AUCTORES
Globalize your Research

Cardiology Research and Reports

Fakhr Z. Al Ayoubi *

Open Access

Research Article

Metabolic Syndrome Among Patients Underwent Coronary Artery Bypass Grafting Surgery: Retrospective Cohort Study

Fakhr Z. Al Ayoubi

King Fahad cardiac Centre, College of Medicine, King Saud University Medical City, Saudi Arabia.

***Corresponding Author:** Fakhr Z. Al Ayoubi, King Fahad cardiac Centre, College of Medicine, King Saud University Medical City, Saudi Arabia.

Received date: January 31, 2024; **Accepted date:** February 08, 2024; **Published date:** February 23, 2024

Citation: Fakhr Z. Al Ayoubi (2023), Metabolic Syndrome Among Patients Underwent Coronary Artery Bypass Grafting Surgery: Retrospective Cohort Study, *Cardiology Research and Reports*. 6(2); **DOI:10.31579/2692-9759/114**

Abstract

Background: A group of factors known as the metabolic syndrome (MS) is linked to a higher risk of cardiovascular disease. The underlying pathophysiology of MS involves a low-grade inflammatory process, which raises the possibility that it may negatively impact coronary procedures, such as coronary artery bypass grafting (CABG) surgery with cardiopulmonary bypass (CPB). In patients following CABG, our goal was to assess the impact of the MS on, complications, morbidity and death rates in the early postoperative period.

Materials and Methods: Retrospectively, 212 patients were included, 183 males and 29 females, mean age of 55.72 ± 12.31 years, 102 with MS. Data collection between January and September 2022, elective heart operations were performed on every patient. Subjects with and without MS were compared in terms of early postoperative morbidity and death rates. The American National Cholesterol Education Program Adult Treatment Panel III (NCEP ATP III) criteria used to make the MS diagnosis.

Results: CABG patients with and without metabolic syndrome revealed a statistically significant difference in terms of gender distribution (P=0.001) and DM (P=0.017), higher preoperative FBS (with a median of 11 vs 6.95 mmol/L, P=0.001), HbA1C (8.7 vs 7.3 %, P=0.02) and triglycerides (2.2 vs 1.42 mmol/L, P<0.001), lower heart rate than those with no MS (with a median of 90 vs 95 bpm, P=0.048). positive correlation between Metabolic syndrome severity score and each of, FBS (r=368, P value<0.001), triglycerides (r=0.422, P value<0.001) and HbA1C (r=0.294, P value=0.006) preoperatively. However, an inverse correlation of a significant value was detected between MetSSS and both HR (-0.218, P value=0.016) and CC time (r=-0.211, P value=0.038). In comparison to patients classified as NYHA I, those classified as NYHA IV had significantly shorter ICU stay with coefficient of -818.28, 95%CI: -1532.96 to -103.6, P value=0.025. Also, patients with COPD had longer ICU stay than others [coefficient = 392.04, 95%CI: 104.14 to 679.93, P value=0.008].

Conclusion: While the MS had no appreciable impact on the mortality rate, it was linked to a higher rate of early postoperative morbidity after CABG.

Keywords: coronary artery bypass grafting surgery; metabolic syndrome; postoperative morbidity and mortality

Introduction

Metabolic syndrome (MS) includes insulin resistance, central obesity, hypertriglyceridemia, low HDL cholesterol, hypertension, and glucose intolerance [1]. Insulin resistance, another characteristic of MS, is the underlying mechanism causing the cluster of cardiovascular risk factors in MS [2]. Although this mechanism and related processes still need to be clarified, it has been suggested that insulin resistance plays a significant unifying role in the increased ischaemic events in MS patients [3-5]. According to the American National Cholesterol Education Program Adult Treatment Panel III (NCEP ATP III), a diagnosis of MS requires that at least three out of five criteria (Table 1) be satisfied [6].

The prevalence of MS has been estimated to be between 35 and 40% in industrialized nations [7]. It is an inflammatory condition marked by elevated levels of free fatty acids, which promote vasoconstriction and endothelial dysfunction, as well as adipocytokines such tumour necrosis factor-, interleukin-6, and C-reactive protein. The MS is sometimes referred to as a low-grade inflammatory condition characterized by elevated levels of inflammatory cytokines in the blood. Patients with MS have been found to have lower plasma levels of adiponectin and higher levels of leptin and resistin. Adiponectin, on the other hand, slows the inflammatory process in the vascular wall, mostly by suppressing the nuclear factor kappa B pathway, in contrast to leptin and resistin, which boost the immune system [2]. Patients

may be more vulnerable to peri-operative complications due to the pro-inflammatory condition associated with MS, which may contribute to the worsening of the systemic inflammatory response brought on by cardiopulmonary bypass (CPB) and surgical stress [8].

The MS is a collection of metabolic disturbances that are mostly brought on by abdominal obesity, which is linked to a higher risk of type 2 diabetes and cardiovascular disease [9]. The relationship between it and early and late mortality and morbidity following coronary artery bypass graft (CABG) surgery has recently been described, and it has been proven to be a predictor of adverse outcomes after cardiovascular treatments, but other studies have been unable to confirm this [11-13]. We created prospective research to examine the influence of the MS on postoperative morbidity and death rates following CABG because we hypothesized that it may have a negative effect on the outcomes in patients receiving CABG surgery.

Methods

Between January and September 2022, 212 patients who underwent elective heart procedures at King Saud University Medical City in Riyadh, Saudi Arabia, were retrospectively included. According to the NCEP ATP III criteria, MS was diagnosed. Depending on the MS diagnosis, patients were split into two groups (those with MS and those without).

All patients' preoperative and postoperative data were gathered and added to a computerized database. A MD physician with a nurse oversaw the trained staff that collected the patients' demographic information, clinical, laboratory, and intensive care unit (ICU) data, as well as information on risk factors, medicines, and functional status. An author noted postoperative problems, and an expert heart surgeon concurrently validated all serious adverse events in accordance with standardized standards.

The research excluded patients with liver failure, emergency surgery, re-operative surgery, CABG on a beating heart, further valve repair or replacement, an ejection fraction of less than 45%, and those needing pre-operative pacemaker insertion. The hospital's institutional review board gave the study procedure its approval.

