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Non-Alcoholic Fatty Liver Disease in Patients with Diabetes and Prediabetes: A Cross-Sectional Study from Puducherry

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ABSTRACT

Background: Individuals with type II diabetes mellitus are more likely to develop non- alcoholic fatty liver disease (NAFLD). Patients with obesity, dyslipidemia, and inadequate glycemic management are at even higher risk. An analysis of the risk factors for non-alcoholic fatty liver disease (NAFLD) found that individuals with NAFLD had greater rates of obesity, hypertension, hyperlipidemia, hyperglycemia, and sedentary lifestyles. Patients with non-alcoholic fatty liver disease who also have type 2 diabetes mellitus are more likely to acquire progressive forms of the illness. To prevent them from developing chronic complications that can be treated with early therapeutic intervention, patients with established type 2 diabetes mellitus should be evaluated for non-alcoholic fatty liver disease (NAFLD). Hence, an attempt was made to study of prevalence of non-alcoholic fatty liver disease among diabetes and prediabetic patients in Tertiary Care Centre.

Materials and Methods: A Cross sectional study conducted in a Tertiary Care Hospital at Puducherry among the diabetic patients aged above 18 years with no history of alcohol intake with purposive sampling technique with a sample of size of 144 for a duration of 18 months. Diabetic and pre diabetic patients above the age of 18 years were included for the study.

Results and Conclusion: In the present study, diabetes and pre diabetes with fatty liver; liver cirrhosis, BMI and their association was studied in-depth. 56.3% of the patients in the study group are male and 43.8% are female, 81.3% of the patients are Diabetic, 18.8% are Pre-Diabetic in the study, 28.2% of the Diabetic patients have grade 0 fatty liver, 26.5% of the Diabetic patients have grade 1 fatty liver, 26.5% of the Diabetic patients have grade 2 fatty liver and 18.8% of the Diabetic patients have grade 3 fatty liver. Similarly, 44.4% of the Pre-Diabetic patients have grade 0 fatty liver, 29.6% of the Pre-Diabetic patients have grade 1 fatty liver, 14.8% of the Pre-Diabetic patients have grade 2 fatty liver and 11.1% of the Pre-Diabetic patients have grade 3 fatty liver. In this study among diabetic and pre diabetic individual, 68.7% of the study population (99 participants) has NAFLD. Diabetic patients those with grade 0 liver fibrosis was 22.2%, with grade 1 liver fibrosis was 28.2%, 27.4% with grade 2 liver fibrosis and 22.2% with grade 3 liver fibrosis. Similarly, 37% of the Pre-Diabetic patients had grade 0 liver fibrosis, 14.8% of the Pre-Diabetic patients have grade 1 liver fibrosis, 37% of the Pre-Diabetic patients have grade 2 liver fibrosis and 11.1% of the Pre-Diabetic patients have grade 3 liver fibrosis. In this study among diabetic and pre diabetic individual, 75% of the study population (108 participants) has Liver Fibrosis.

INTRODUCTION

Diabetes

Diabetes is a hazardous condition that is one of the main long-term health problems that the globe is dealing in the twenty-first century. The largest incidences of adult diabetes are seen in the United States, China, and India [1]. Complications such as neuropathy, retinopathy, cardiovascular disease, and diabetic foot disease are more likely to occur in people with diabetes. India now has the second-highest prevalence of diabetes in the world, with an estimated 77 million cases in 2019; by 2030, that number is expected to rise to 101 million cases.(1) According to the Indian Council of Medical Research (ICMR)-India Diabetes (ICMR-INDIAB) study, diabetes prevalence has been identified in 15 of the 31 Indian states and union territories that have been completed and published as of this writing. While the average frequency was 7.3%, there are notable variations in prevalence throughout the states, suggesting an epidemiological shift.(2) Genetics and lifestyle factors are the main causes of type 2 diabetes.(3) Type 2 diabetes in children and adolescents is thought to have increased as a result of the rise in juvenile obesity between the 1960s and 2000s.(4) Toxins found in the environment could be a factor in the recent rise in type 2 diabetes cases. Bisphenol A, a component of various plastics, has been discovered to have a weakly positive connection with the incidence of type 2 diabetes in urine.(5)

Family members with type 2 diabetes, especially first-degree relatives, greatly increases the risk of developing the condition because it is highly hereditary. There is a family history of diabetes mellitus in around 25% of patients, and

nearly all monozygotic twins exhibit concordance.(6) Age, high-fat diets, and a less active lifestyle have also been linked to an increased risk of type 2 diabetes. Certain disorders like Acromegaly, Cushing's disease, thyrotoxicosis, pheochromocytoma, chronic pancreatitis, malignancy, and medications are some of the causes.(7,8,9)

