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Original article

Echocardiographic Abnormalities and Carotid Artery Atherosclerosis in Metabolic Associated Fatty Liver Disease Patients

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Abstract:

Background: MAFLD is prevalent throughout the world, with an estimated prevalence 25%. Although advanced liver fibrosis has been shown to have a significant impact on the incidence and mortality of cardiovascular diseases (CVDs) in individuals with MAFLD, the relationship between the degree of liver fibrosis and carotid atherosclerosis is still debated. **Aim and objectives:** to evaluate the echocardiographic abnormalities and carotid artery atherosclerosis in MAFLD patients. **Patients and methods:** This cross-sectional study was carried out on 49 patients diagnosed with MAFLD at hepatology, gastroenterology outpatient clinic at mahalla hepatology teaching hospital. **Results:** The mean age ±SD was 43.69 ± 11.36; there were 20.4 % male, 79.6 % female. There was statistically significant correlation between steatosis score and age, AST to platelets ratio, FIB4 score, NAFLD score, systolic blood pressure (SBP), diastolic blood pressure (DBP), fibrosis, triglycerides (TG), total cholesterol, high density lipoprotein (HDL), and low-density lipoprotein (LDL). There was a statistically significant correlation between steatosis score and left Carotid and left ventricular global longitudinal strain (LVGLS). **Conclusion:** we can conclude that MAFLD has a significant association with higher cardiovascular risk in terms of carotid artery atherosclerosis and echocardiographic abnormalities.

Keywords: Echocardiographic abnormalities, carotid artery, atherosclerosis, metabolic associated fatty liver disease (MAFLD)

Introduction

MAFLD is prevalent worldwide with estimated prevalence about 25%. It has been more than 4 decades since the term NAFLD appeared, with the disease moving from a clinical and pathologic description to one that has a set of diagnostic criteria. The NAFLD definition includes: (1) evidence of hepatic steatosis, (2) absence of secondary etiologies of hepatic fat accumulation, and (3) no coexisting etiologies of chronic liver disease. [1]

Metabolic associated fatty liver disease (MAFLD) (formerly known as nonalcoholic fatty liver disease NAFLD) is a novel concept proposed by an international consensus in 2020.[2, 3]

MAFLD is a new nomenclature whose major advantage is the shift towards a diagnosis of inclusion based on metabolic dysfunction, the corner stone of the disease. Hence, it is possible to diagnose MAFLD coexistence with other liver pathology such as chronic viral hepatitis, alcoholic and other liver diseases.[4]

Extrahepatic complications, including diabetes, cardiovascular disease (CVD) and some types of cancer present with MAFLD.[5]

CVDs, which include ischemic heart disease and cerebrovascular stroke, are the most common non- communicable diseases globally, responsible for an estimated 17.8 million deaths in 2017, of which most of them were in low-income and middle-income countries, the global deaths increased by nearly 21% between 2007 and 2017, and were greater for men than for women at most ages in 2017, except for ages≥85 years where there was the largest female-to-male ratio of CVD deaths.[6]

Recently, there is evidence indicating that MAFLD is strongly associated with valvular heart disease (mainly aortic valve sclerosis and mitral annulus calcification), increased risk of cardiomyopathy (mainly left ventricular dysfunction and hypertrophy, leading to the heart failure), arrhythmias (mainly atrial fibrillation and increased QTc interval prolongation) and some cardiac conduction diseases as persistent first-degree atrioventricular block and left anterior hemiblock. Also associated with increased carotid intimal media thickness (CIMT) and subclinical atherosclerosis [7].

This work aimed to evaluate the echocardiographic abnormalities and carotid artery atherosclerosis in MAFLD patients.

Patients and Methods

This cross-sectional study was carried out on consecutive 49 patient diagnosed with MAFLD at hepatology, gastroenterology outpatient clinic at mahalla hepatology teaching hospital and hepatology, gastroenterology Department, Faculty of Medicine, Benha University, from the May 2022 to May 2023. The study was approved by the Ethical committee of Faculty of Medicine, Benha University {M.S.23.3.2022}.

Inclusion criteria

Patients aged ≥18 years who attended hepatology, gastroenterology outpatient clinic at Mahalla hepatology teaching hospital who fulfilled the criteria of MAFLD: Liver steatosis with the presence of at least 1 of 3 criteria including: overweight or obesity, type 2 diabetes mellitus or clinical evidence of metabolic dysfunction.