Age, gender, mean blood pressure, waist circumference, smoking status, and co-morbidities such type 2 diabetes mellitus, systemic hypertension, and obesity were among the demographic and clinical characteristics. Body mass index (BMI) was computed after using a calibrated stadiometer to measure height in centimeters and a calibrated digital scale to measure weight in kilograms. A skilled nurse used a cotton tape around the waist to measure the circumference at the midway between the lowest part of the costal margin and the highest point of the iliac crest. Usage of diabetes drugs or a fasting plasma glucose level of less than 110 mg/dl (6.11 mmol/l) were used to characterize diabetes mellitus.

Age, gender, height, BMI, waist circumference, duration of diabetes, use of insulin or anti-diabetic medications, low-density lipoprotein (LDL-C), high-density lipoprotein cholesterol (HDL-C), triglyceride and fasting blood glucose levels, smoking status, postprandial blood glucose (PPBG), and blood urea nitrogen levels were some of the patients' characteristics (BUN), creatinine, left ventricular ejection fraction, bilirubin, thyroid stimulating hormone (TSH), aspartate aminotransferase (AST), alanine aminotransferase (ALT), hematocrit, hemoglobin, thyroid stimulating hormone (free T4), and thyroid stimulating hormone (TSH).

Prior to surgery, blood pressure (BP) readings were taken using a mercury sphygmomanometer while the patient was seated and after at least 10 minutes of rest. Clinical blood pressure is the average of three readings obtained at two-minute intervals. Antihypertensive treatment or a blood pressure reading of less than 140/90 mmHg from at least two readings were used to identify hypertension. Hyperlipidaemia was defined as a total cholesterol level of greater than 200 mg/dl (5.18 mmol/l) or a history of increased serum total cholesterol within the previous six months that led to the prescription of lipid-lowering medications. Smokers were defined as both active smokers and former smokers who had given up smoking during the previous three years.

The number of CABG procedures, number of grafts, cardiopulmonary bypass time (min), and aortic cross-clamp time were among the perioperative factors. All-cause mortality, death within one month of surgery, renal failure, postoperative creatinine level > 2.5 mg/dl (221 mmol/l), need for haemodialysis, prolonged use of pulmonary ventilator > 24 hours, acute myocardial infarction, ST-segment changes, prolonged ventilation (more than 72 hours), re-intubation, wound infection, stroke, and localized neurological dysfunctions that resolved within 24 hours without complications were postoperative variables. The amount of time spent in the ICU and hospital was additional information.

Radial and pulmonary arterial catheters were inserted while under local anesthesia. Using midazolam (0.05–0.1 mg/kg), Fentanyl (4-6 g/kg) or Sufentanil (0.6–0.8 g/kg), Atracurium (0.5 mg/kg) or Pancuronium (0.1 mg/kg), and Thiopental sodium (1-2 mg/kg), anaesthesia was inducted before tracheal intubation was performed on all patients. Under CPB, all procedures were carried out under mild to moderate hypothermia (28–32°C). Intermittent antegrade or mixed antegrade and retrograde saline or blood cardioplegia was used to preserve the myocardium. CPB and aortic cross-clamp times were two surgical outcomes.

Statistical analysis

Statistical analysis was done by SPSS version 28 (IBM Co., Armonk, NY, USA). Quantitative parametric data were presented as mean and standard deviation (SD), analyzed by unpaired student t-test. Quantitative non-parametric data were presented as the median and interquartile range (IQR), analyzed by Mann Whitney-test. Categorical data were presented as frequency and percentage (%), analyzed using the Chi-square test or Fisher's exact test when appropriate. The overall survival analysis was conducted using Kaplan Meier plot and Log-rank test to assess the survival probability and the expected duration until mortality occurred. Spearman's rank correlation coefficient was calculated to assess the degree of correlation between two quantitative variables. Linear regression analysis was conducted to assess different factors associated with ICU length of stay. A two tailed P value < 0.05 was considered statistically significant.

Results

Data are presented as frequency (%) or mean ± SD as appropriate, BMI: Body mass index, CABG: Coronary artery bypass graft This study included 183 males and 29 females with a mean age of 55.72 ± 12.31 years, a mean BMI of 27.9 ± 5.47 kg/m2 and a mean waist circumference of 93.56 ± 14.39 cm. Of the included patients, 39.6% were Saudi. More than half of patients (57.5%) were subjected to CABG surgery as summarized in Table 1, Figure 1

	Total patients (n=212)
Age (years)	55.72 ± 12.31
BMI (kg/m^2)	27.9 ± 5.47
Waist circumference (cm)	93.56 ± 14.39
Gender	
Male	183 (86.3%)
Female	29 (13.7%)
Nationality	
Saudi	84 (39.6%)

Non-Saudi	128 (60.4%)
Type of surgery	
CABG	122 (57.5%)
Non-CABG	59 (27.8%)
Both	31 (14.6%)

Table 1: Baseline characteristics of the studied patients

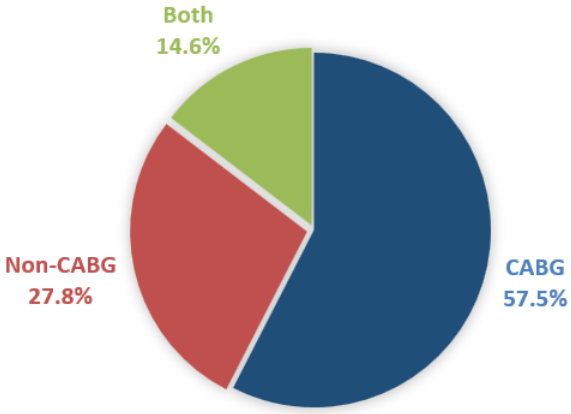

Figure 1: Type of surgery performed on patients

Data are presented as frequency (%) or mean ± SD as appropriate, MetSSS: Metabolic Syndrome Severity Score Out of 122 CABG patients, 27% had metabolic syndrome. All patients had a mean MetSSS of 1.89 ± 0.89. As for males and females, they had mean scores of 1.77 ± 0.83 and 3 ± 0.77 respectively. [Table 2, Figure 2]

	CABG patients (n=122)
Metabolic syndrome	
No	89 (73%)
Yes	33 (27%)
MetSSS	1.89 ± 0.89
Male	1.77 ± 0.83
Female	3 ± 0.77