There are many easily accessible tests for DM diagnosis and screening. A positive screen is the same as a diagnosis of pre-diabetes or diabetes mellitus because the tests used for screening and diagnosis are the same.(10) Approximately 25% of those diagnosed with type 2 diabetes already have microvascular problems, indicating that they have had the condition for more than five years.(11) The American Diabetic Association's (ADA) recommendations and the World Health Organization's (WHO) 2006 National Diabetic Group Criteria are still in use. According to these standards, two hours following the oral dosage, there must be two elevated readings of either fasting plasma glucose (FPG) 7.0 mmol/L (126 mg/dL) or, in the case of an oral glucose tolerance test (OGTT), a plasma glucose of 11.1 mmol/L (200 mg/dL).(12) Although the WHO emphasizes the OGTT, the 1997 ADA criteria for diagnosing DM place greater emphasis on the FPG.(12) Over time, fructosamine and glycated hemoglobin (HbA1c) continue to be valuable markers of blood sugar management. Nevertheless, practical doctors often take additional safety measures beyond what is advised. The International Expert Committee (IEC) suggested in July 2009 that a HbA1c value of ±6.5% be included as an additional diagnostic criterion for DM patients.(12) There is no exact HbA1c cutoff threshold between normalcy and diabetes, much like with glucose-based testing. The IEC made the decision to recommend a specificity-focused cut-off point for the diagnosis of diabetes mellitus. They found that this counterbalanced the minimal clinical consequences of delaying the diagnosis in a patient with HbA1c level <6.5% and the cost and embarrassment of misdiagnosing someone with diabetes.(12).

Non-Alcoholic fatty Liver Disease

Non-alcoholic fatty liver is the commonest cause of liver dysfunction in the western world. It is often associated with obesity, hyperlipidemia, hypertension, diabetes. Indian population has a high diabetes population and so NAFLD often gets undiagnosed among this population and later presents as advanced stage of the disease.

Nonalcoholic fatty liver disease (NAFLD) is a serious public health concern in India and other nations due to the present worldwide obesity and diabetes mellitus (DM) epidemics, easy availability to high-calorie meals, and sedentary lifestyles. Nonalcoholic fatty liver disease (NAFLD) has been associated with cirrhosis, liver transplants, and hepatocellular carcinoma (HCC) in India.(13). Given its vast population, India is predicted to have a high prevalence of NAFLD, which might significantly impact the country's meagre health care resources. A prevalence rate of 8.7% was found in groups that were predominantly non-obese in a previous population-based study carried out in rural India. It was discovered that the prevalence of type 2 diabetes, prediabetes, obesity, and metabolic syndrome was higher among the high-risk categories.(13) The latest study, which indicates a significant frequency of NAFLD in obese Indian youngsters, is concerning.

Diabetes Mellitus and Non-Alcoholic Fatty Liver Disease

People with type 2 diabetes mellitus (T2DM) are likely to have a high prevalence of non-alcoholic fatty liver disease (NAFLD) because of the disease's association with obesity and insulin resistance. Weight loss achieved by diet and exercise is helpful in treating and preventing non-alcoholic fatty liver disease (NAFLD) in obese diabetic patients. NAFLD is a somewhat common condition that has been becoming more commonplace worldwide. The percentage of Americans with non-alcoholic fatty liver disease (NAFLD) has increased over the past 20 years, according to a population-based study that used data from the US National Health and Nutrition Examination Survey.(14) The two biggest environmental factors that lead to the development of obesity and insulin resistance are increasing calorie consumption and decreased physical activity.

Regardless of its co-occurrence with diabetes and the metabolic syndrome, there is evidence that non-alcoholic fatty liver disease (NAFLD) may be a risk factor for cardiovascular disease on its own. To determine the degree to which NAFLD is associated with these long-term diabetes problems and whether it actually plays a causative role, more research is required. Hence; this study aimed to study the prevalence of non-alcoholic fatty liver disease among diabetes and prediabetic patients in tertiary care center.

OBJECTIVES:

1. To estimate the prevalence of non-alcoholic fatty liver disease among diabetic and prediabetic patients.
2. To assess the grade of non-alcoholic fatty liver disease using ultrasonography and to find its association with the duration of Diabetes.

MATERIALS AND METHODS

A Cross sectional study conducted in a Tertiary Care Hospital at Puducherry among the diabetic patients aged above 18 years with no history of alcohol intake with purposive sampling technique with a sample of size of 144 for a duration of 18 months after the institutional ethical clearance (No:7/SVMCH/IEC-Cert/Aug22). Diabetic and pre diabetic patients above the age of 18 years were included for the study. Patients who are not teetotaller, patients with history of any viral hepatitis, chronic liver disease due to autoimmune disease, Wilsons disease, haemochromatosis, alpha 1 antitrypsin, history of cirrhosis, history of malignancy, history of drug intake which are known to cause steatosis, history of gestational diabetes, and history of hypothyroidism were excluded from the study. Data was collected by Semi structured questionnaire.

Patients were given a semi structured proforma and consent was obtained. Diabetic patients with no history of alcohol intake were screened for NAFLD using ultrasonography and blood investigations (FBS, PPBS, HBA1c and LFT) was sent. Other causes of NAFLD were excluded. The patients who have NAFLD were graded using ultrasound and Transient elastography (fibroscan). The prevalence of NAFLD was calculated and its correlation to the staging of NAFLD was determined.

STATISTICAL ANALYSIS

Data was entered in excel and analyzed using SPSS software version 23.0. Categorical variables were reported as frequency and percentages and continuous variables as mean and standard deviation. Association between categorical variables were done using Chi-Square test. P value of <0.05 is considered significant.