Exclusion criteria

Patients with active malignancy decompensated liver cirrhosis, congestive hepatopathy, alternative causes of fatty liver (e.g. consumption of amiodarone and tamoxifen) and alcoholism.

Methods

All patients were subjected to the following**:** history taking (Personal history (Name, age and occupation)**,** medical history and current drugs, smoking and alcohol consumption), body mass index (BMI), waist circumference, Blood pressure, laboratory investigations: Complete blood count (CBC), lipids

profile, glucose after fasting for 8 h overnight, glycated hemoglobin (HbA1c), homeostatic model assessment for insulin resistance (HOMA-IR), liver profile. Clinical non invasive scores of fibrosis were calculated:

- The aspartate transaminase (AST) to platelet ratio index (APRI**)** : AST/ (upper limit of normal)/platelet count ($\times 10^9$ /L) $\times 100$.[8]
- Fibrosis index based on 4 factors (FIB-4): {Age × AST (IU/l)}/{platelet count ($\times 10^9$/L) × alanine transaminase (ALT) (IU/L)}.[9]
- The NAFLD fibrosis score: -1.675+{0.037 × age (years)} +{0.094 × BMI (kg/m2)} +{1.13× impaired fasting glucose/diabetes (yes=1, no=0)} +{0.99× AST/ALT ratio}–{0.013× platelet count ($\times 10^9$/l)} – {0.66× albumin (g/dl)} [10].

Abdominal ultrasonography

The patients were divided into three groups according to the grade of steatosis:

- **Grade 1**: Mild steatosis.
- **Grade 2**: Moderate steatosis.
- **Grade 3**: Severe steatosis [11].

FibroScan examination

During the hepatology clinic visit, liver stiffness measurement (LSM) and controlled attenuation parameter (CAP) were obtained using FibroScan 502. All patients fasting for at least 8 hours before the procedure, the LSM score was represented by the median of 10 measurements and was considered reliable only if at least 10 successful acquisitions are obtained and the interquartile range (IQR) to median ratio of the 10 acquisitions are ≤0.3, LSM of patients was graded to F0, F1, F2, F3, and F4 disease b 5.9 ± 1. 8, 7.3 ± 2.8, 8.7 ± 3.4, 11.2 ± 3.8, and 21.2 ± 14.7 kPa, respectively. The CAP score was represented by the median value. CAP measurements were considered reliable and included in the final analysis if 10 successful acquisitions were obtained Hepatic steatosis was graded by CAP using the M probe according to published cut-offs (S1=222–232; S2=233–289; S3 ≥290 dB/m) [12].

Echocardiography

Comprehensive echocardiography was performed by specialist following the American society of echocardiography guidelines. Echocardiography was performed with a standard ultrasound machine (Vivid 9, General Electric Medical Systems, Horten, Norway) equipped with 2.5 MHz variable-frequency harmonic-phased array transducers with a simultaneous ECG signaling. All subjects were studied in the left lateral recumbent position. Images were recorded in the standard parasternal long axis and short-axis and apical four, two, and five chamber views.

Conventional echocardiography:

Routine M-mode, two-dimensional, pulsed, and continuous wave Doppler recordings were obtained for each subject to measure:

- The end-diastolic LV diameter (LVEDD).
- End-systolic LV diameter (LVESD).
- Left Atrial dimensions (LAD).
- Mitral annular plane systolic excursion (MAPSE).
- Tricuspid annular plane systolic excursion (TAPSE).
- LV ejection fraction (EF).
- E/A ratio.

All measurements were made based on the standards of the American Society of Echocardiography (ASE).

Two-dimensional strain and strain rate imaging:

For measurement of left ventricle longitudinal strain and strain rate, two dimensional images from the apical four-chamber, two-chamber and three chamber views were obtained. All recordings included at least three cardiac cycles and were digitally stored for off-line analysis. Stored images were opened by the machine software, which automatically brings up the end-systolic frame of the cardiac cycle.

In the end-systolic frame, endocardial border was traced manually, beginning at one end of the mitral annulus, and ending at the other end. The software then generated a region of interest (ROI) including the entire myocardial thickness. The ROI was manually adjusted to achieve a satisfactory image. The software then tracked the myocardial speckles frame by frame and generated moving images displaying the tracking. Careful visual inspection of the moving image was done to determine the adequacy of the tracking. If the tracking was not accurate, readjustment of the ROI or selection of a new ROI was done.