Table 1: The incidence rate of metabolic syndrome among CABG patients

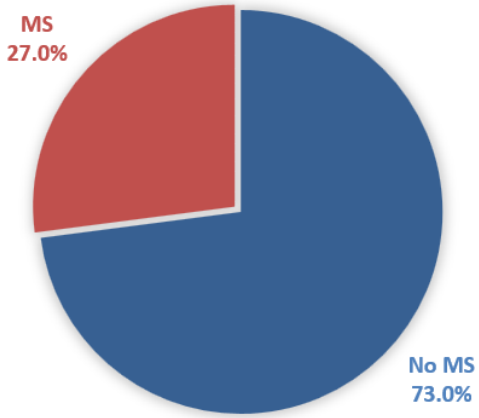

Figure 2: The incidence rate of metabolic syndrome among CABG patients

Data are presented as frequency (%) or mean ± SD as appropriate, *: Statistically significant as P value<0.05, BMI: body mass index, MI: Myocardial infarction, NYHA: New York Heart Association, EF: Ejection fraction, DM: Diabetes mellitus, HTN: Hypertension, COPD: Chronic obstructive pulmonary disease, PVD: Peripheral vascular disease, RF: Renal failure

The comparison between CABG patients with and without metabolic syndrome revealed a statistically significant difference in terms of gender distribution (P=0.001) and DM (P=0.017) as MS patients had higher prevalence rates of DM than those with no MS. [Table 3, Figure 3 - Figure 4]

	Metabolic syndrome		P value
	Absent (n=89)	**Present (n=33)**	
Age (years)	57.56 ± 10.11	56.42 ± 9.14	0.572
BMI (kg/m^2)	28.36 ± 5.44	28.46 ± 4.59	0.922
Waist circumference (cm)	95.36 ± 15.06	93.03 ± 10.41	0.415
Gender			
Male	86 (96.63%)	25 (75.76%)	0.001*
Female	3 (3.37%)	8 (24.24%)	
Nationality			
Saudi	38 (42.7%)	8 (24.24%)	0.062
Non-Saudi	51 (57.3%)	25 (75.76%)	
Previous MI	39 (46.43%)	15 (48.39%)	0.852
Type of MI			
STEMI	27 (30.34%)	7 (21.21%)	0.297
NSTEMI	12 (13.48%)	8 (24.24%)	
Unknown	50 (56.18%)	18 (54.55%)	
NYHA			
I	17 (19.1%)	6 (18.18%)	0.3
II	61 (68.54%)	24 (72.73%)	
III	11 (12.36%)	2 (6.06%)	
IV	0 (0%)	1 (3.03%)	
EF (%)			
<20	0 (0%)	1 (3.03%)	0.402
20 – 39	14 (15.73%)	4 (12.12%)	
40 – 59	52 (58.43%)	19 (57.58%)	
≥60	23 (25.84%)	9 (27.27%)	
DM and treatment			
Non-diabetic	43 (48.31%)	6 (18.18%)	0.017*
On diet	1 (1.12%)	0 (0%)	
On insulin	11 (12.36%)	9 (27.27%)	
On Oha	34 (38.2%)	18 (54.55%)	
HTN	57 (64.04%)	24 (72.73%)	0.367
FH of heart disease	3 (3.41%)	0 (0%)	0.564
COPD	4 (4.49%)	2 (6.25%)	0.654
PVD	1 (1.12%)	1 (3.03%)	0.469
Smoking			
Non-smoker	45 (50.56%)	19 (57.58%)	0.787
Ex-smoker	13 (14.61%)	4 (12.12%)	
Current smoker	31 (34.83%)	10 (30.3%)	
RF	5 (5.62%)	1 (3.03%)	>0.999

Table 3: Association between metabolic syndrome and patients' characteristics

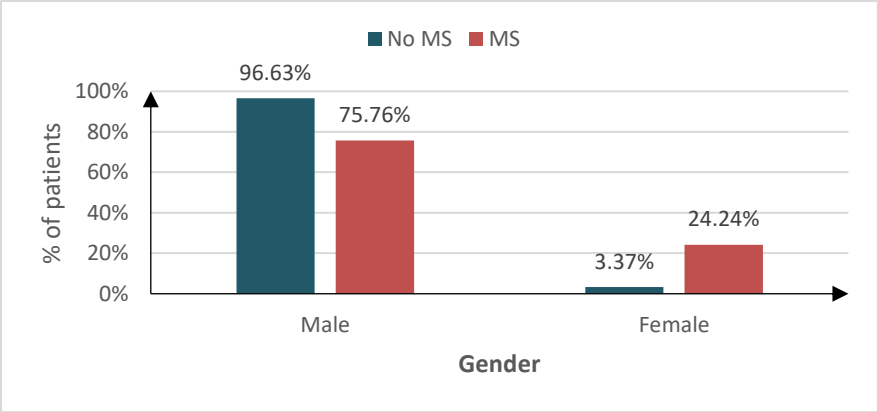

Figure 3: Association between metabolic syndrome and gender distribution among CABG patients

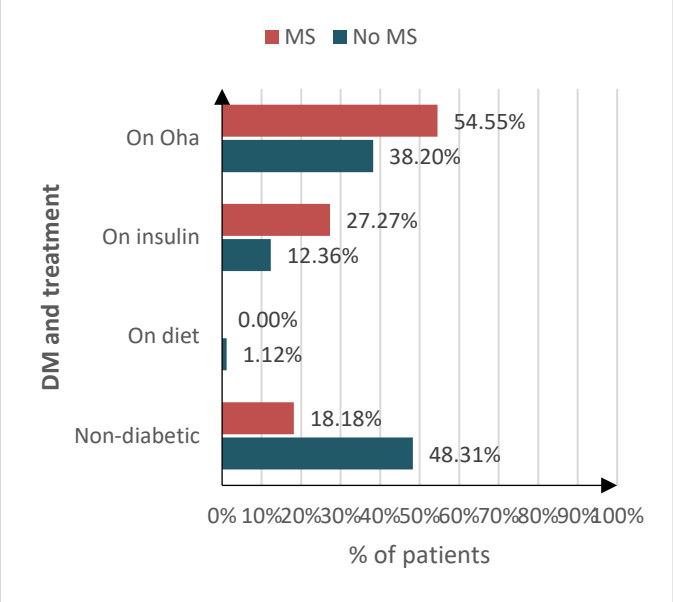

Figure 4: Association between metabolic syndrome and DM prevalence among CABG patients

Data are presented as median (IQR) or frequency (%) as appropriate, *: Statistically significant as P value<0.05, ALT: Alanine transaminase, AST: Aspartate aminotransferase, ALP: Alkaline phosphatase, LDH: Lactate dehydrogenase, GGT: Gamma-glutamyl transferase, CK-MB: Creatine kinase-MB, FBS: Fasting blood sugar, RBS: Random blood sugar, LDL: Low-density lipoprotein, HDL: High-density lipoprotein