RESULTS AND DISCUSSION

Distribution of patients based on Age, Gender, consumption of alcohol, level of Diabetes, duration of Diabetes, BMI Categories, prevalence of Hypertension:

Majority of the patients (30.6%) belong to the age group of 51to 60 years, followed by 20.1%of age group 61-70 years, 23.6% of the Patients are less than 40 years of age, 17.4% of them are between 41 and 50 years of age and 8.3% are above 70 years of age. The Mean

age of the Patients in the study was 53.09±14.308 years with a minimum of 23 years and a maximum of 85 years (Figure 1). This was similar to the earlier studies of Ramya et al. and Marieke et al. (15,16) In the present study, 56.3% of the patients are male and 43.8% are female. All the patients in the study group do not consume alcohol. Diabetic patients are of 81.3% and 18.8% are Pre- Diabetic (Figure 2).

Based on duration of prevalence of Diabetes 39.6% of the patients are suffering from Diabetes for less than 5 years, 34.7% have diabetes between 6 and 10 years of age, 14.6% have diabetes between 11 and 15 years of age and 11.1% have diabetes above 15 years of age. Based on BMI Categories, 41% of the patients are overweight, 29.2% are normal, 27.1% are Obese and 2.8% are underweight. (Figure 3)

It is evident from figure 4 that 63.9% of the patients are not having Hypertension and 36.1% are with Hypertension. In the earlier study by Ramya et al., 51% of the patients had Hypertension.(15)

Statistical Analysis of Physical Parameters, Duration of Diabetes, RBS, FBS, PPBS, HbA1c, Liver Function Parameters and Lipid Profile in Patients:

The average height of the patients is 161.99±9.499 cm with a minimum of 142cm and maximum of 185 cm. The average weight of the patients is 72.42±13.251 kgs with a minimum of 44 kg and a maximum of 105 kgs. The average waist circumference of the patients in the study is 93.06±8.226 cm with a minimum of 67 cm and a maximum of 130 cm. The average waist hip ratio of the patients in the study is 0.8904±0.11818 with a minimum of 0.71 and a maximum of 1.20.

It can be inferred that the mean duration of Diabetes in the patients are 8.19±6.121 years with a minimum of 1 and a maximum of 33. The mean Random Blood Sugar level is 189.18±60.813 mg/dl with a minimum of 21 and a maximum of 390. The average Fasting Blood Sugar level is 156.59±31.373 mg/dl with a minimum of 88 and a maximum of 360. The average Post Prandial Blood sugar level is 236.74±74.361 mg/dl with a minimum of 116 and a maximum of 416. The mean HbA1c is 7.598±1.4084% with a minimum of 5.5% and a maximum of 12%. Liver function parameters, Aspartate Amino transferase (AST), Alanine Transaminase (ALT), Alkaline Phosphatase (ALP), Total Bilirubin and Serum Albumin shows the mean value of AST is 28.68±11.376 U/L with a minimum of 10 and a maximum of 81. The average ALT is 24.82±11.538 U/L with a minimum of 10 and a maximum of 79. The average ALP is 109.24±21.384 IU/L with a minimum of 54 and a maximum of 178. The average total bilirubin is2.7947±17.55483mg/dl with a minimum of 0.10 and a maximum of 201.The average Serum albumin is 4.871±5.6347 mg/dl with a minimum of 2.8 and a maximum of 46.0.

The descriptive statistics on Lipid profile of the patients; can be inferred that the mean total Cholesterol is 178.33±34.00mg/dl with a minimum of 62 and a maximum of 293. The average HDL is 46.15±8.240mg/dl with a minimum of 30 and a maximum of 71. The average LDL is 102.01±31.958mg/dl with a minimum of 45 and a maximum of 250. The average VLDL is 32.23±16.738 mg/dl with a minimum of 11 and a maximum of 95. The average Triglyceride is 160.58±87.805 mg/dl with a minimum of 59 and a maximum of 615.

In the current study, 28.2% of the Diabetic patients have grade 0 fatty liver, 26.5% of the Diabetic patients have grade 1 fatty liver, 26.5% of the Diabetic patients have grade 2 fatty liver and 18.8% of the Diabetic patients have grade 3 fatty liver. Similarly, 44.4% of the Pre-Diabetic patients have grade 0 fatty liver, 29.6% of the Pre-Diabetic patients have grade 1 fatty liver, 14.8% of the Pre-Diabetic patients have grade 2 fatty liver and 11.1% of the Pre-Diabetic patients have grade 3 fatty liver. In the earlier study by Naresh et al., grade I fatty liver disease was noted to be of 21.43%, but, in a study by Kim et al, 22.04% had grade 1 NAFLD and 11.11% had grade 2 NAFLD.(17,18)

Association between level of diabetes and grade of liver fibrosis in the given table depicts that 22.2% of the Diabetic patients have grade 0 liver fibrosis, 28.2% of the Diabetic patients have grade 1 liver fibrosis, 27.4% of the Diabetic patients have grade 2 liver fibrosis and 22.2% of the Diabetic patients have grade 3 liver fibrosis. Similarly, 37% of the Pre-Diabetic patients have grade 0 liver fibrosis, 14.8% of the Pre-Diabetic patients have grade 1 liver fibrosis, 37% of the Pre-Diabetic patients have grade 2 liver fibrosis and 11.1% of the Pre-Diabetic patients have grade 3 liver fibrosis. (Table 1)

It is clear from the table 2; that 50.9% of the patients with Diabetes for less than 5 years have grade 0 fatty liver, 33.3% of the patients with Diabetes for less than 5 years have grade 1 fatty liver, 14% of the patients with Diabetes for less than 5 years have grade 2 fatty liver and 1.8% of the patients with Diabetes for less than 5 years have grade 3 fatty liver.

