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The association between non-alcoholic fatty liver disease and chronic kidney disease in Egyptian patients

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Abstract

Background NAFLD is a spectrum of disorders ranging from hepatic steatosis to nonalcoholic steatohepatitis (NASH), NASH related cirrhosis and hepatocellular carcinoma (HCC). There is sparse data on the prevalence CKD in Egyptian patients with NAFLD. The aim of this study is to estimate the prevalence of CKD in the subjects with NAFLD and to assess the risk factors of CKD among them.

Methods A cross-sectional study was conducted on 430 patients from the Internal Medicine Department, Menoufia University Hospitals, including 215 patients with NAFLD, and 215 patients without NAFLD. NAFLD was diagnosed by abdominal ultrasonography. The liver fibrosis was assessed by NAFLD fibrosis score (NFS) and fibrosis-4 index (FIB-4). CKD was defined as an estimated glomerular filtration rate (eGFR) < 60 ml/min/1.73 m2 and/or abnormal albuminuria (urinary albumin-to-creatinine ratio ⩾ 30 mg/gm). The logistic regression analysis was performed to examine the association between NAFLD and risk of CKD.

Results The prevalence of CKD was higher in individuals with NAFLD than in those without NAFLD (38.1% vs 7.4%, $p < 0.001$). Logistic regression analysis demonstrated that both NAFLD and CKD were risk factors of each other. The presence of hypertension, high levels of BMI and waist circumference were the other independent risk factors of NAFLD. While the presence of DM, and the high level of BMI were the other significant risk factors of CKD in the NAFLD group.

Conclusion The presence and severity of NAFLD are associated with an increased risk of CKD.

Keywords Chronic kidney disease, CKD, Non-alcoholic fatty liver disease, NAFLD, Risk factors

Background

Nonalcoholic fatty liver disease (NAFLD) is one of the most frequent chronic liver diseases and it has become a global health problem in the last two decades [1]. The frequency of NAFLD in the general population has been estimated to be over 25%, and it tends to be rapidly increasing, with an estimated 3.6 million new cases per year [2].

NAFLD is characterized by fat infiltration of the liver in the absence of significant alcohol intake, use of medications, or medical conditions that cause fatty liver [3]. It covers a wide range of conditions, including basic hepatic steatosis and nonalcoholic steatohepatitis (NASH), which can lead to cirrhosis, end-stage liver disease, hepatocellular carcinoma (HCC), or the need for a liver transplant over time [4]. NAFLD has been linked to several extrahepatic disorders, including obesity, diabetes, dyslipidemia,

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and hypertension, as well as a few other serious chronic diseases, including chronic kidney disease [5].

Chronic kidney disease (CKD) is a leading cause of death and disability-adjusted life years (DALYs). The global burden of CKD is increasing, and it has emerged as a major public health concern [6]. To lessen the worldwide burden of CKD, it is critical to identify the causes and risk factors. NAFLD and CKD share some risk factors in common, such as visceral obesity, type 2 diabetes, hypertension, and metabolic syndrome, and both disorders are connected to an elevated risk of cardiovascular disease [7].

The potential relationship between NAFLD and CKD has recently attracted scientists' interest. Establishing a relationship between liver and kidney injury would help to identify kidney illness sooner and enable for the selection of medicines that target both liver and kidney disease, with potentially beneficial preventative and therapeutic implications [8].

To our knowledge, no studies have assessed the relationship between NAFLD and CKD in the Egyptian population. So, the aim of this study was to estimate the prevalence of CKD in the subjects with NAFLD and to assess the risk factors of CKD among them.

Methods

This cross-sectional study was conducted on 430 eligible patients from those admitted to the Internal Medicine Department, Menoufia University Hospitals, including 215 patients with NAFLD, and 215 patients without NAFLD aiming to compare the prevalence of CKD in the NAFLD and non-NAFLD group and to assess the risk factors of CKD in NAFLD individuals.

Exclusion criteria

Individuals with a history of hepatitis B surface antigen or hepatitis C antibody positivity, a history of excessive alcohol consumption (⩾30 g/day in men and ⩾20 g/day in women) [5], individuals with decompensated liver cirrhosis, with active malignancy, and those who refuse to join the study were excluded.