In comparison to patients with no MS, those with MS showed significantly higher preoperative FBS (with a median of 11 vs 6.95 mmol/L, P=0.001), HbA1C (8.7 vs 7.3 %, P=0.02) and triglycerides (2.2 vs 1.42 mmol/L, P<0.001). On the other hand, both groups were similar as regards pre and postoperative measurements of ALT, AST, ALP, LDH, total bilirubin, GGT, creatinine, CK-MB, troponin, RBS, cholesterol, LDL and HDL. [Table 4, Figure 5 - Figure 7]

	Metabolic syndrome		**P value**
	Absent	**Present**	
ALT (U/L)			
Preoperative	39 (26.5 - 56)	37.5 (23 - 43)	0.828
Day1	38 (29 - 64.5)	38.5 (29 - 51)	0.525
Day2	44 (32 - 56.5)	38 (30 - 58.25)	0.953
AST (U/L)			
Preoperative	22 (17 - 38)	20.5 (15 - 41)	0.817
Day1	53 (36 - 80)	48.5 (37.75 - 69.25)	0.923
Day2	65 (42 - 110)	62.5 (42.25 - 107.25)	0.894
ALP (U/L)			
Preoperative	90 (75.5 - 114)	98 (79 - 112)	0.875
Day1	68 (54.5 - 82.5)	72 (59 - 88)	0.684
Day2	63 (52 - 78.5)	70 (57 - 96)	0.122
LDH (U/L)			
Preoperative	200.5 (163 - 327.25)	204 (168 - 284)	0.847
Day1	390.5 (313.25 - 483.5)	367 (308 - 454)	0.875
Day2	432.5 (357.5 - 524.5)	414 (349 - 501)	0.737
Total bilirubin (mg/dL)			
Preoperative	8 (5.49 - 12)	8.44 (4.33 - 11)	0.815
Day1	13 (9.5 - 20.73)	13.5 (8.75 - 19.15)	0.802
Day2	12 (8 - 19.07)	10.15 (6.46 - 17.6)	0.657
GGT (U/L)			
Preoperative	46.5 (35 - 66.75)	47.5 (30.25 - 95)	0.471
Day1	38 (32 - 55)	35 (30.25 - 53.75)	0.549
Day2	43 (30.75 - 57.25)	36.5 (32.5 - 65.25)	0.367
Creatinine (µmol/L)			
Preoperative	95 (82.25 - 109.75)	91 (74 - 105)	0.134
Day1	107.5 (85.75 - 120)	105 (86 - 122)	0.819
Day2	103.5 (90.25 - 136)	105 (82 - 124)	0.219
CK-MB (U/L)			

Day1	56 (39.3 - 82)	44.9 (41.1 - 68)	0.476
Day2	44.8 (29.9 - 76)	42.7 (25.8 - 62.2)	0.821
Positive Troponin			
Preoperative	30 (33.71%)	10 (30.3%)	0.722
Day1	86 (96.63%)	30 (90.91%)	0.342
Day2	84 (94.38%)	30 (90.91%)	0.445
FBS (mmol/L)			
Preoperative	6.95 (5.48 - 12.15)	11 (7.15 - 14.2)	0.001*
RBS (mmol/L)			
Day1	10.2 (7.5 - 13)	11.3 (9.3 - 14.4)	0.216
Day2	7.9 (6.35 - 9.5)	7.4 (5.8 - 10.1)	0.442
HbA1C (%)			
Preoperative	7.3 (6.25 - 8.8)	8.7 (7.3 - 9.6)	0.02*
Cholesterol (mmol/L)			
Preoperative	3.5 (3 - 4.4)	3.8 (3.5 - 4.7)	0.077
LDL (mmol/L)			
Preoperative	1.87 (1.46 - 2.71)	1.95 (1.57 - 2.52)	0.644
HDL (mmol/L)			
Preoperative	0.86 (0.71 - 1)	0.83 (0.68 - 0.91)	0.279
Triglycerides (mmol/L)			
Preoperative	1.42 (1 - 1.82)	2.2 (1.72 - 2.92)	<0.001*

Table 4: Association between metabolic syndrome and laboratory investigations of CABG patients

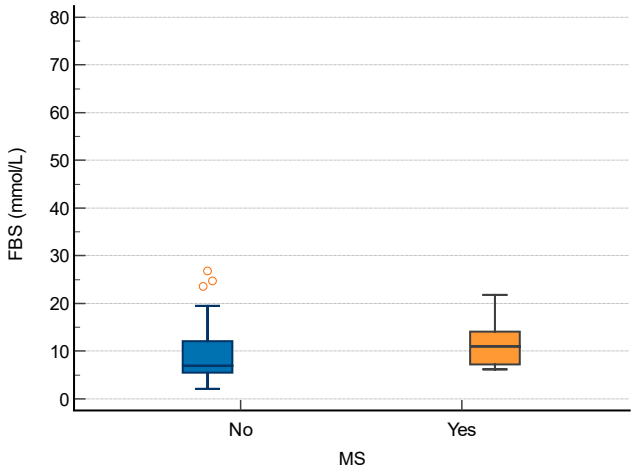

Figure 5: Association between metabolic syndrome and preoperative FBS of CABG patients

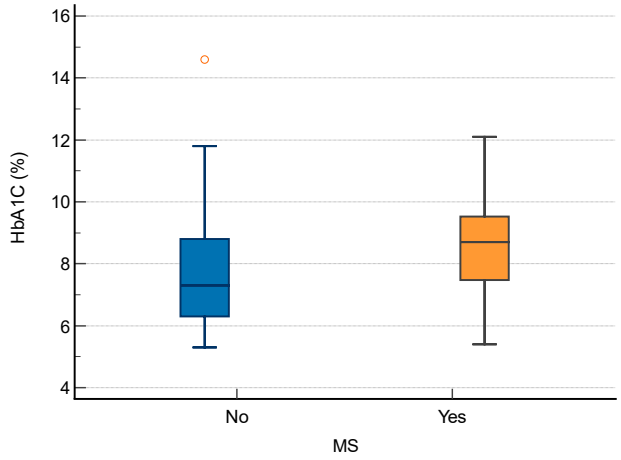

Figure 6: Association between metabolic syndrome and preoperative HbA1C of CABG patients

