liver size	Enlarged	4 (14.8)	23 (85.2)	27	<0.001
	Normal	268 (76.1)	84 (23.9)	352	
	Reduced	3 (100.0)	0 (0.0)	3	
Echogenicity	Increased	2 (1.9)	106 (98.1)	108	<0.001
	Normal	272 (99.6)	1 (0.4)	273	
	Reduced	1 (100.0)	0 (0.0)	1	

DISCUSSION

A study was conducted to establish the frequency of fatty liver on ultrasound in patients presenting to MMC Mardan. In this study, 107 patients out of 382 had fatty liver (frequency 28.0%) and 72.0% did not have fatty liver on ultrasonography. This suggests that fatty liver is a frequent sonographic finding among the study population, and reflects a high prevalence of fatty liver disease in patients presenting for ultrasonography. This finding is within the spectrum reported in many other hospital and regional studies, in which fatty liver has become a more common incidental or significant finding. (19)

The high prevalence of fatty liver in this study could be attributed to the rising metabolic risk factors, with recent dietary and lifestyle changes, declining physical activity and increasing obesity and overweight in the community. The reported prevalence is consistent with the notion that fatty liver disease is no longer an uncommon liver disease but a common metabolic condition that is often encountered in clinical practice. The large number of positive cases in the study also highlights the advantages of ultrasonography as a screening and diagnostic method in low-resource settings (such as public hospitals). (20)

In terms of gender representation, 55.5% of the study subjects were females and 44.5% were males. But, the incidence of fatty liver was slightly higher in males (32.4%) than females (24.5%). While the difference between the two genders was not statistically significant, it indicates a male predominance in the prevalence of fatty liver in the current study. This finding has been reported in several studies in which males were found to have a higher prevalence of hepatic steatosis, possibly because of different visceral fat distribution, lifestyle and metabolic characteristics. However, the absence of statistically significant difference suggests both sexes are significantly affected and that fatty liver disease is an issue of concern among both males and females. (21)

In this study, most of the patients were in the 21-40 years age group followed by the 41-60 years age group. The proportion of patients with fatty liver was lowest in the 20 years and below age group, but increased in the 21-40 years and 41-60 years age groups. While the age groups were not statistically significant for fatty liver, the observed pattern suggests that fatty liver is more prevalent in adults and middle-aged people. This finding is not unexpected since metabolic risk factors (obesity, insulin resistance and hypertension) are more prevalent with increasing age, leading to hepatic fat accumulation. The proportion in the younger age group may show a lower percentage as the exposure to these metabolic abnormalities is less. (22)

Notably, the current study showed the body mass index (BMI) status. The majority of patients were overweight (41.9%) or obese (30.6%) with only 27.2% having normal BMI and one patient being underweight. Cross-tabulation showed a significant association between BMI category and fatty liver, with increasing rates (15.4% in normal weight, 31.2% in overweight and 35.0% in obese). This finding is in accord with the known link between obesity and fatty liver. Obesity, especially abdominal obesity, is closely associated with insulin resistance and the flux of free fatty acids to the liver, leading to hepatic steatosis. Therefore, the current study supports the notion that increased BMI is a significant risk factor for fatty liver in this population. (23)

The step-wise increase in the frequency of fatty liver across increasing BMI identified in this study also underscores the importance of overweight as a stepping-stone to obesity. Overweight individuals already had a significantly higher rate of fatty liver, i.e., prior to developing obesity. This is significant from a clinical perspective as it suggests that prevention strategies should not be restricted to obese individuals. Early intervention in overweight patients for diet, exercise and weight loss may have a beneficial effect by limiting progression of hepatic steatosis and subsequent metabolic complications. (24)

We also found a significant association of diabetes mellitus with fatty liver. In diabetes patients, 71.7% of patients had fatty liver compared to only 22.0% of non-diabetic patients, with a significant statistical difference. This is one of the major findings of our study and is in accordance with the known pathophysiological association between diabetes and fatty liver. Both diseases are linked with insulin resistance, which is responsible for the increased hepatic lipid influx, defective lipid metabolism and the progression of liver disease. The fact that a large proportion of patients with diabetes had fatty liver in this study shows that diabetes is a significant risk factor for hepatic steatosis in patients who report to MMC Mardan. (25)