Study methods

- Full medical history was taken from each patient including socio demographic data e.g., age, sex, chronic illnesses as DM, hypertension.
- Blood pressure was measured.
- Anthropometric measures were taken including: weight, height, and waist circumference.
- Laboratory investigations which were done to all patients include: CBC, Creatinine, Urea, Uric acid, eGFR, Urinary albumin-to-creatinine ratio (ACR), ALT, AST, Total bilirubin, Prothrombin activity, LDH, Albumin, Fasting blood sugar (FBS), Lipid profile (total cholesterol, triglycerides, LDL, and HDL).
- BMI was calculated as weight in kilograms divided by height in meters squared); Obesity was defined as a BMI of ⩾30 kg/m2 [9].
- Metabolic syndrome (MetS) was defined according to the National Cholesterol Education Program ATP III criteria [10] as the presence of any three or more of the following metabolic conditions:
- Abdominal obesity, waist circumference ⩾ 102 cm in men and ⩾ 88 cm in women.
- Serum triglycerides (TG) ⩾ 150 mg/dL (1.7 mmol/L) or drug treatment for elevated triglycerides.
- Serum high-density lipoprotein cholesterol < 40 mg/dL (1.0 mmol/L) in men and < 50 mg/dL (1.3 mmol/L) in women or drug treatment for low high-density lipoprotein cholesterol.
- Blood pressure ⩾ 130/85 mmHg or drug treatment for elevated blood pressure.
- Fasting blood glucose ⩾ 100 mg/dL (5.6 mmol/L) or drug treatment for elevated blood glucose.
- Diabetes mellitus (DM) was defined as a fasting blood glucose level of ⩾125 mg/dl, [11], or prescription of antidiabetic drugs.
- Hypertension was defined as systolic blood pressure (SBP) ⩾ 130 mmHg, diastolic blood pressure (DBP) ⩾ 85 mmHg [12], or prescription of antihypertensive drugs.
- NAFLD was diagnosed based on evidence of fatty liver on ultrasonography. According to the presence of fatty liver in ultrasonography, participants will be divided into the NAFLD group and non-NAFLD group.
- The severity of liver fibrosis was assessed noninvasively using the NAFLD fibrosis score (NFS) and fibrosis 4 (FIB-4) score.

The NFS was calculated as: $-1.675 + 0.037 \times$ age (years) $+ 0.094 \times$ BMI (kg/m2) $+ 1.13 \times$ impaired fasting glucose/diabetes (yes = 1, no = 0) $+ 0.99 \times$ AST/ALT ratio $- 0.013 \times$ platelet count ($\times 109$ /L) $- 0.66 \times$ albumin (g/dL) [13].

The FIB-4 score was calculated according to the following formula:

$$\text{Age} \times \text{AST (IU/L)} / \left[\text{platelet count } (\times 109\ /\text{L}) \times \text{ALT (IU/L)}\frac{1}{2}\right]$$

The lower and upper cutoffs for NFS will be -1.455 and 0.676, respectively, and those for FIB-4 will be 1.3 and 2.67, respectively. A score below the lower cutoff will be used to exclude advanced fibrosis, while a score above the upper cutoff will be indicative of advanced fibrosis [13].

The estimated glomerular filtration rate (eGFR) was calculated using the Modification of Diet in Renal Disease (MDRD) equation as follows: eGFR = 186 × [serum creatinine (mg/dL)] − 1.154 × [age (years)] − 0.203 × (0.742 if female) [14].

CKD was defined as eGFR < 60 mL/min/1.73 m2 and/or urinary albumin-to-creatinine ratio (ACR) ⩾ 30 mg/gm [15].

Stages of CKD were defined according to the kidney disease: Improving Global Outcomes (KDIGO) guidelines [15].

- Stage 1, urinary albumin-to-creatinine ratio (ACR) ⩾ 3 mg/mmol with eGFR ⩾ 90 mL/min/1.73 m2.
- Stage 2, ACR ⩾ 3 mg/mmol with eGFR of 60–89 mL/min/1.73 m2.
- Stage 3, eGFR of 30–59 mL/min/1.73 m2 (with or without ACR ⩾ 3 mg/mmol).
- Stage 4, eGFR of 15–29 mL/min/1.73 m2.
- Stage 5, eGFR < 15 mL/min/1.73 m2.