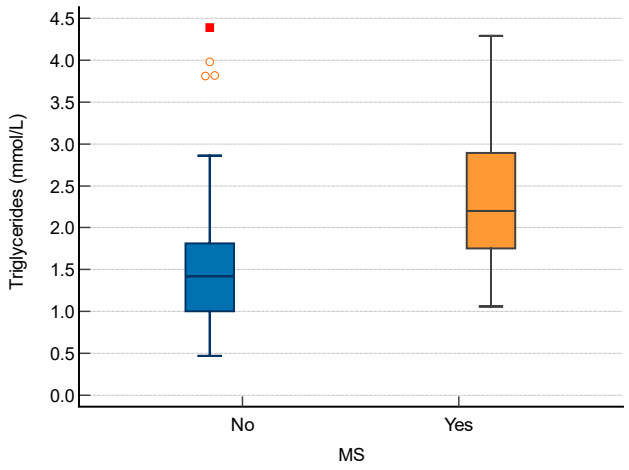

Figure 7: Association between metabolic syndrome and preoperative triglycerides of CABG patients

Data are presented as median (IQR), *: Statistically significant as P value<0.05, EuroSCORE: European System for Cardiac Operative Risk Evaluation, SVO2: Venous Oxygen Saturation, CVP: Central venous pressure, PAWP: Pulmonary capillary wedge pressure, SVR: Systemic Vascular Resistance

As shown in **Table 5,** patients with MS elicited significantly lower heart rate than those with no MS (with a median of 90 vs 95 bpm, P=0.048). However, both groups showed no significant differences in terms of EuroSCORE, MAP, SVO2, CVP, PAS, PAD, PAWP, SVR or C. index. [Figure 8].

	Metabolic syndrome		P value
	Absent	Present	
Euro SCORE	0.96 (0.76 - 1.35)	0.96 (0.79 - 1.38)	0.979
MAP (mmHg)	83 (75 - 88)	85 (78.5 - 96)	0.108
HR (bpm)	95 (86.5 - 105)	90 (82.5 - 97.5)	0.048*
SVO_2 (%)	69 (62.15 - 73.9)	66.1 (62.4 - 74.1)	0.725
CVP (mmHg)	9 (7 - 11)	11 (8 - 12)	0.102
PAS	28.5 (24 - 34)	30.5 (25.5 - 34.75)	0.357
PAD	14 (11 - 17)	15 (11 - 17.75)	0.962
PAWP (mmHg)	13 (10.75 - 16)	13 (12 - 17)	0.413
SVR (dynes s/cm^5)	1094 (902 - 1248)	1140 (895 - 1394.5)	0.28
C. Index	2.9 (2.4 - 3.5)	2.9 (2.55 - 3.45)	0.784

Table 5: Association between metabolic syndrome and preoperative measurements of CABG patients

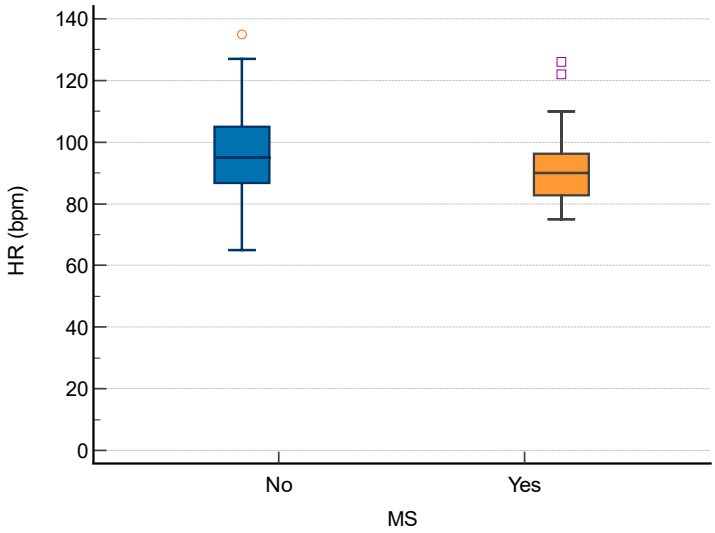

Figure 8: Association between metabolic syndrome and heart rate of CABG patients

Data are presented as frequency (%) or median (IQR) as appropriate, CPBP: Cardiopulmonary bypass pump, IABP: intra-aortic balloon pump, SVG: Saphenous vein grafts, Pops: Pulsating Organ Perfusion

Both groups with and without metabolic syndrome were comparable in terms of cross clamp, pump type, bypass time, IABP, mammary, radial, SVG grafts and their numbers, perfusion vs pops as summarized in Table 6

	Metabolic syndrome		P value
	Absent	Present	
Cross clamp	70 (78.65%)	27 (81.82%)	0.7
Cross clamp time (min)	83.5 (61 - 106.5)	79 (65 - 92)	0.316
Pump Type			
CPBP	69 (77.53%)	27 (81.82%)	0.762
Beating on-pump	19 (21.35%)	6 (18.18%)	
Off-pump bypass	1 (1.12%)	0 (0%)	
Bypass time (min)	95 (56 - 121)	99 (71 - 111)	0.881
IABP	7 (7.87%)	1 (3.03%)	0.681
Mammary graft	79 (88.76%)	27 (81.82%)	0.367
Radial graft	7 (7.87%)	4 (12.12%)	0.486
SVG graft	83 (93.26%)	31 (93.94%)	>0.999
Number of grafts	2 (2 - 3)	2 (1 - 3)	0.865
Perfusion Vs pops	89 (100%)	33 (100%)	---

Table 6: Association between metabolic syndrome and operative data of CABG patients

Data are presented as frequency (%) or median (IQR) as appropriate, ECG: Electrocardiogram

No statistically significant difference was detected between both groups regarding complications and outcome including (ECG changes, low output syndrome, renal failure, ventricular dysrhythmia, AF, pulmonary complications, stroke, bleeding, tamponade, shock or arrest, infection, dehiscence and redoing of surgery as well as mechanical ventilation, ICU durations and mortality rate). [Table 7].