The software divided the left ventricle myocardium into six segments and generates segmental and global longitudinal strain, strain rate, velocity and displacement curves. As the myocardium usually shortens in longitudinal direction during systole, the longitudinal strain and strain rate curves are displayed below the baseline. The apical long-axis image (i.e. three-chamber view) was first image to be analysed. In this view, the movement of aortic valve leaflets helps in timing the aortic valve closure which is essential for the software to be able to perform the deformation analysis. The same process was then repeated with the apical four chambers and two-chamber images also. The strain values for all the segments were recorded and averaged to obtain the global longitudinal strain (GLS) which was > 18% normal, 16%-18% borderline, and < 16% abnormal (expressed as a negative number).

Carotid Artery Evaluation

The carotid intima-media thickness (CIMT) which is an accepted marker for atherosclerosis and correlate to the pathology and parallel to cardiovascular risk factors is the difference between intima media and media adventitia of far and near wall of carotid arteries, the CIMT was evaluated by an exported radiologist using b-mode ultrasonography, the carotid artery was investigated in longitudinal projection of both left and right of common carotid ,bulb and internal carotid near and far wall at multiple angels .The edge detection was performed manually, a carotid plaque was identified as a focal thickening is >1.3 mm.

Expected outcome.

This work would aid in filling the current gaps of knowledge on the burden of extra-hepatic manifestation of MAFLD in Egypt and this work aimed to increase awareness by MAFLD among other specialist and represent a nucleus for consideration screening for MAFLD in diabetes and cardiovascular guidelines.

Administrative and Ethical Design: An official permission was obtained from faculty of medicine, Benha university, an official permission was obtained from hepatology, gastroenterology and infectious diseases department at mahalla teaching hospital, approval from ethical committee in the faculty of medicine (Institutional Research Board IRB) and A written consent was obtained from each patient enrolled in the study.

Statistical analysis

The collected data were coded, processed, and analysed using the SPSS (Statistical Package for Social Sciences) version 27 for Windows® (IBM SPSS Inc, Chicago, IL, USA).

Data were tested for normal distribution using the Shapiro Walk test. Parametric quantitative data were expressed as mean ± SD (Standard deviation) while non-parametric quantitative data were expressed as median (range).

Qualitative data were represented as frequencies and relative percentages**.**

Data analysis

Qualitative data:

- Chi-Square test for comparison of 2 or more groups
- Monte Carlo test as correction for Chi-Square test when more than 25% of cells have count less than 5 in tables (>2*2).
- The Fischer Exact test was used as correction for Chi-Square test when

more than 25% of cells have count less than 5 in 2*2 tables.

Quantitative data between two independent groups:

Parametric data:

- Student t-test was used to compare 2 independent groups.

Non-Parametric data:

- Mann-Whitney U test was used to compare 2 independent groups.

Spearman's correlation was used to test the correlation between two variables with quantitative data.

The value of the test expressed as r; values are interpreted as follows:

- Positive value indicated Direct proportion
- Negative correlation indicated inverse correlation.
- r from (0: 0.3) or (0: -0.3)…… weak correlation.
- r from (0.3: 0.6) or (-0.3: -0.6)…… moderate correlation
- r from (0.6: 1) or (-0.6: -1)…… strong correlation

Level of significance (P-value)

In all applied tests, the *P*-values associated with test statistics indicated the significance level at which the null-hypothesis (the hypothesis of no difference) was rejected, and it was set at 0.05 so that a *P*-values ≥ 0.05 are statistically non-significant, *P*-values < 0.05 are significant, and *P*-values < 0.01 are highly significant.

Results

The studied patients were divided regarding the steatosis grades into: S1 6 patients, S2 17 patients and S3 26 patients. As regards to demographic data the mean age ±SD was 43.69 ± 11.36, median was 40 years ranged from 19 to 70 years, there were 20.4 % male, 79.6 % female.

The results showed that as regards to fibrosis grading there were 38.8% of the studied cases F0, 30.6% had F1, 4.1% had F2, 6.1 % had F2-F3, 2.0% had F3, 4.1% had F3-F4, 14.3% had F4, (the commonest was F0)

Regarding to Steatosis grading there were 12.2 % had S1, 34.7% had S2, 53.1% had S3, (the commonest was S3) .Regarding to US grading there were 12.2% G1, 34.7% G2, and 53.1% G3. (Table1).