Similarly, 28% of the patients with Diabetes for 6-10 years have grade 0 fatty liver, 32% of the patients with Diabetes for 6-10 years have grade 1 fatty liver, 32% of the patients with Diabetes for 6-10 years have grade 2 fatty liver and 8% of the patients with Diabetes for 6-10 years have grade 3 fatty liver.

Similarly, 4.8% of the patients with Diabetes for 11-15 years have grade 0 fatty liver; 19% of the patients with Diabetes for 11-15 years have grade 1 fatty liver, 38.1% of the patients with Diabetes for 11-15 years have grade 2 fatty liver and 38.1% of the patients with Diabetes for 11-15 years have grade 3 fatty liver.

Similarly, 6.3% of the patients with Diabetes for more than 15 years have grade 0 fatty liver, 18.8% of the patients with Diabetes for more than 15 years have grade 2 fatty liver and 75% of the patients with Diabetes for more than 15 years have grade 3 fatty liver. There is a highly significant association between duration of Diabetes and grade of Fatty liver as depicted by the significant chi square value of 73.089 ($p<0.01$). Also, as the duration of diabetes increases the severity of fatty liver also increases. Similarly, in the study by Kuldeep et al., 16.50% of the patients with NAFLD had diabetes for less than 5 years, whereas 34.95% had Diabetes between 5 and 10 years and 48.54% had Diabetes for more than 10 years.(19)

It is clear from the table 2; that 33.3% of the patients with Diabetes for less than 5 years have grade 0 liver fibrosis, 28.1% of the patients with Diabetes for less than 5 years have grade 1 liver fibrosis, 29.8% of the patients with Diabetes for less than 5 years have grade 2 liver fibrosis and 8.8% of the patients with Diabetes for less than 5 years have grade 3 liver fibrosis.

Similarly, 20% of the patients with Diabetes for 6-10 years have grade 0 liver fibrosis, 26% of the patients with Diabetes for 6-10 years have grade 1 liver fibrosis, 26% of the patients with Diabetes for 6-10 years have grade 2 liver fibrosis and 28% of the patients with Diabetes for 6-10 years have grade 3 liver fibrosis.

Similarly, 14.3% of the patients with Diabetes for 11-15 years have grade 0 liver fibrosis, 28.6% of the patients with Diabetes for 11-15 years have grade 1 liver fibrosis, 33.3% of the patients with Diabetes for 11-15 years have grade 2 liver fibrosis and 23.8% of the patients with Diabetes for 11-15 years have grade 3 liver fibrosis.

Similarly, 25% of the patients with Diabetes for more than 15 years have grade 0 liver fibrosis, 12.5% of the patients with Diabetes for more than 15 years have grade liver fibrosis and 31.3% of the patients with Diabetes for more than 15 years have grade 3 liver fibrosis.

There is no significant association between duration of Diabetes and grade of liver fibrosis as depicted by the insignificant chi square value of 10.968 ($p>0.05$). (Table 2)

There is a highly significant association between BMI and grade of fatty liver as depicted by the highly significant Chi-Square value of 38.111 ($p<0.01$). 50% of the underweight patients have grade 0 fatty liver, 25% of them have grade 1 fatty liver, 25% of them have grade 2 fatty liver and none of them had grade 3 fatty liver. 47.6% of the patients with normal weight have grade 0 fatty liver, 28.6% of them have grade 1 fatty liver, 16.7% of them grade 2 fatty liver and 7.1%

have grade 3 fatty liver. Among the patients who are overweight, 35.6% have grade 0 fatty liver, 33.9% have grade 1 fatty liver, 20.3% have grade 2 fatty liver and 10.2% have grade 3 fatty liver. Among the patients who are obese, 5.1% have grade 0 fatty liver, 15.4% have grade 1 fatty liver, 38.5% have grade 2 fatty liver and 41% have grade 3 fatty liver.