Abnormal albuminuria was defined as ACR ⩾ 30 mg/gm [14].

Statistical analysis

The data was analyzed by SPSS (statistical package for social science) version 26.0 on IBM compatible computer (SPSS Inc., Chicago, IL, USA). The qualitative data was described as number and percentage and mean ± SD or median (IQR) for quantitative data. Data analysis was done by using Chi squared test, student's t test, and Mann Whitney U test. Binary logistic regression analysis (inter method) was performed to identify independent risk factors for NAFLD and CKD. The accepted level of significance in this work was started at 0.05 ($P < 0.05$ was considered significant).

Results

Four hundred and thirty subjects were enrolled in this cross-sectional study, and they were divided into two groups: the NAFLD group and non-NAFLD group including two hundred and fifteen subjects in each group. The mean age of the NAFLD group was 51.8 ± 11.5, while the non-NAFLD group mean age was 53.5 ± 9.2 years. The NAFLD group included 92 (42.8%) males and 123 (57.2%) females while the non-NAFLD group included 106 (49.3%) males and 109 (50.7%) females. The mean BMI and waist circumference of the NAFLD group were significantly higher than the non-NAFLD group ($p < 0.001$). DM, hypertension, metabolic syndrome, and CKD (Fig. 1) were significantly more prevalent in the NAFLD than the non-NAFLD group, ($p < 0.001$) (Table 1).

The mean values of the patients' platelets, creatinine, urea, uric acid, ACR, AST, ALT, total cholesterol, triglycerides, LDL, FBS, and LDH were significantly higher among the NAFLD group. While the mean values of the patients' eGFR, albumin, prothrombin activity, and HDL were significantly higher among the non-NAFLD group. Abnormal albuminuria was significantly more present in the NAFLD than non-NAFLD group (24.7% vs 7%). There were no significant differences between either group regarding TLC, Hb, or total bilirubin (Table 1).

The multivariate regression analysis revealed that the presence of hypertension, CKD, and the high levels of BMI and waist circumference were the independent risk factors of NAFLD (Table 2).

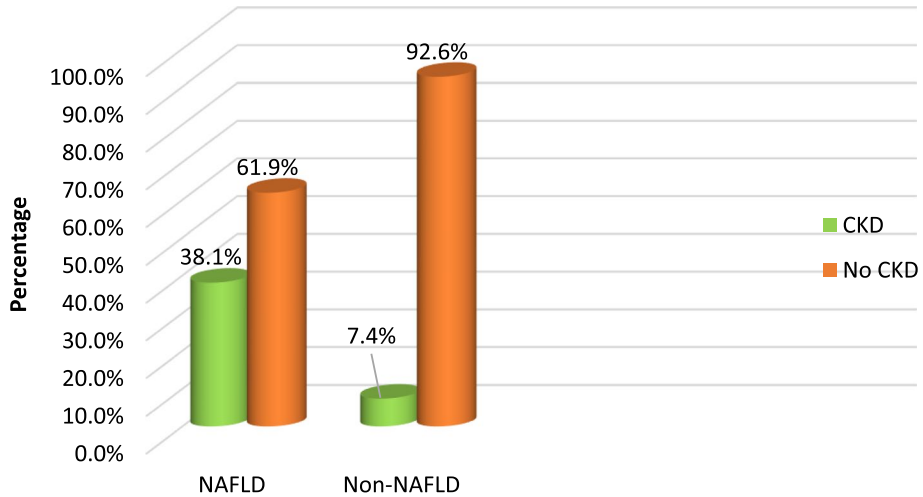

Fig. 1 Bar chart displaying the difference between NAFLD and non-NAFLD cases regarding the prevalence of CKD ($N = 430$)

Table 1 Basic and laboratory characteristics of the NAFLD and non-NAFLD groups ($N=340$)