Table (1): Fibrosis grading, steatosis, and US grading in the cases of the study.

Items	**Study patients N = 49**	
Fibrosis grading	N	%
F0	19	38.8
F1	15	30.6
F2	2	4.1
F2-F3	3	6.1
F3	1	2.0
F3-F4	2	4.1
F4	7	14.3
Steatosis grading	N	%
S1	6	12.2
S2	17	34.7
S3	26	53.1
US grading	N	%
G1	6	12.2
G2	17	34.7
G3	26	53.1

Categorical data expressed as Number (%).

Regarding to US grading there was statistically significant difference between different grades of steatosis P < 0.001* **(**Table 2).

There was statistically significant difference between different grades of steatosis regarding Triglycerides, Total cholesterol (mg/dl) HDL (mg/dl), LDL (mg/dl) (P value <0.0001 (Table 3).

Comparing the angiographic findings within the study patients with different grades of steatosis, there was no statistically significant difference among the study patients regarding Right carotid intimal thickening, Left carotid intimal thickening, Plaque (Table 4).

Comparing the echocardiographic findings within the study patients with different grades of steatosis there was no statistically significant difference among the study groups regarding EDD, ESD, EF (%), LAD, E/A ratio, e, a, TAPSE, MAPSE. While there was statistically significant difference among the study groups regarding LV GLS (%) (Table 5)

In Correlation between steatosis score with clinical and laboratory data in the cases of the study, there were statistically significant correlation between steatosis score and age, AST to platelets ratio, FIB4 score, NAFLD score, SBP, DBP, fibrosis, TG, total cholesterol, HDL, and LDL. While there was no statistically significant correlation between steatosis score and waist circumference, BMI, AST, ALT, Albumin, Platelets, HBA1C, and HOMAIR.

There was statistically significant correlation between steatosis score and left Carotid and LV GLS. While there was no Statistically significant correlation between steatosis score and right Carotid, EDD, ESD, EF, LAD, E/A ratio, e, a, TAPSE, and MAPSE.

Table (2): Comparison of the ultrasound grading within the study patients with different grades of steatosis.

Variable	Steatosis grade 1 (S1) N= 6	Steatosis grade 2 (S2) N= 17	Steatosis grade 3 (S3) N= 26	Test of sig.
US grading				
G1	6 (100%)	0 (0%)	0 (0%)	$\chi 2$= 98
G2	0 (0%)	17 (100%)	0 (0%)	P < 0.001*
G3	0 (0%)	0 (0%)	26 (100%)	

$\chi 2$: Chi-square test *: statistically significant if P <0.05

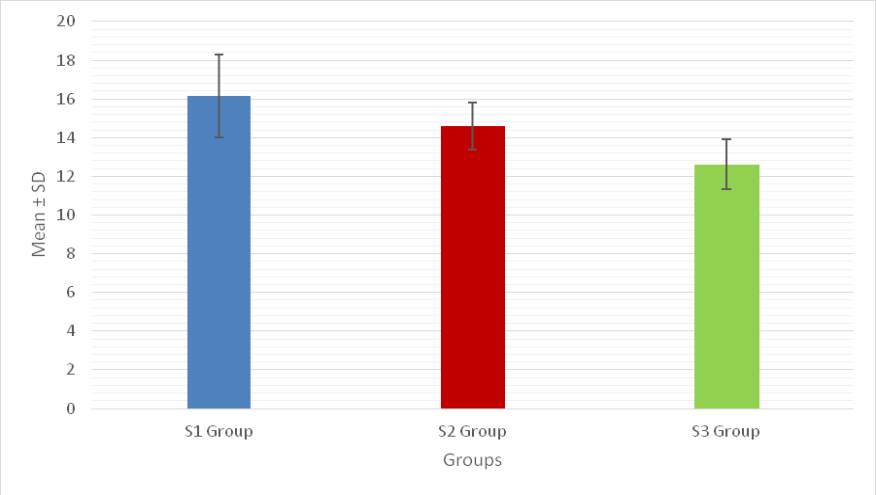

Figure 1: LV GLS (%) in study patients with different grades of steatosis

Table (3): Comparison of the other laboratory findings and non invasive scores within the study patients with different grades of steatosis.