Table 3 presents the association between BMI and grading of liver fibrosis. There no significant association between BMI and grading of liver fibrosis as depicted by the insignificant Chi-Square value of 14.395 ($p>0.0$). 75% of the underweight patients have grade 0 liver fibrosis and 25% of them have grade 3 liver fibrosis. 26.2% of the patients with normal weight have grade 0 liver fibrosis, 31% of them have grade 1 liver fibrosis, 28.6% of them grade 2 liver fibrosis and 14.3% have grade 3 liver fibrosis. Among the patients who are overweight, 25.4% have grade 0 liver fibrosis, 25.4% have grade 1 liver fibrosis, 33.9% have grade 2 liver fibrosis and 15.3% have grade 3 liver fibrosis. Among the patients who are obese, 17.9% have grade 0 liver fibrosis, 32.1% have grade 1 liver fibrosis, 23.1% have grade 2 liver fibrosis and 35.9% have grade 3 liver fibrosis. (Table 3)

Figure 5 illustrates presents the association between grading for fatty liver and Liver Fibrosis. There is a highly significant association between fatty liver and liver fibrosis as depicted by the highly significant Chi-Square value of 38.794 ($p<0.01$). 40% of the patients with grade 0 fatty liver have grade 0 liver fibrosis, 35.9% of the patients with grade 1 fatty liver have grade 1 liver fibrosis, 40% of the patients with grade 2 fatty liver have grade 2 liver fibrosis and 52% of the patients with grade 3 fatty liver have grade 3 liver fibrosis. (Figure 5)

In the current study, the mean Random Blood Sugar was 198.17±63.329 mg/dl in Diabetic patients and 150.22±22.522 mg/dl in Pre-Diabetic patients. The Fasting Blood sugar in Diabetic patients was164.82±53.108 mg/dl and 120.93±17.495 mg/dl in Pre-diabetic patients, but in the earlier study by Kuldeep et al., the mean FBS was 96±10.5mg/dl.(19) The Post Prandial Blood Sugar in Diabetic Patients was 252.03±73.169 mg/dl and 170.52±30.352 mg/dl in Pre-Diabetic patients which was 128±16.2 mg/dl. The HbA1c in Diabetic patients was 7.938±1.3391% and 6.126±0.3748% in Pre-Diabetic patients respectively, which was much higher when compared to the study by Kuldeep et al., where the average HbA1c was only 5.2±1.5%.(19)

The average liver function was based on the level of Diabetes. The mean AST is 29.30±11.498 U/L in Diabetic patients and 26.00±10.623 U/L in Pre-Diabetic patients. The ALT in Diabetic patients is 24.92±11.242 U/L and 24.37±12.965 U/L in Pre-diabetic patients. But in the study by Kuldeep et al., the mean ALT was 27.6±18.1 U/L in patients with NAFLD and Diabetes and 40 (27–61) U/L in a study by Anand et al.(19,20) The ALP in Diabetic Patients is 110.49±20.607 IU/L and 103.85±24.148 IU/L in Pre-Diabetic patients. The Total Bilirubin in Diabetic patients is 1.5349±6.22270 mg/dl and 8.2537±38.52398 mg/dl in Pre-Diabetic patients. The Serum Albumin in Diabetic patients is 4.674±4.8578 g/dl and 5.722±8.2712 g/dl in Pre-Diabetic patients. But in the study by Kuldeep et al., the mean ALP was 108.12±56.8 IU/L in patients with NAFLD and Diabetes and 220 (152–284) U/L in a study by Anand et al.(19,20)

Similarly, the lipid profile based on level of diabetes was analysed. The total cholesterol is 179.13 mg/dl in Diabetic and 174.85 mg/dl in Pre-Diabetic patients. Average HDL in Diabetic patients is 45.57 mg/dl and 48.67 mg/dl in Pre-Diabetic patients. Average LDL in Diabetic patients is 102.88 mg/dl in Diabetic patients and 98.22 mg/dl in Pre-Diabetic patients. Average VLDL is 32.09 mg/dl in Diabetic patients and 32.81 mg/dl in Pre-Diabetic patients. Average Triglycerides is 160.01 mg/dl in Diabetic patients and 163.07 mg/dl in Pre-Diabetic patients.

The average blood sugar level was also seen based on duration of Diabetes. The Random Blood Sugar level has reached its peak in the patients who have diabetes for 11 – 15 years. But the fasting Blood Sugar is higher in Patients who have Diabetes for less than 5 years. The Post Prandial Blood Sugar is maximum in Patients who have Diabetes for more than 15 years. But the HbA1c levels do not change much irrespective of the number of years a Patient is suffering from Diabetes.

The average liver function parameters based on duration of Diabetes AST and ALT was found to be maximum in patients, who have Diabetes for 5 – 10 years, but the average ALP and Total Bilirubin was maximum in patients who have Diabetes for 11-15 years and the Serum Albumin did not show much fluctuation based on the duration of Diabetes.

The lipid profile based on duration of Diabetes showed the total Cholesterol, HDL and LDL were maximum for the Patients who have diabetes for 11-15 years, but VLDL was maximum for patients who have Diabetes for less than 5 years and Triglycerides were maximum for patients who have Diabetes for more than 15 years.