			NAFLD ($n=215$)	Non-NAFLD ($n=215$)	*P* value
	Age (Y)	Mean ± SD	51.8 ± 11.5	53.5 ± 9.2	0.128*
	Sex	Male Female	92 (42.8%) 123 (57.2%)	106 (49.3%) 109 (50.7%)	0.176#
	BMI (kg/m^2)	Mean ± SD	32.1 ± 5.0	27.7 ± 2.0	**< 0.001***
	Waist circumference (cm)	Mean ± SD	98.0 ± 14.1	84.7 ± 8.5	**< 0.001***
	DM	Yes No	73 (34%) 142 (66%)	41 (19.1%) 174 (80.9%)	**< 0.001#**
	Hypertension	Yes No	128 (59.5%) 87 (40.5%)	70 (32.6%) 145 (67.4%)	**< 0.001#**
	Metabolic syndrome	Yes No	78 (36.3%) 137 (63.7%)	16 (7.4%) 199 (92.6%)	**< 0.001#**
	CKD	Yes No	82 (38.1%) 133 (61.9%)	16 (7.4%) 199 (92.6%)	**< 0.001#**
Laboratory investigations	CBC	TLC (10*3/Ul)	7.3 ± 2.4	6.9 ± 2.0	0.060*
		Hb	10.7 ± 1.6	11.0 ± 1.5	0.120*
		PLts	261.6 ± 98.5 248 (187 – 330)	241.7 ± 93.3 224 (169 – 300)	0.032$
	KFT	Creatinine (mg/dl)	1.35 ± 1.37 0.8 (0.7 – 1.1)	0.72 ± 0.19 0.8 (0.6 – 0.8)	**< 0.001$**
		Urea (mg/dl)	46.4 ± 31.0 36 (33 – 43)	36.2 ± 20.1 33 (26 – 38)	**< 0.001$**
		Uric acid (mg/dl)	5.3 ± 1.4	0.7 ± 0.2	**< 0.001***
		ACR (mg/gm)	45.5 ± 95.4	12.0 ± 18.7	**0.001$**
		eGFR (ml/min/1.73 m^2)	79.9 ± 39.8 80.4 (58.8 – 104.5)	117.4 ± 48.7 105.5 (81.6 – 130.4)	**< 0.001$**
		Albuminuria Abnormal Normal	53 (24.7%) 162 (75.3%)	15 (7%) 200 (93%)	**< 0.001#**
	LFT	AST	38.6 ± 24.2 40 (19 – 56)	27.0 ± 11.9 25 (19 – 34)	**< 0.001$**
		ALT	30.4 ± 16.6 31 (15 – 42)	22.3 ± 15.6 19 (13 – 28)	**< 0.001$**
		T bilirubin	0.58 ± 0.31 0.6 (0.3 – 0.8)	0.63 ± 0.42 0.6 (0.3 – 0.9)	0.189$
		Albumin	3.7 ± 0.6	3.9 ± 0.4	**< 0.001***
		Prothrombin activity	75.3 ± 11.2	87.3 ± 9.2	**< 0.001***
	Lipid profile	Total cholesterol	218.3 ± 96.9	175.5 ± 46.6	**< 0.001***
		Triglycerides	193.9 ± 106.2 170 (130 – 221)	157.1 ± 61.9 178 (99 – 200)	**< 0.001$**
		LDL	111.8 ± 40.6	96.5 ± 31.5	**< 0.001***
		HDL	40.9 ± 11.8	51.5 ± 16.5	**< 0.001***
	FBS		101.9 ± 33.9	87.1 ± 14.6	**< 0.001***
	LDH		202.3 ± 55.7	190.7 ± 31.6	**0.008***

Values are expressed as mean ± SD or n (%)

Chi^2 test

* student's t test

$ Mann-whitey U test

The mean value of the NAFLD cases' NFS score was -0.83 ± 1.87, while the mean value of the NAFLD cases' FIB-4 score was 1.59 ± 1.16. By NFS stratification, advanced fibrosis was present in 17.2% of the NAFLD cases, while by FIB-4 score stratification, advanced fibrosis was present in 11.6% of the NAFLD cases (Table 3).