The findings of the present study regarding the link between diabetes and fatty liver have clinical implications. Diabetic patients are routinely assessed for glucose control and blood vessel complications, while their liver may not be routinely assessed unless they have symptoms. The current study suggests diabetic patients should be more frequently evaluated for fatty liver, particularly by ultrasonography, to detect it early. This may enable intervention in the form of weight loss, better glycemic control and treatment of other metabolic risk factors. (26)

Hypertension was detected in 17.8% of the present study population and was strongly associated with fatty liver. Hypertensive patients were more likely to have fatty liver (58.8%) than non-hypertensive patients (21.3%). This finding is consistent with the notion that fatty liver is associated with the metabolic syndrome. The common pathophysiological mechanisms underlying hypertension and fatty liver include insulin resistance, endothelial dysfunction, chronic low-grade systemic inflammation and dyslipidemia. So, the strong correlation found in this study adds to the notion that fatty liver disease is not simply a localised liver disease, but also a manifestation of a generalised metabolic syndrome. (27)

The presence of hypertension and fatty liver in this study group also has prognostic implications. Such patients may have an increased risk of developing cardiovascular disease and liver disease in the long term. Therefore, the presence of fatty liver on ultrasonography may be a valuable clue to identify those patients who need to be further investigated for blood pressure control and other metabolic assessment. (28)

In terms of liver size, most patients had normal liver size, a few had enlarged liver and very few had reduced liver size. There was a strong association of fatty liver with liver size where 85.2% of patients with enlarged liver had fatty liver, while none of the patients with reduced liver was found to have fatty liver. The findings are expected to show such an association as hepatomegaly is one of the ultrasonographic features observed in patients with fatty liver. The presence of fat in hepatocytes may lead to hepatomegaly in the early and moderate phases of fatty liver. Thus, the association between an enlarged liver and fatty liver in the current study suggests the consistency of the ultrasonographic results. (29)

Likewise, 7.1% of patients had hepatomegaly and it was significantly associated with fatty liver. Fatty liver was found in 85.2% of patients with hepatomegaly, compared to 23.7% of those without hepatomegaly. This is an important finding as hepatomegaly is readily identified clinically and by ultrasound and may be suggestive of hepatic steatosis. This strong association recommends that hepatomegaly be taken seriously, especially when accompanied by other risk factors for fatty liver, including obesity, diabetes and hypertension. (30)

Increased echogenicity was the strongest predictor of fatty liver in this study. Echogenicity was increased in 28.3% of patients, with 98.1% of these patients having fatty liver. However, only 0.4% of patients without increased echogenicity had fatty liver. This relationship was statistically very significant and is in full agreement with the sonographic criteria of the diagnosis of fatty liver. Elevated hepatic echogenicity is due to the build-up of fat in the liver and is one of the main sonographic criteria for the diagnosis of steatosis. Thus, the strong association here demonstrates the efficacy of sonographic diagnosis of fatty liver in the patients studied. (31)

In this study, 72.0% of patients had Grade 0, 23.8% had Grade I and 4.2% Grade II fatty liver, whereas no patient had Grade III fatty liver. This observation suggests that the majority of sonographically identified cases in the current study were Grade I (mild) disease, with a minor number having Grade II (moderate) disease, and none having Grade III (severe) disease. The high proportion of Grade I fatty liver might suggest that many patients were diagnosed with the disease at an early stage. This is good news as mild steatosis may be treatable, especially with lifestyle changes and metabolic normalisation. (32)

Why there were no patients with Grade III fatty liver in this study could be explained by several factors. First, severe fatty liver may not be as prevalent in the population being examined. Second, patients with severe fatty liver may be referred to a hepatology or tertiary medical center, rather than a general ultrasound department. Third, the study may have focused on a more general population of outpatients in whom the mild and moderate stages of fatty liver predominate. Whatever the reason, the absence of Grade III fatty liver does not diminish the value of the study findings because even mild and moderate fatty liver are important to detect and may still progress if not addressed. (33)