Association between Fatty liver with abdominal obesity, hypertriglyceridemia, low HDL-Cholesterol, High Blood pressure, and High Fasting Blood Glucose:

There is a significant association between fatty liver and abdominal obesity as depicted by the significant Chi-Square value of 10.922 ($p<0.05$). 82.2% of the patients with grade 0 fatty did not have Abdominal obesity. Similarly, 69.2% of the patients with grade 1 fatty liver do not have abdominal obesity. In the same way, 65.7% of the patients with grade 2 fatty liver do not have Abdominal Obesity. But, 56% of the patients with grade 3 fatty liver have Abdominal Obesity. With the increase in the number of patients with abdominal obesity, their severity of fatty liver also increases. Similarly, in a study by Anand et al., 84.5% had increased waist circumference.(20)

The association between grading for fatty liver and hypertriglyceridemia showed that 51.1% of the patients with grade 0 fatty have Hypertriglyceridemia; 59% of the patients with grade 1 fatty liver do not have Hypertriglyceridemia. In the same way, 54.3% of the patients with grade 2 fatty liver do not have Hypertriglyceridemia. In the same way, 56% of the patients with grade 3 fatty liver do not have Hypertriglyceridemia. Thus, there is no significant association between severity of fatty liver and Hypertriglyceridemia as depicted by the insignificant Chi-Square value of 0.902 ($p>0.05$). Similarly, in a study by Anand et al., 46.2% had abnormal triglycerides.(20)

The association between grading for fatty liver and HDL-Cholesterol showed no significant association between severity of fatty liver and HDL-Cholesterol as depicted by the insignificant Chi-Square value of 4.604 ($p>0.05$).

There is a highly significant association between severity of fatty liver and Blood pressure as depicted by the highly significant Chi-Square value of 19.201 ($p<0.01$).

Table 4 presents the association between grading for fatty liver and fasting Blood glucose. 97.8% of the patients with grade 0 fatty have high fasting blood glucose. Similarly, 84.6% of the patients with grade 1 fatty liver have high fasting blood glucose. In the same way, 88.6% of the patients with grade 2 fatty liver have high fasting blood glucose. Similarly, 84% of the patients with grade 3 fatty liver have fasting blood glucose. Also, there is no significant association between severity of fatty liver and fasting blood glucose as depicted by the insignificant Chi-Square value of 5.143 ($p>0.05$). Similarly, in a study by Anand et al., 55.4% had elevated fasting blood glucose.(20)

HbA1c levels in fatty liver Patients; the mean HbA1c level in patients with Grade 0 fatty liver is 7.436±1.4243 %, 7.467±1.3419% in Grade 1 fatty liver patients, 7.669±1.3907% in Grade 2 fatty liver patients and 7.996±1.5032% in grade 4 fatty liver patients. The Severity of fatty liver increases, HbA1c level also increases, but it is not statistically significant as indicated by the insignificant F value of 1.007 ($p>0.05$).

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Table 1: Association between grading of fatty liver and grading of liver Fibrosis among Diabetic and Prediabetic Patients

Level of Diabetes	Grading for fatty liver by USG				Total	Grading for fatty liver by USG				Total
	0	1	2	3		0	1	2	3	
Diabetic	Frequency	33	31	31	22	117	26	33	32	
	% within Diabetic	28.2%	26.5%	26.5%	18.8%	100.0%	22.2%	28.2%	27.4%	
Pre-Diabetic	Frequency	12	8	4	3	27	10	4	10	
	% within Pre-Diabetic	44.4%	29.6%	14.8%	11.1%	100.0%	37.0%	14.8%	37.0%	
Total		45	39	35	25	144	36	37	42	
Total %		31.3%	27.1%	24.3%	17.4%	100.0%	25.0%	25.7%	29.2%	

Table 2: Association between duration of diabetes and grading of fatty liver and liver fibrosis

Duration of Diabetes	Grading for fatty liver by USG				Total	Chi-Square value	Grading of liver Fibrosis				Total	Chi-Square value
	0	1	2	3			0	1	2	3		
≤ 5 years	Frequency	29	19	8	1	57		19	16	17	5	57
	% within ≤5 years	50.9%	33.3%	14.0%	1.8%	100.0%		33.3%	28.1%	29.8%	8.8%	100.0%
6–10 years	Frequency	14	16	16	4	50		10	13	13	14	50
	% within 6–10 years	28.0%	32.0%	32.0%	8.0%	100.0%		20.0%	26.0%	26.0%	28.0%	100.0%
11–15 years	Frequency	1	4	8	8	21	**73.089 (p < 0.01)**	3	6	7	5	21
	% within 11–15 years	4.8%	19.0%	38.1%	38.1%	100.0%		14.3%	28.6%	33.3%	23.8%	100.0%
>15 years	Frequency	1	0	3	12	16		4	2	5	5	16
	% within >15 years	6.3%	0.0%	18.8%	75.0%	100.0%		25.0%	12.5%	31.3%	31.3%	100.0%
Total		45	39	35	25	144		36	37	42	29	144
Total %		31.3%	27.1%	24.3%	17.4%	100.0%		25.0%	25.7%	29.2%	20.1%	100.0%

Table 3: Association between BMI and grading for fatty liver, grading for fatty liver