The mean BMI, TLC, creatinine, urea, uric acid, ACR, total cholesterol, FBS, LDH, and NFS score of the CKD patients were significantly higher than the

Table 2 Binary logistic regression analysis (inter method) for independent risk factors for NAFLD

Risk factors		Univariate		Multivariate	
		Adjusted OR (95% CI)	*P* value	Adjusted OR (95% CI)	*P* value
DM	**Not present**	**Reference**		**Reference**	
	Present	2.18 (1.40 – 3.40)	**0.001**	0.77 (0.37 –1.61)	0.480
Hypertension	**Not present**	**Reference**		**Reference**	
	Present	3.**05** (2.05 – 4.52)	**< 0.001**	2.75 (1.55 – 4.85)	**0.001**
Metabolic syndrome	**Not present**	**Reference**		**Reference**	
	Present	7.08 (3.96 – 12.65)	**< 0.001**	1.99 (0.80 – 4.95)	0.136
CKD	**Not present**	**Reference**		**Reference**	
	Present	7.67 (4.30 – 13.68)	**< 0.001**	5.02 (2.30 – 10.94)	**< 0.001**
BMI		1.69 (1.50 – 1.90)	**< 0.001**	1.53 (1.34 – 1.74)	**< 0.001**
Waist circumference		1.11 (1.09 – 1.14)	**< 0.001**	1.09 (1.06 – 1.13)	**< 0.001**

Table 3 NAFLD severity of the NAFLD group (*N* = 215)

		NAFLD cases (*n* = 215)
NFS score	Mean ± SD	-0.83 ± 1.87
	Median (IQR)	-0.94 (-2.13 – 0.38)
NFS categories	NFS < -1.455	77 (35.8%)
	-1.455 ≤ NFS < 0.676	101 (47%)
	NFS > 0.676	37 (17.2%)
FIB-4 score	Mean ± SD	1.59 ± 1.16
	Median (IQR)	1.37 (0.93 – 2.0)
FIB-4 categories	FIB-4 < 1.3	101 (47%)
	1.3 ≤ FIB-4 < 2.67	89 (41.4%)
	FIB-4 > 2.67	25 (11.6%)

non-CKD patients. While the mean eGFR, albumin, and HDL of the CKD patients were significantly lower than the non-CKD patients among the NAFLD group. The rates of DM, metabolic syndrome, NAFLD, and abnormal albuminuria were significantly higher in the CKD patients among the NAFLD group. There were no significant differences between both groups regarding waist circumference, platelets, Hb, AST, ALT, total bilirubin, prothrombin activity, triglycerides, LDL, FIB-4 score, age, sex, or the rate of hypertension (Table 4).

The multivariate regression analysis revealed that the presence of DM, and the high level of BMI were the significant risk factors of CKD in the NAFLD group. While the high albumin level was a significant protective factor from CKD in NAFLD subjects (Table 5).

There was a significant difference between NFS severity categories of the NAFLD group regarding the CKD prevalence, the higher the NFS, the higher the CKD prevalence (Fig. 2).

Discussion

Nonalcoholic fatty liver disease (NAFLD) is one of the most common chronic liver diseases and has become a worldwide health burden over the past two decades. The prevalence of NAFLD has been reported to be rapidly increasing, with an estimated 3.6 million new cases annually [16]. NAFLD includes a broad range of disease spectrum, such as simple hepatic steatosis and nonalcoholic steatohepatitis (NASH), which with time can progress to cirrhosis, end stage liver disease, hepatocellular carcinomic (HCC), or the need for a liver transplant [17]. NAFLD not only leads to end-stage liver disease but is also found to be strongly associated with increased prevalence of chronic kidney disease (CKD) [18].

NAFLD and CKD

This study showed that the prevalence of CKD was 38.1% among the NAFLD group (Fig. 1). Studies that assessed the prevalence of CKD in patients with NAFLD reported a relatively wide range. A Chinese cross-sectional study found that CKD is present in 15.8% of the NAFLD cases [5]. An analytical study based upon cross-sectional data from the NHANES database 1988–1994, consisting of more than 10,000 individuals who had periodic surveys conducted by the National center for Health Statistics (NCHS) of the Centers for Disease Control and Prevention of the United States, reported that the prevalence of CKD among the NAFLD cases was 26.65% [19].