The study participants also had a high prevalence of overweight and obesity, which may have played a significant role in the high prevalence of fatty liver. Given the strong link between obesity and diabetes and chronic inflammation, the fact that many patients were overweight and had diabetes and hypertension partially explains the prevalence of fatty liver in this hospital cohort. These results highlight the inter-relationship between metabolic diseases and suggest a holistic approach to patient assessment rather than a liver-centred approach. (34)

In our population, dyslipidemia and drugs toxic for the liver were reported to be absent in all patients. As a result, we were unable to examine their association with fatty liver in this study. While these variables are important in many studies of fatty liver, their absence in the present study may be due to under-documentation, absence in the subjects studied or the inability to assess the history of the patient. This needs to be borne in mind when interpreting the current study findings and when designing further studies. (35)

The current study has several strengths. First, it involved a substantial number of patients (382) and used the non-invasive and readily available technique of ultrasonography. It also assessed various medical factors, such as age, sex, body mass index (BMI), diabetes, hypertension, liver size, echogenicity and hepatomegaly, which may provide insight into other associations with fatty liver in this population. It is a hospital-based survey from MMC Mardan that offers valuable local insights that may serve to raise awareness and guide further research. (36)

Clinically, This study's results also have local public-health implications. The high rate of overweight and obesity in the study population suggests that public health measures to prevent it, including healthy diet, physical activity, and good metabolic health, are required. The detection of fatty liver in hospital settings may provide an opportunity for lifestyle modification and preventive measures, but public awareness and prevention of risk factors are also crucial to minimising the burden of fatty liver in the population. (37)

CONCLUSION

The current study found that fatty liver is a frequent finding on ultrasonography of patients at MMC Mardan with a prevalence of 28.0%. It was found to be more frequent in mild to moderately diseased patients as 23.8% of patients had Grade I fatty liver and 4.2% had Grade II while none of the patients had Grade III fatty liver. The current study also showed that the prevalence of fatty liver was higher in those with higher BMI, especially overweight and obese individuals, and was significantly associated with diabetes mellitus, hypertension, hepatomegaly, increased liver size and increased echogenicity of liver on ultrasonography. While fatty liver was more prevalent in males and middle-aged persons, these differences were not significant. In summary, the results demonstrate that fatty liver is a major health burden in the population investigated, and underline the need for early detection by ultrasonography and prompt identification of metabolic risk factors, to prevent the development of liver disease and complications.

Recommendations

The results of the current study suggest that more frequent use of ultrasonography for early diagnosis of fatty liver in patients attending tertiary care hospitals, especially obese people, people with diabetes,

hypertension and other metabolic risk factors should be encouraged. Patients with fatty liver detected on ultrasonography should be evaluated for any other clinical and metabolic abnormalities so that any underlying condition can be detected early. More effort should be made to advise lifestyle modification such as weight loss, healthy diet, regular exercise and control of blood glucose and blood pressure as this may prevent disease progression in patients with fatty liver. Radiologists and clinicians should also pay attention to the incidental findings of fatty liver on ultrasound, and report and follow up these findings accordingly. Also, larger multicentre studies should be undertaken in different parts of the country to provide larger data from our region and also to investigate other risk factors for fatty liver disease.

Limitations

There are some limitations that need to be taken into account when interpreting the findings of the current study. First, the present study is a cross-sectional hospital-based study which could only detect prevalence and association, but not causality, between fatty liver and the examined risk factors. Second, it is a single centre study and the results may not be entirely representative of the general population. Third, a diagnosis of fatty liver was made using ultrasonography, which is non-invasive and easy to perform, but depends on the level of the operator and is less sensitive than liver biopsy or the newer imaging techniques (magnetic resonance imaging and computed tomography) for the diagnosis of mild steatosis. Fourth, we did not include some of the important variables, including serum lipid profile, liver function tests, waist circumference, dietary habits, physical activity and alcohol intake. Last, there were no cases of dyslipidemia and hepatotoxic drugs in the dataset; this prevented exploration of their impact on fatty liver.

REFERENCES:

Ludwig J, Viggiano TR, McGill DB, Oh BJ. Nonalcoholic steatohepatitis: Mayo Clinic experiences with a hitherto unnamed disease. Mayo Clin Proc. 1980;55(7):434-8.