Variable	Steatosis grade 1 (S1) N= 6	Steatosis grade 2 (S2) N= 17	Steatosis grade 3 (S3) N= 26	Test of sig.
Hemoglobin (gm/dl) [Mean ± SD]	10.92 ± 2.50	10.39 ± 2.07	10.63 ± 1.94	F= 0.897 P = 0.532
WBCs (10^3/ml) [Mean ± SD]	7.51 ± 2.07	7.76 ± 1.88	7.40 ± 2.11	F= 1.224 P = 0.270
PLTs (10^3/ml) [Mean ± SD]	296,67 ± 64.32	261.17 ± 78.19	260.4 ± 73.74	F= 0.616 P = 0.545
HbA1c [Mean ± SD]	6.47 ± 0.55	6.35 ± 0.83	6.53 ± 0.70	F= 0.335 P = 0.717
FBG (gm/dl) [Mean ± SD]	110.66 ± 13.7	117.9 ± 19.32	125.40 ± 18.93	F= 2.148 P = 0.066
HOMAIR [Mean ± SD]	2.38 ± 0.29	2.47 ± 0.47	2.65 ± 0.63	F= 0.845 P = 0.436
Albumin [Mean ± SD]	4.18 ± 0.26	4.02 ± 0.44	4.18 ± 0.61	F= 0.559 P = 0.576
ALT [Median(min-max)]	15.50 (10-18)	20 (10-46)	18 (10-54)	KW= 3.173 P = 0.205
AST [Median(min-max)]	10.50 (8-14)	17 (8-40)	14.50 (7-50)	KW= 3.367 P = 0.186
Triglycerides [Mean ± SD]	113 ± 25.69	138.12 ± 29.58	153.46 ± 29.99	F= 5 P = 0.011* P1= 0.181 P2= 0.011* P3= 0.277
Total cholesterol (mg/dl) [Mean ± SD]	167,50 ± 13.32	197.24 ± 21.92	208.19 ± 19,31	F= 15.530 P < 0.001* P1= 0.007* P2< 0.001* P3= 0.187
HDL (mg/dl) [Mean ± SD]	58.33± 5.16	50.06 ± 8.04	46.92 ± 6.36	F= 6.812 P = 0.003* P1= 0.039* P2= 0.002* P3= 0.319
LDL (mg/dl) [Mean ± SD]	82.83± 18.71	110 ± 23.72	120.62 ± 21.75	F= 7.230 P = 0.002* P1= 0.034* P2= 0.001* P3= 0.284
AST to platelets ratio [Median (min-max)]	0.10 (0.10- 0.10)	0.10 (0.10- 0.60)	0.10 (0.10- 0.90)	KW= 3.356 P = 0.161
FIB4 [Median(min-max)]	0.33 (0.24-0.74)	0.51 (0.22- 2.27)	0.51 (0.27- 3.40)	KW= 3.935 P = 0.140
NAFLD score [Median (min-max)]	-3.12 (-4.49: -1.34)	-1.92 (-4.23: 2.88)	1.53 (-4.50: 0.72)	KW= 3.839 P = 0.147

F: One way ANOVA KW: Kruskal Wallis test
*: statistically significant if P <0.05
P1: Significance between S1 and S2 group
P2: Significance between S1 and S3 group
P3: Significance between S2 and S3 group
WBCs: White blood cells. HOMAIR: Homeostatic Model Assessment Insulin Resistance.
PLTs: Platelets. AST: aspartate aminotransferase.
FBS: Fasting blood sugar.
HBA1C: Glycated haemoglobin
ALT: alanine aminotransferase.
LDL: Low density lipoprotein.
HDL: High density lipoprotein

Table (4): Comparison of the angiographic findings within the study patients with different grades of steatosis.

Variable	Steatosis grade 1 (S1) N= 6	Steatosis grade 2 (S2) N= 17	Steatosis grade 3 (S3) N= 26	Test of sig.
Right carotid intimal thickening [Median (min-max)]	0.40 (0.4- 0.7)	0.5 (0.3-0.7)	0.5 (0.3-1.40)	KW= 1.539 P = 0.463
Left carotid intimal thickening. [Median (min-max)]	0.4 (0.4-0.5)	0.5 (0.4-0.7)	0.5 (0.3-1.3)	KW= 3.995 P = 0.136
Plaque				
No plaques	6 (100%)	16 (94.1%)	23 (88.5%)	MC= 1.444
Single plaque	0 (0%)	1 (5.9%)	2 (7.7%)	P= 0.837
Two plaques	0 (0%)	0 (0%)	1 (3.8%)	

KW: Kruskal Wallis test MC: Monte- Carlo test

Table (5): Comparison of the echocardiographic findings within the study patients with different grades of steatosis.