The prevalence of CKD in this study was significantly higher in the NAFLD than the non-NAFLD group (38.1% vs 7.4%). Another cross-sectional analysis of 343 cases from Italy showed that the percentage of CKD in those with NAFLD was 54.4% vs. 24.2% in those without steatosis [20].

Table 4 Comparison between CKD and non-CKD subjects with NAFLD (*N* = 215)

			CKD (*n* = 82)	Non-CKD (*n* = 133)	*P* value
Sociodemographic	**Age (y)**	**Mean ± SD**	52.9 ± 10.6	51.1 ± 12.0	0.265*
	Sex	**Male** **Female**	32 (39%) 50 (61%)	60 (45.1%) 73 (54.9%)	0.381#
Comorbidities	**BMI (kg/m^2)**	**Mean ± SD**	33.6 ± 6.0	31.1 ± 3.9	< 0.001*
	Waist circumference (cm)	**Mean ± SD**	98.8 ± 15.2	79.5 ± 13.3	0.530*
	DM	**Yes** **No**	47 (57.3%) 35 (42.7%)	26 (19.5%) 107 (80.5%)	< 0.001#
	Hypertension	**Yes** **No**	55 (67.1%) 27 (32.9%)	73 (54.9%) 60 (45.1%)	0.077#
	Metabolic syndrome	**Yes** **No**	44 (53.7%) 38 (46.3%)	34 (25.6%) 99 (74.4%)	< 0.001#
Laboratory investigations	**CBC**	TLC (10*3/Ul)	8.0 ± 2.5	6.9 ± 2.3	0.001*
		Hb	10.6 ± 1.4	10.8 ± 1.7	0.306*
		PLts	271.6 ± 96.4	255.4 ± 99.6	0.243$
	KFT	Creatinine (mg/dl)	2.3 ± 1.9	0.8 ± 0.1	< 0.001$
		Urea (mg/dl)	61.2 ± 44.8	37.2 ± 10.4	< 0.001$
		Uric acid (mg/dl)	5.6 ± 1.7	5.1 ± 1.2	0.007*
		ACR (mg/gm)	117.7 ± 150.0	4.2 ± 7.2	< 0.001$
		eGFR	50.9 ± 38.7	97.8 ± 28.3	< 0.001$
		Albuminuria Abnormal Normal	53 (64.6%) 29 (35.4%)	0 133 (100%)	< 0.001#
	LFT	AST	39.7 ± 26.3	38.0 ± 22.9	0.622$
		ALT	31.3 ± 15.5	29.8 ± 17.3	0.530$
		T. bilirubin	0.56 ± 0.29	0.60 ± 0.33	0.382$
		Albumin	3.5 ± 0.6	3.8 ± 0.5	< 0.001*
		Prothrombin activity	75.8 ± 12.2	75.0 ± 10.6	0.603*
	Lipid profile	Total cholesterol	237.7 ± 139.8	206.4 ± 53.5	0.021*
		Triglycerides	195.7 ± 73.7	192.8 ± 122.3	0.845$
		LDL	115.1 ± 40.3	109.8 ± 40.8	0.355*
		HDL	38.8 ± 13.4	42.2 ± 10.6	0.041*
	FBS		115.3 ± 44.9	93.6 ± 21.2	< 0.001*
	LDH		212.3 ± 64.3	196.2 ± 49.0	0.039*
NFS score			-0.29 ± 2.1	-1.17 ± 1.7	0.001*
FIB-4 score			1.6 ± 1.3	1.5 ± 0.9	0.509*

Values are expressed as mean ± SD, n (%), or median (IQR)

Chi^2 test

* student's t test

$ Mann-whitey U

Logistic regression analysis revealed that both CKD and NAFLD were independent risk factors for each other (Tables 2 and 5). CKD is significantly associated with ~ fivefold increased risk of NAFLD, and NAFLD is significantly associated with ~ threefold increased risk of CKD. This bidirectional relationship can be explained as that CKD shares similar risk factors with NAFLD, such as increasing age, obesity, hypertension, DM, and metabolic syndrome [19, 21]. Similarly, previous studies demonstrated that NAFLD was a risk factor of CKD [5, 22].