Matteoni CA, Younossi ZM, Gramlich T, Boparai N, Liu YC, McCullough AJ. Nonalcoholic fatty liver disease: a spectrum of clinical and pathological severity. Gastroenterology. 1999;116(6):1413-9.

Angulo P. Nonalcoholic fatty liver disease. N Engl J Med. 2002;346(16):1221-31.

Clark JM, Brancati FL, Diehl AM. Nonalcoholic fatty liver disease. Gastroenterology. 2002;122(6):1649-57.

Marchesini G, Bugianesi E, Forlani G, Cerrelli F, Lenzi M, Manini R, et al. Nonalcoholic fatty liver, steatohepatitis, and the metabolic syndrome. Hepatology. 2003;37(4):917-23.

Bedogni G, Miglioli L, Masutti F, Tiribelli C, Marchesini G, Bellentani S. Prevalence of and risk factors for nonalcoholic fatty liver disease: the Dionysos nutrition and liver study. Hepatology. 2005;42(1):44-52.

Browning JD, Szczepaniak LS, Dobbins R, Nuremberg P, Horton JD, Cohen JC, et al. Prevalence of hepatic steatosis in an urban population in the United States: impact of ethnicity. Hepatology. 2004;40(6):1387-95.

Chalasani N, Younossi Z, Lavine JE, Charlton M, Cusi K, Rinella M, et al. The diagnosis and management of nonalcoholic fatty liver disease: Practice guidance from the American Association for the Study of Liver Diseases. Hepatology. 2018;67(1):328-57. (Wiley Online Library)

European Association for the Study of the Liver (EASL), European Association for the Study of Diabetes (EASD), European Association for the Study of Obesity (EASO). EASL-EASD-EASO Clinical Practice Guidelines for the management of non-alcoholic fatty liver disease. J Hepatol. 2016;64(6):1388-402. (Journal of Hepatology)

Younossi ZM, Koenig AB, Abdelatif D, Fazel Y, Henry L, Wymer M. Global epidemiology of nonalcoholic fatty liver disease: Meta-analytic assessment of prevalence, incidence, and outcomes. Hepatology. 2016;64(1):73-84. (Wiley Online Library)

Estes C, Anstee QM, Arias-Loste MT, Bantel H, Bellentani S, Caballeria J, et al. Modeling NAFLD disease burden in four countries in Europe, 2016-2030. J Hepatol. 2018;69(4):896-904.

Wong SW, Chan WK. Epidemiology of non-alcoholic fatty liver disease in Asia. Indian J Gastroenterol. 2020;39(1):1-8. (PubMed)

Abbas Z, Zaheer R. Non-alcoholic fatty liver disease: A real threat in Pakistan. J Pak Med Assoc. 2020;70(12(B)):2437-40. (PubMed)

Aziz B, Nazar T, Irfan M. The frequency of non-alcoholic fatty liver disease in non-obese young medical professionals. J Pak Med Assoc. 2021;71(7):1878-81. (PubMed)

Mofrad P, Contos MJ, Haque M, Sargeant C, Fisher RA, Luketic VA, et al. Clinical and histologic spectrum of nonalcoholic fatty liver disease associated with normal ALT values. Hepatology. 2003;37(6):1286-92.

Adams LA, Lymp JF, St Sauver J, Sanderson SO, Lindor KD, Feldstein A, et al. The natural history of nonalcoholic fatty liver disease: A population-based cohort study. Gastroenterology. 2005;129(1):113-21.

Angulo P, Keach JC, Batts KP, Lindor KD. Independent predictors of liver fibrosis in patients with nonalcoholic steatohepatitis. Hepatology. 1999;30(6):1356-62.

Ekstedt M, Franzén LE, Mathiesen UL, Thorelius L, Holmqvist M, Bodemar G, et al. Long-term follow-up of patients with NAFLD and elevated liver enzymes. Hepatology. 2006;44(4):865-73.

Neuschwander-Tetri BA, Caldwell SH. Nonalcoholic steatohepatitis: Summary of an AASLD single topic conference. Hepatology. 2003;37(5):1202-19.

Bellentani S, Saccoccio G, Masutti F, Crocè LS, Brandi G, Sasso F, et al. Prevalence of and risk factors for hepatic steatosis in Northern Italy. Ann Intern Med. 2000;132(2):112-7.