	Metabolic syndrome		P value
	Absent	Present	
ECG Changes	0 (0%)	1 (3.03%)	0.27
Low Output Syndrome	40 (44.94%)	14 (42.42%)	0.803
Renal Failure	1 (1.12%)	1 (3.03%)	0.469
Ventricular Dysrhythmia	2 (2.25%)	0 (0%)	>0.999
Atrial Fibrillation	4 (4.49%)	0 (0%)	0.573
Pulmonary complication	8 (8.99%)	2 (6.06%)	0.727
Stroke	1 (1.12%)	2 (6.06%)	0.178
Bleeding	2 (2.25%)	1 (3.03%)	>0.999
Tamponade	0 (0%)	1 (3.03%)	0.27
Shock or arrest	3 (3.37%)	2 (6.06%)	0.611
Infection	4 (4.49%)	2 (6.06%)	0.661
Dehiscence	0 (0%)	1 (3.03%)	0.27
Redoing of surgery	0 (0%)	1 (3.03%)	0.27
Mechanical ventilation duration (hr)	12.15 (11.1 - 15.78)	11.9 (10.2 - 14.05)	0.555
ICU stay (hr)	45 (24.03 - 68.5)	42.25 (30.88 - 67.2)	0.42
Mortality	3 (3.37%)	1 (3.03%)	>0.999

Table 7: Association between metabolic syndrome and postoperative outcome of CABG patients

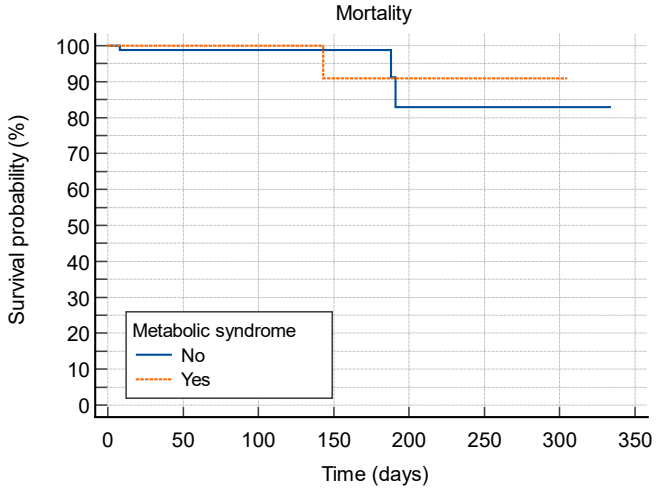

Figure 9: Kaplan-Meier plot for overall survival analysis according to the presence of metabolic syndrome.

Kaplan–Meier survival analysis revealed that metabolic syndrome had no statistically significant influence on the survival of CABG patients (Log-rank P value= 0.716) as survival rates were 96.97% vs 96.63% respectively in patients with MS and those without MS with hazards ratio (95%CI) of 0.679 (0.084 to 5.47) and 1.473 (0.183 to 11.861) as demonstrated in [Figure 9]

	MetSSS	
	r_s	P value
Age (years)	-0.047	0.61
BMI (kg/m^2)	-0.091	0.317
Preoperative		
ALT (U/L)	0.011	0.902
AST (U/L)	0.022	0.808
ALP (U/L)	0.086	0.35
LDH (U/L)	-0.053	0.657
Total bilirubin (mg/dL)	-0.103	0.265
GGT (U/L)	0.125	0.187
FBS (mmol/L)	0.368	<0.001*
Creatinine (µmol/L)	-0.175	0.054
Cholesterol (mmol/L)	0.113	0.243
LDL (mmol/L)	0.004	0.968
HDL (mmol/L)	-0.083	0.395
Triglycerides (mmol/L)	0.422	<0.001*
HbA1C (%)	0.294	0.006*
Euro SCORE	0.085	0.355
MAP (mmHg)	0.081	0.376
HR (bpm)	-0.218	0.016*
CC time (min)	-0.211	0.038*
Hospital stays (days)	0.003	0.977
ICU stay (hr)	-0.021	0.815
MV duration (hr)	-0.057	0.536

Table 8: Correlation between MetSSS and different risk factors and outcomes of CABG patients

*rs: Spearman's rank correlation coefficient, *: Statistically significant as P value<0.05*

There was a significant positive correlation between Metabolic syndrome severity score and each of, FBS (r=368, P value<0.001), triglycerides (r=0.422, P value<0.001) and HbA1C (r=0.294, P value=0.006) preoperatively. However, an inverse correlation of a significant value was detected between MetSSS and both HR (-0.218, P value=0.016) and CC time (r=-0.211, P value=0.038). [Table 8, Figure 10 - Figure 14]

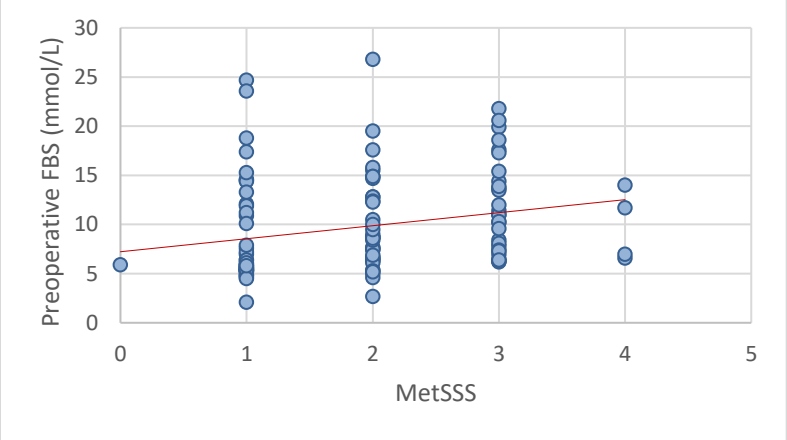

Figure 10: Scatter plot showing the correlation between preoperative FBS and MetSSS of CABG patients

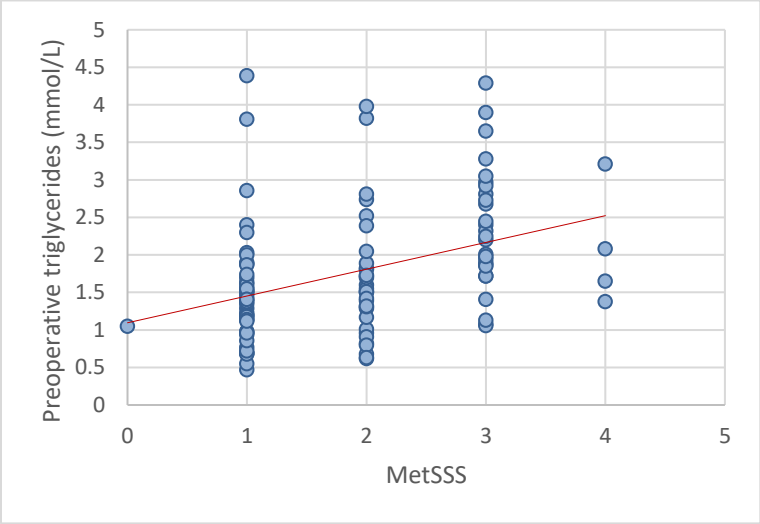

Figure 11: Scatter plot showing the correlation between preoperative triglycerides and MetSSS of CABG patients