Moreover, the incidence of CKD increases as the NAFLD severity increases (Fig. 2), which may suggest that NAFLD could be a driving force for the development and progression of CKD [6]. An updated meta-analysis of 13 studies with 1,222,032 individuals indicated the risk of CKD seems to parallel the severity of NAFLD [22]. The same results were found by Cao, et al., who revealed that

Table 5 Binary logistic regression analysis (inter method) for independent risk factors for CKD in NAFLD cases

Risk factors			Univariate		Multivariate	
			Adjusted OR (95% CI)	***P* value**	**Adjusted OR (95% CI)**	***P* value**
Comorbidities	DM	**Not present**	**Reference**		**Reference**	
		Present	5.53 (3.0 – 10.20)	**< 0.001**	4.83 (1.89 – 12.37)	**0.001**
	Metabolic syndrome	**Not present**	**Reference**		**Reference**	
		Present	3.37 (1.88 – 6.04)	**< 0.001**	1.09 (0.49 – 2.41)	0.831
	BMI		1.12 (1.05 – 1.20)	**0.001**	1.12 (1.03 – 1.21)	**0.006**
Laboratory	TLC		1.21 (1.07 – 1.36)	**0.002**	1.08 (0.94 – 1.25)	0.256
	Albumin		0.30 (0.17 – 0.52)	**< 0.001**	0.38 (0.19 – 0.77)	**0.006**
	Total cholesterol		1.01 (1.00 – 1.01)	**0.031**	1.004 (1.0 – 1.008)	0.069
	HDL		0.98 (0.95 – 1.0)	**0.043**	0.99 (0.96 – 1.02)	0.387
	FBS		1.02 (1.01 – 1.03)	**< 0.001**	1.01 (1.0 – 1.02)	0.244
	LDH		1.005 (1.00 – 1.01)	**0.049**	1.00 (0.99 – 1.003)	0.234
Severity score	NFS score		1.30 (1.11 – 1.52)	**0.001**	0.88 (0.71 – 1.09)	0.244

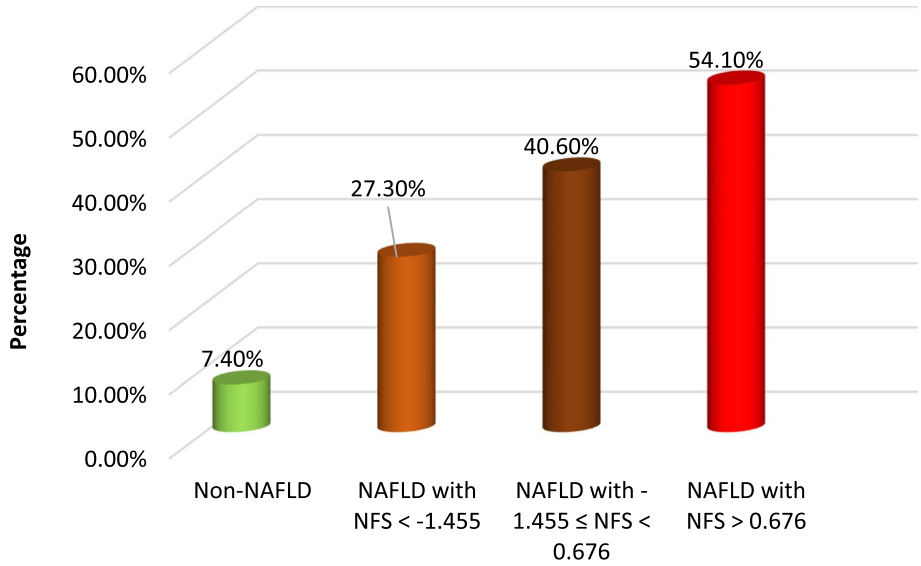

Fig. 2 Bar chart displaying the prevalence of CKD between subjects with non-NAFLD and NAFLD stratified by NAFLD fibrosis score (NFS)

the prevalence of CKD gradually increased in accordance with the severity of NAFLD [5].

NAFLD and metabolic comorbidities

This study showed that the rates of DM, hypertension, metabolic syndrome, the mean BMI and waist circumference were higher among the NAFLD group (Table 1). This agrees with a previous study in Bangladesh [23], and another Chinese study [5], which showed that the individuals with NAFLD had significantly higher BMI and were more likely to have hypertension and diabetes.