BMI	Grading for fatty liver by USG				Total	Chi-Square value	Grading of Liver Fibrosis					Total	Chi-Square value
	0	1	2	3			0	1	2	3	4		
Underweight	Frequency	2	1	1	0	4		3	0	1	0	4	
	% within Underweight	50.0 %	25.0 %	25.0 %	0.0%	100.0 %		75.0 %	0.0%	25.0 %	0.0%	100.0 %	
Normal	Frequency	20	12	7	3	42		11	13	12	6	42	
	% within Normal	47.6 %	28.6 %	16.7 %	7.1%	100.0 %		26.2 %	31.0 %	28.6 %	14.3 %	100.0 %	
Overweight	Frequency	21	20	12	6	59	**38.111 (p < 0.01)**	15	15	20	9	59	**14.395 (p > 0.05)**
	% within Overweight	35.6 %	33.9 %	20.3 %	10.2 %	100.0 %		25.4 %	25.4 %	33.9 %	15.3 %	100.0 %	
Obese	Frequency	2	6	15	16	39		7	9	9	14	39	
	% within Obese	5.1%	15.4 %	38.5 %	41.0 %	100.0 %		17.9 %	23.1 %	23.1 %	35.9 %	100.0 %	
Total		45	39	35	25	144		36	37	42	29	144	
Total %		31.3 %	27.1 %	24.3 %	17.4 %	100.0 %		25.0 %	25.7 %	29.2 %	20.1 %	100.0 %	

Table 4: Association between Fatty liver with abdominal obesity, hypertriglyceridemia, low HDL-Cholesterol, High Blood pressure, and High Fasting Blood Glucose

Fatty Liver Grade	Abdominal Obesity (%)	Hypertriglyceridemia (%)	Low HDL-Cholesterol (%)	High Blood Pressure (%)	High Fasting Blood Glucose (%)
Grade 0	17.8	51.1	53.3	20.0	97.8
Grade 1	30.8	41.0	41.0	33.3	84.6
Grade 2	34.3	45.7	48.6	34.3	88.6
Grade 3	56.0	44.0	28.0	72.0	84.0
Total (%)	31.9	45.8	44.4	36.1	89.6
Chi-Square (p-value)	10.922 ($p < 0.05$)	0.902 ($p > 0.05$)	4.604 ($p > 0.05$)	19.201 ($p < 0.01$)	5.143 ($p > 0.05$)