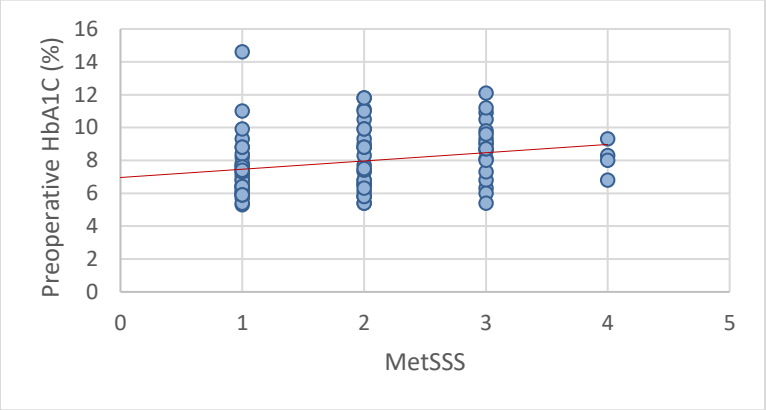

Figure 12: Scatter plot showing the correlation between preoperative HbA1C and MetSSS of CABG patients

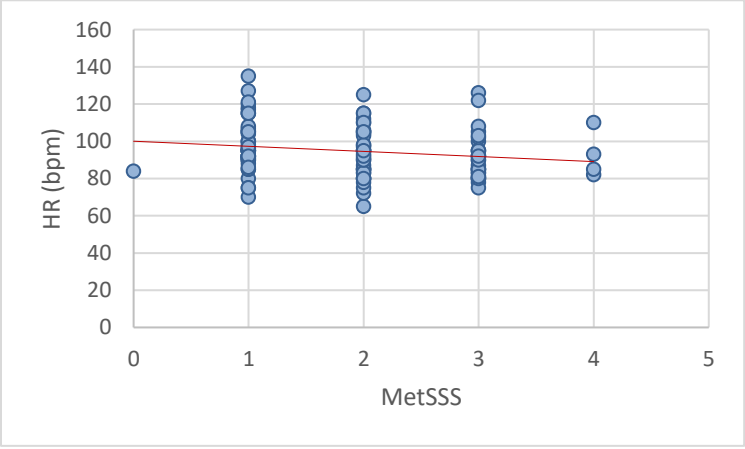

Figure 13: Scatter plot showing the correlation between HR and MetSSS of CABG patients

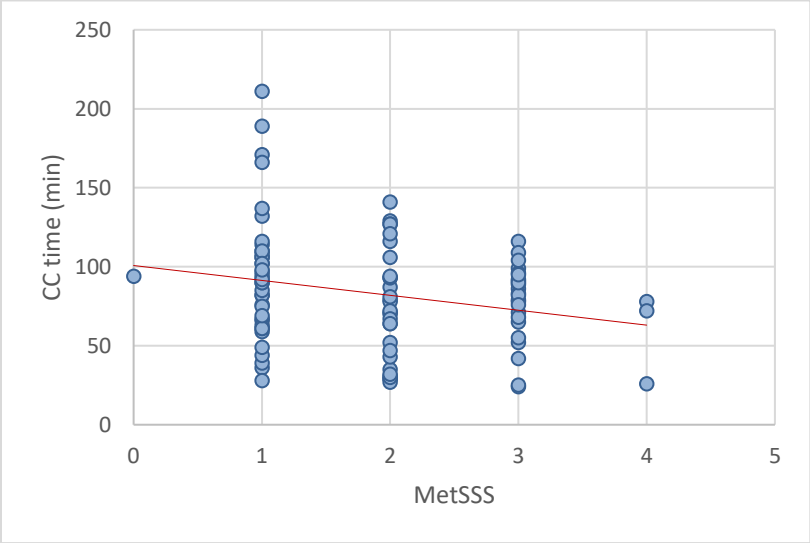

Figure 14: Scatter plot showing the correlation between CC time and MetSSS of CABG patients

	Coefficient	95%CI	P value
Age (years)	6.31	-0.48 to 13.11	0.068
BMI (kg/m^2)	6.26	-5.99 to 18.51	0.313
Gender			
Male	Ref		
Female	462.33	205.5 to 719.17	0.001*
NYHA			
I	Ref		
II	-60.38	-240.11 to 119.34	0.507
III	-189.87	-449.49 to 69.74	0.15
IV	-818.28	-1532.96 to -103.6	0.025*
EF (%)			
<20	Ref		
20 – 39	16.07	-649.68 to 681.83	0.962
40 – 59	43.65	-604.07 to 691.37	0.894
≥60	-21.7	-685.05 to 641.65	0.948
DM			
Non-diabetic	Ref		
On diet	90.8	-559.96 to 741.55	0.783
On insulin	-142.29	-337.07 to 52.49	0.15
On Oha	-15.56	-157.58 to 126.46	0.828
HTN (present)	67.17	-69.35 to 203.69	0.331
COPD (present)	392.04	104.14 to 679.93	0.008*
PVD (present)	8.09	-474.58 to 490.76	0.974
Smoking			
Non-smoker	Ref		
Ex-smoker	-68.85	-253.72 to 116.02	0.462
Current smoker	-92.14	-237.58 to 53.3	0.212
RF (present)	-281.21	-591.93 to 29.52	0.076
MS (present)	51.63	-95.23 to 198.5	0.487

CI: Confidence interval, *: Statistically significant as P value<0.05

Table 9: Multivariable linear regression model for factors associated with ICU LOS of CABG patients

Based on the results of multiple regression analysis, we found that gender, NYHA classification and COPD were significantly associated with ICU length of stay as:

Females had significantly longer ICU stay than males with coefficient of 462.33, 95%CI: 205.5 to 719.17, P value=0.001. In comparison to patients classified as NYHA I, those classified as NYHA IV had significantly shorter ICU stay with coefficient of -818.28, 95%CI: -1532.96 to -103.6, P value=0.025. Also, patients with COPD had longer ICU stay than others [coefficient = 392.04, 95%CI: 104.14 to 679.93, P value=0.008]. [Table 9]

Discussion

MS patients should be assessed in accordance with coronary artery disease recommendations since they have a high risk of developing coronary artery disease. The NCEP ATP III highlighted the cardiovascular risk factors

related to MS in paragraphs 10–14 and 15–17 [6]. Three out of every eight adults in Turkey have MS, which is a significant prevalence rate [16]. Patients with coronary artery disease have a prevalence of 53.0% overall, with a male to female ratio of 42.7% and a female to male ratio of 64.0%.16 Similar to earlier studies on MS patients following CABG (42, 48, 47%), 42% of the individuals in our study had the disease [11,12,17].