The relationship between NAFLD and DM can be explained by the fact that NAFLD is known as the hepatic component of metabolic syndrome, and stronger evidence demonstrates its association with diabetes mellitus [24, 25].

And regarding the relationship between obesity and NAFLD, this study showed that the mean BMI and waist circumference were higher among the NAFLD group (Table 1). This is supported by the similar findings of previous studies [5, 26].

Evidence revealed that fat distribution is a main pathophysiological mechanism for metabolic disease,

and abdominal obesity differs from a more equal fat distribution [27].

This study also demonstrated that high levels of both BMI and waist circumference were significantly independent risk factors for NAFLD (Table 2). Previous studies found similar results by logistic regression analysis [26, 28]. Likewise, a cohort of 2017 subjects showed that visceral fat was associated with increased incidence of NAFLD [29].

CKD risk factors in NAFLD subjects

This study showed that the multivariate regression analysis revealed that the presence of DM (OR = 4.83, 95% CI: 1.89–1237), and the high level of BMI (OR = 1.12, 95% CI: 1.03 – 1.21) were the significant risk factors of CKD in NAFLD subjects (Table 5). A previous Indian study also demonstrated that type 2 diabetes mellitus, was found to be an independent predictor of impaired renal function in patients with NAFLD [30].

Evidence showed that type 2 diabetes mellitus is an important risk factor for development of impaired renal function in the general population [31]. However, there are only few studies which have studied the causative role of presence of type 2 diabetes mellitus in causing impaired renal function in patients with NALFD. Studies from Asian population have found significant association of presence of type 2 diabetes mellitus and impaired renal function in patients with NAFLD [32].

On the other hand, a meta-analysis of correlation between impaired renal function and NAFLD found no association between presence of type 2 diabetes mellitus and impaired renal function in patients with NAFLD [33]. This meta-analysis comprised predominantly of data from studies done on the Western population and thus showed different results.

In concordance with our results, the Indian study [30] and another study [32] also found that BMI was one of the predictors of CKD in patients with NAFLD.

Evidence showed that obesity is one of the strongest risk factors for ESRD in the twenty-first century [34]. Glomerular hypertrophy and hyperfiltration may accelerate kidney injury by increasing capillary wall tension of the glomeruli and decreasing podocyte density [35]. Several studies have assessed the role of obesity in CKD and found that the higher BMI, the higher risk of CKD [36].

Obesity may contribute to the pathogenesis of kidney damage through inflammation, oxidative stress, endothelial dysfunction, prothrombotic state, hypervolemia, and adipokine derangements [37].

Conclusion

This study showed that the prevalence of CKD was higher in individuals with NAFLD than in those without NAFLD. Both NAFLD and CKD were risk factors for each other. The presence of hypertension, and the high levels of BMI and waist circumference were the other independent risk factors of NAFLD. While the presence of DM, and the high level of BMI were the other significant risk factors of CKD in the NAFLD group. And the presence and severity of NAFLD were associated with an increased risk of CKD.

Abbreviations

NAFLD	Non-alcoholic fatty liver disease
CKD	Chronic kidney disease
NASH	Nonalcoholic steatohepatitis
HCC	Hepatocellular carcinoma
NFS	NAFLD fibrosis score
FIB-4	Fibrosis-4 index.
BMI	Body mass index
DM	Diabetes miletus
DALYs	Disability-adjusted life years
eGFR	Estimated glomerular filtration rate.
ACR	Albumin-to-creatinine ratio
MetS	Metabolic syndrome

Supplementary Information

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Additional file 1. Sample size calculation

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Authors' contributions

HEK, study concept and design; EAA and AMM, study concept; EMA, clinical examination, and cases enrollment; AMM, examination, data collection, and first draft; All the authors read and approved the final manuscript.

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Availability of data and materials

The authors confirm that the data supporting the findings of this study are available within the article.

Declarations

Ethics approval and consent to participate

The study was approved by the faculty of medicine (Menoufia University), Ethics Committee and informed consents were taken from the patients recruited to the study.

Consent for publication

Not applicable.

Competing interests

The authors declared no potential competing interests with respect to the research, authorship, and/or publication of this article.

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