Variable	Steatosis grade 1 (S1) N= 6	Steatosis grade 2 (S2) N= 17	Steatosis grade 3 (S3) N= 26	Test of sig.
EDD [Mean ± SD]	4.62 ± 0.39	4.94 ± 0.46	4.96 ± 0.53	F= 1.202 P = 0.310
ESD [Mean ± SD]	2.88 ± 0.50	3.08 ± 0.46	3.08 ± 0.42	F= 0.528 P = 0.593
EF (%) [Mean ± SD]	68.67 ± 9.54	67.59 ± 6.65	67.69 ± 6.44	F= 0.058 P = 0.944
LAD [Mean ± SD]	3.68 ± 0.19	3.75 ± 0.22	3.65 ± 0.59	F= 0.230 P = 0.795
E/A ratio [Mean ± SD]	1.11 ± 0.38	1.06 ± 0.33	1.05 ± 0.33	F= 0.096 P = 0.909
E [Mean ± SD]	6.33 ± 1.21	5.92 ± 1.14	5.73 ± 1.19	F= 0.667 P = 0.518
A [Mean ± SD]	12 ± 1.67	10.88 ± 1.90	10.35 ± 1.23	F= 2.916 P = 0.064
TAPSE [Median (min-max)]	2 (1.80-2.60)	2.20 (1.70- 11)	2.30 (1.70- 3.16)	KW= 0.666 P = 0.710
MAPSE [Mean ± SD]	1.52 ± 0.28	1.61 ± 0.23	1.56 ± 0.22	F= 0.334 P = 0.718
LV GLS (%) [Mean ± SD]	16.17 ± 2.14	14.59 ± 1.23	12.62 ± 1.30	F= 20.765 P < 0.001* P1= 0.054 P2< 0.001* P3< 0.001*

KW: Kruskal Wallis test F: One way ANOVA
*: statistically significant if P <0.05
P1: Significance between S1 and S2 group
P2: Significance between S1 and S3 group
P3: Significance between S2 and S3 group
ESD: End systolic dysfunction EDD: End diastolic dysfunction EF: Ejection fraction.
LAD: Left atrial diameter TAPSE: Tricuspid annular plane systolic excursion
MAPSE: Mitral annular plane systolic excursion
LV GLS: Left ventricular global longitudinal strain.

Discussion

Non-alcoholic fatty liver disease (NAFLD) encompasses a wide spectrum of pathological hepatic conditions ranging from simple steatosis to non-alcoholic steatohepatitis, and may ultimately progress to advanced fibrosis, cirrhosis, and end-stage liver disease.[13, 14] .Over the last 20 years, NAFLD has become the leading cause of chronic liver disease, with an estimated 1billion people affected worldwide.[15]

The current study aimed to evaluate the echocardiographic abnormalities and carotid artery atherosclerosis in MAFLD patients.

The main results as follows:

Regarding the demographic data the results showed that the mean age was 43.69 ± 11.36, there were 20.4 % male, 79.6 % female, and median was 40 years ranged from 19 to 70 years.

The results showed that regarding fibrosis grading there were 38.8% of the studied cases F0, 30.6% had F1, 4.1% had F2, 6.1 % had F2-F3, 2.0% had F3, 4.1% had F3-F4, 14.3% had F4, (the commonest was F0)

Regarding steatosis grading there were 12.2 % had S1, 34.7% had S2, 53.1% had S3, (the commonest was S3)

Regarding US grading there were 12.2% G1, 34.7% G2, and 53.1% G3. (Table1)

This comes in agreement with [16] who found that steatosis grades (0-3) < 5% 0 5%-33% 1 34%-66% 2 > 66% 3 , but disagreed with [17] who found that fibrosis stages were 43 % F1, 25% F0, 13 % F2, 10 % F3 and 9% F4. (The commonest was F1).

In the current study, comparing the ultrasound grading within the patients with different grades of steatosis, there was statistically significant difference among the study patients with different grades of steatosis which increased with the grade of steatosis P < 0.001*. (Table 2).