Amarapurkar DN, Hashimoto E, Lesmana LA, Sollano JD, Chen PJ, Goh KL. How common is non-alcoholic fatty liver disease in the Asia-Pacific region and are there local differences? J Gastroenterol Hepatol. 2007;22(6):788-93.

Farrell GC, Wong VW, Chitturi S. NAFLD in Asia—as common and important as in the West. Nat Rev Gastroenterol Hepatol. 2013;10(5):307-18.

Fan JG, Farrell GC. Epidemiology of non-alcoholic fatty liver disease in China. J Hepatol. 2009;50(1):204-10.

Das K, Das K, Mukherjee PS, Ghosh A, Ghosh S, Mridha AR, et al. Nonobese population in a developing country has a high prevalence of nonalcoholic fatty liver and significant liver disease. Hepatology. 2010;51(5):1593-602.

Leite NC, Salles GF, Araujo ALE, Villela-Nogueira CA, Cardoso CRL. Prevalence and associated factors of non-alcoholic fatty liver disease in patients with type 2 diabetes mellitus. Liver Int. 2009;29(1):113-9.

Williamson RM, Price JF, Glancy S, Perry E, Nee LD, Hayes PC, et al. Prevalence of and markers of NAFLD detected by ultrasound in people with type 2 diabetes: the Edinburgh Type 2 Diabetes Study. Diabetes Care. 2011;34(5):1139-44.

Hanif MW, Khan SA, Iqbal A, Manzoor SM, Aziz A. Nonalcoholic fatty liver disease in patients with type 2 diabetes mellitus. Pak J Med Sci. 2019;35(5):1346-51.

Saadeh S, Younossi ZM, Remer EM, Gramlich T, Ong JP, Hurley M, et al. The utility of radiological imaging in nonalcoholic fatty liver disease. Gastroenterology. 2002;123(3):745-50.

Hernaez R, Lazo M, Bonekamp S, Kamel I, Brancati FL, Guallar E, et al. Diagnostic accuracy and reliability of ultrasonography for the detection of fatty liver: A meta-analysis. Hepatology. 2011;54(3):1082-90.

Dasarathy S, Dasarathy J, Khiyami A, Joseph R, Lopez R, McCullough AJ. Validity of real-time ultrasound in the diagnosis of hepatic steatosis: A prospective study. J Hepatol. 2009;51(6):1061-7.

Hamaguchi M, Kojima T, Itoh Y, Harano Y, Fujii K, Nakajima T, et al. The severity of ultrasonographic findings in nonalcoholic fatty liver disease reflects the metabolic syndrome and visceral fat accumulation. Am J Gastroenterol. 2007;102(12):2708-15.

Palmentieri B, de Sio I, La Mura V, Masarone M, Vecchione R, Bruno S, et al. The role of bright liver echo pattern on ultrasound B-mode examination in the diagnosis of liver steatosis. Dig Liver Dis. 2006;38(7):485-9.

Shannon A, Alkhouri N, Carter-Kent C, Monti L, Devito R, Lopez R, et al. Ultrasonographic quantitative estimation of hepatic steatosis in children with NAFLD. J Pediatr Gastroenterol Nutr. 2011;53(2):190-5.

Lee SS, Park SH, Kim HJ, Kim SY, Kim MY, Kim DY, et al. Non-invasive assessment of hepatic steatosis: Prospective comparison of the accuracy of imaging examinations. J Hepatol. 2010;52(4):579-85.

Joseph AE, Saverymuttu SH, al-Sam S, Cook MG, Maxwell JD. Comparison of liver histology with ultrasonography in assessing diffuse parenchymal liver disease. Clin Radiol. 1991;43(1):26-31.

Fishbein MH, Miner M, Mogren C, Chalekson J. The spectrum of fatty liver in obese children and the relationship of ultrasound findings to liver histology. J Pediatr Gastroenterol Nutr. 2003;36(1):54-61.

Bohte AE, van Werven JR, Bipat S, Stoker J. The diagnostic accuracy of US, CT, MRI and 1H-MRS for the evaluation of hepatic steatosis compared with liver biopsy: A meta-analysis. Eur Radiol. 2011;21(1):87-97.