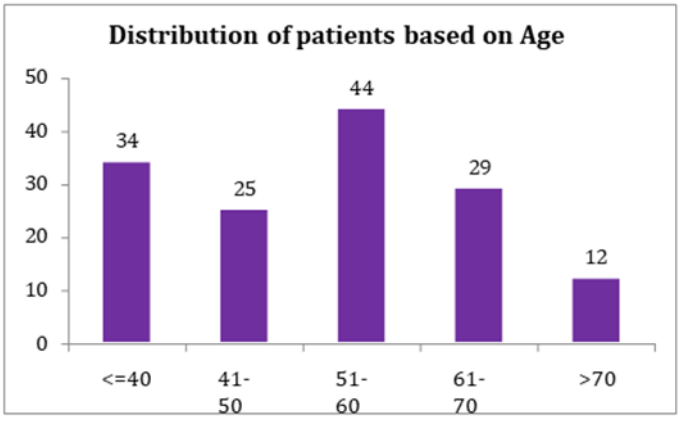

Figure 1: Distribution of patients based on Age

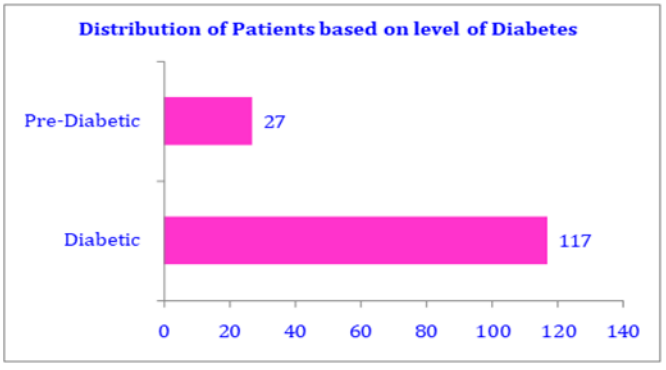

Figure 2: Diabetic and Pre-diabetic Patients

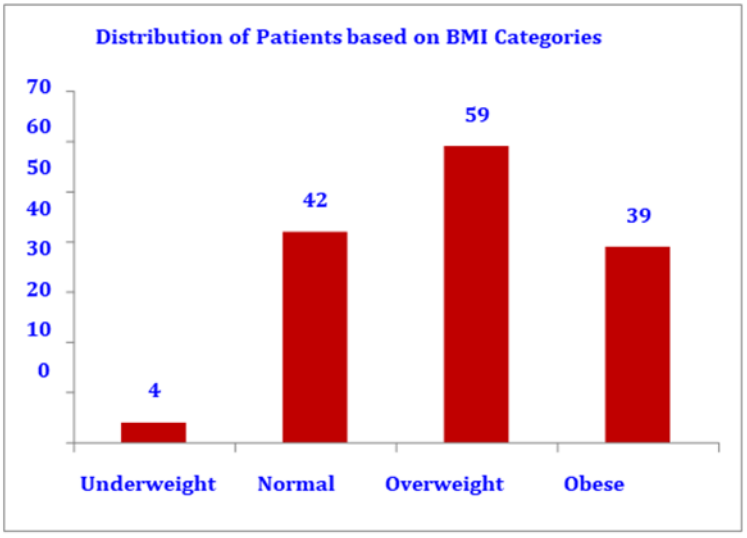

Figure 3: Bar diagram representing the BMI of patients

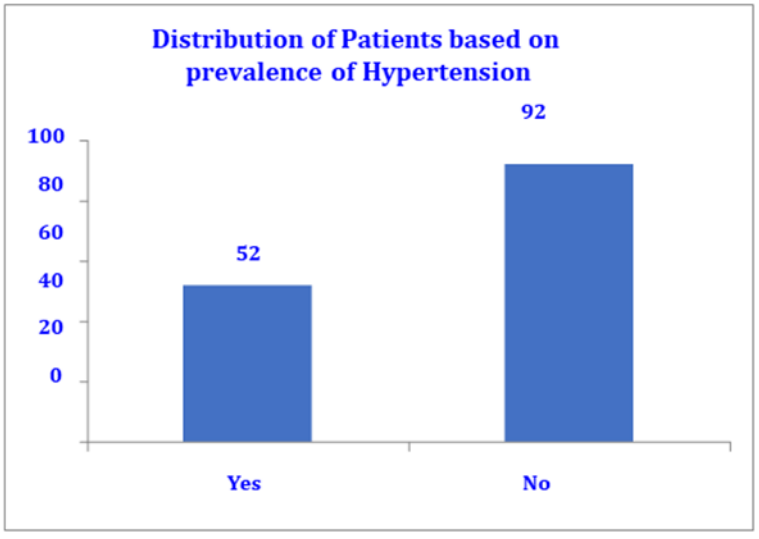

Figure 4: Shows Prevalence of hypertension in patients

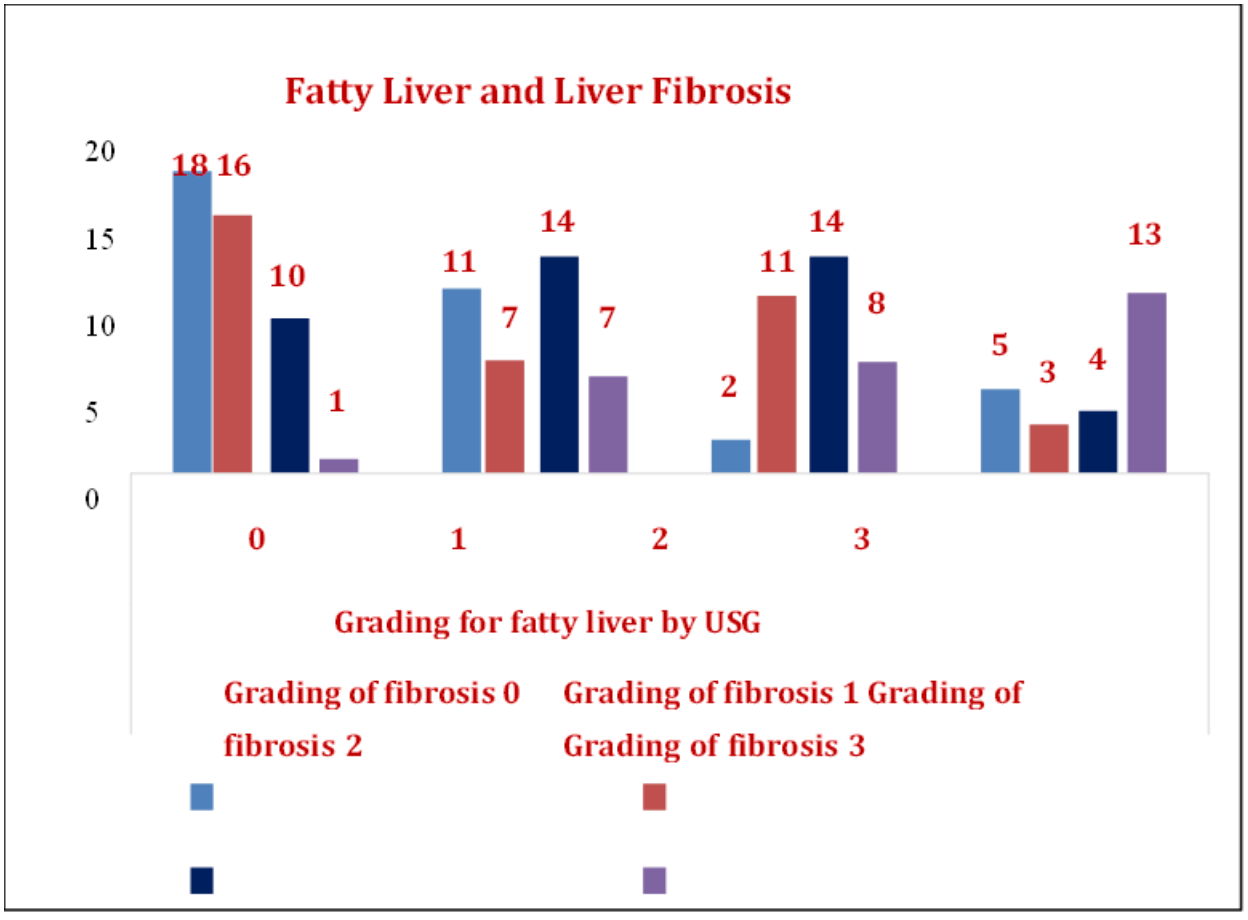

Figure 5: Association between grading for fatty liver and Liver Fibrosis