The results proposed with [18] Who found that US examination is by far the commonest way of diagnosing NAFLD and the presence of > 33% fat on liver biopsy was optimal for radiological detection of steatosis**.**

In the present study, comparing the other laboratory findings in different grades of steatosis, there was no statistically significant difference among the study patients regarding hemoglobin (gm/dl), WBCs (103/ml), PLTs (103/ml), HbA1C, fasting blood glucose (gm. /dl), HOMAIR, Albumin, ALT, AST, AST to platelets ratio, FIB4 score and NAFLD score. While there was statistically significant difference in different grades of steatosis regarding triglycerides (TG) which increases between S1 and S3 group P < 0.011*, total cholesterol (mg/dl), and LDL (mg/dl) which all increases between S1 and S2 group , S1 and S3 P < 0.001*,While HDL decreases between S1 and S2 group, S1 and S3 group (mg/dl) P = 0.003* (Table 3).

The results agree with [19] who found that patients with NAFLD had significantly higher levels of LDL cholesterol and triglycerides and lower levels HDL cholesterol than those of non-NAFLD group.

However, disagree with [20] who found that total cholesterol was statistically non-significant between the study groups.

In the current study, there was an increase in the right carotid intimal thickening and left carotid intimal thickening with increasing the grade of steatosis, however, it didn't reach a statistically significant difference. Also, there was an increase in the plaques with an increase in the steatosis grade. The lack of significant difference is mostly due to small sample size (Table 4).

Also, researchers [21] agreed that patients with NAFLD were found to be associated with increased carotid atherosclerosis, data analyzed from 30 studies involving 7,951 patients with NAFLD, 35.02% had carotid atherosclerosis**.**

However, this comes in disagreement with [22] study investigated the association between NAFLD and carotid intima-media thickness (CIMT). The outcomes included the presence of increased CIMT.

In the study, comparing the echocardiographic findings within different grades of steatosis there was no statistically significant difference regarding EDD, ESD, EF (%), LAD, E/A ratio, e, a, TAPSE, MAPSE**.** While there was statistically significant difference regarding LV GLS (%) which decrease among S1 and S3 group and S1 and S2 group P < 0.001* (Table 5)

The results agreed with others[23] who assessed several functional echocardiographic parameters including average GLS (p-value < 0.001*), which were significantly lower in MAFLD patients compared to controls. , while disagreed regarding EF % (p <.04*) and E/A ratio (p <.001)* which were significantly lower in MAFLD patients.

However, the current results disagreed with other previous results [24] of the investigation of the relationship between the severity of hepatic steatosis with MAFLD and LVDD by the same method as above, was done. Moderate to severe hepatic steatosis had higher prevalence of LVDD (p < 0.0001). The lack of significant difference mostly due to small sample size and the lack of control group The results showed that the correlation between steatosis score with clinical and laboratory data in the cases of the study, there were statistically significant correlation between steatosis score and age, aspartate aminotransferase (AST) to platelets ratio (APRI), FIB4, NAFLD score, SBP, DBP, fibrosis, TG, total cholesterol, HDL, and LDL. While there was no statistically significant correlation between steatosis score and waist circumference, body mass index (BMI), aspartate aminotransferase (AST), alanine aminotransferase (ALT), albumin, Platelets, HBA1c, and HOMA-IR.

The results of the current study agree with others [18] who found that significantly higher blood pressure, and lipid profile were found in the subjects with NAFLD, while disagree with the same study who found that significantly higher BMI and liver enzymes in subjects with NAFLD. Also, [25] found that the systolic blood pressure (SBP), diastolic blood pressure (DBP), hepatic enzymes AST, ALT gamma-glutamyl transferase [GGT] lipid profile (triglyceride [TG], total cholesterol [TC], high density lipoprotein [HDL], correlated with NAFLD. However, there was no correlation between age, alkaline phosphatase, and low-density lipoprotein [LDL].

Conclusion

Based on the findings, the conclusion is MAFLD has a significant association with higher cardiovascular risk in terms of carotid artery atherosclerosis and echocardiographic abnormalities. There was a statistically significant correlation between steatosis score and age, AST to platelets ratio (APRI), FIB4 score, NAFLD score, SBP, DBP, fibrosis, TG, total cholesterol, HDL, and LDL. There was a statistically significant correlation between steatosis score and left carotid and LV GLS.

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