MS patients also had a greater smoking rate, which represented their habits and lifestyle, however it was not statistically significant. Mortality rates for individuals with and without MS were similar; two patients in the MS group (3.1%) and one patient in the non-MS group (1.1%) both died.

Similar death rates in the two patient groups were found in other investigations. Swart et al. [11] examined the mortality and morbidity rates following CABG in 370 patients with the MS (as defined by the International Diabetes Federation and NCEP ATP III criteria) with 503 individuals without the MS. The death rates for the two groups were identical in terms of age distribution and were 1.9 and 1.6%, respectively ($p = 0.7348$). The median Euro SCORE for the MS group was 3.61 and the median Euro SCORE for the non-MS group was 3.26, a significant difference between the two groups ($p = 0.0494$). In both groups, there were comparable rates of re-exploration, stroke, renal failure, protracted mechanical ventilation, and the requirement for sternal dehiscence repair. Similar amounts of mediastinal drainage (624 vs. 670 ml) were also produced. The MS group required fewer homologous blood transfusions ($p = 0.0012$), but their hospital stays were longer (p 0.00001). That concluded that MS had no negative clinical effects on pre-operative risk variables or outcomes following CABG.

Zyazcolu et al. [12], looked at how the MS affected postoperative mortality and morbidity rates in CABG patients. The incidence of wound infection was higher in MS patients (defined by NCEP ATP III criteria) than in patients without MS (p 0.05), but atrial fibrillation, revision surgery for hemorrhage, ventricular tachycardia, ventricular fibrillation, prolonged intubation, and mortality rates were similar.

The disparities in the definitions of postoperative morbidity and postoperative severe events, as well as the length of follow-up periods, may be to blame for these inconsistencies. The criteria used to define the MS may also provide inconsistent findings; for example, the MS's characteristics (waist circumference rather than BMI) may differ depending on the populations studied. Assessing the relationship between preoperative MS and postoperative problems may be complicated by these variations [11,12].

Obese individuals have higher levels of immunomodulatory substances and adipocyte inhibition. Because a prothrombotic state frequently develops postoperatively, MS patients undergoing CABG are more likely to experience thromboembolic events [2], Ylmaz et al., [18], proposed that the MS may be used as a predictor of saphenous vein graft postoperative occlusion following CABG. In our study, individuals with and without MS experienced equal rates of peri-operative myocardial infarction. It is possible that variables linked to myocardial protection techniques or unidentified factors, rather than early graft occlusion, dictate peri-operative myocardial infarction, which might account for why there is no discernible difference between patients with and without MS.

In the current study, the MS group's hospitalization and ICU stays were noticeably longer. According to Brackbill et al. [13], female patients with MS who underwent CABG surgery were more likely to experience a prolonged postoperative stay as well as to pass away while still in the hospital. According to Bardakc et al. [19], patients with MS had a significantly higher female-to-male ratio, significantly higher rates of family history of ischaemic heart disease, and significantly higher rates of coronary artery occlusions involving the anterior descending coronary, circumflex, and right coronary arteries than patients without MS. This discrepancy could be significant due to rising rates of morbidity as well as rising medical expenses.

Similar to earlier studies [11,12,17,20], it was determined that there was no significant difference between the MS and non-MS groups in the incidence of stroke and renal impairment following CABG (p 0.05). However, MS patients had significantly longer ICU and hospital stays, as well as higher rates of AF, wound infection, pulmonary complications, prolonged intubation, and other morbidity parameters (p 0.01). According to Ardeshiri et al. [20] research, patients with MS experienced lengthier stays in the intensive care unit (ICU) after CABG and had a higher chance of developing atelectasis. According to zyazcolu et al. [12], individuals with coronary artery disease who also had MS had wound infection substantially more frequently than those who did not (p 0.05). The odds ratios for postoperative stroke and kidney failure in MS patients were determined to be 2.47 and 3.81, respectively, in a multivariate analysis [17].

BMI and a higher frequency of diabetes may be linked to the high prevalence of postoperative complications in MS patients [21]. In contrast to our study, Bardakç et al, [19], found that MS patients had significantly higher rates of pulmonary complications, significantly longer intubation times, longer ICU and hospital stays, and significantly longer intubation times; however, they also reported significantly higher rates of mortality and peri-operative myocardial infarction.

According to Moulton et al, [22], obesity was not a risk factor for adverse outcomes following cardiac surgery, with the exception of a greater prevalence of atrial arrhythmias and a larger number of superficial surgical site infections. According to Kopelman et al. [23], thoracic and abdominal adipose tissue may contribute to ventilation and perfusion mismatches, which can lead to resistance to breathing exercises and a deterioration in respiratory performance.

In this study, individuals with MS had considerably higher rates of pulmonary problems (p 0.01). This may be attributed to the MS having a detrimental influence on postoperative respiratory function, which raises the risk of postoperative pulmonary problems. Regarding the connection between pulmonary function and MS, it was discovered that men with the disease had lower vital capacity [24]. According to Bagheri et al [25], pulmonary problems were independent predictors of death in the postoperative period although BMI was not a predictor of mortality following CABG.

Procedures using cardiopulmonary bypass are linked to inflammatory reaction and free radical buildup.8 It is well known that people with MS experience persistent, low-grade inflammation, which can get worse after surgery. Additionally, they experience more severe systemic oxidative stress brought on by LDL-C's oxidative transformation [26]. It has been emphasized that the synthesis of free fatty acids is influenced by the lipolytic activity of belly fat storage.26 In ischemic events, these free fatty acids have a significant pro-arrhythmic impact. Although this effect has been confirmed for ventricular arrhythmogenicity, it has not yet been proven to cause AF. Therefore, more investigation is required to determine whether the hyperlipolytic visceral fat storage-associated free fatty acid burden also plays a role in the development of postoperative AF [27].

Through a potential pathway, it is thought that MS patients are more prone to postoperative AF [28]. Atrial architecture, which acts as an anatomical substrate and is involved in atrial dilatation and fibrosis, and electrical inhomogeneity, which acts as a functional substrate and is involved in abnormal automaticity, dispersion of refractoriness and conduction, and anisotropic conduction, are both involved in atrial remodelling [29]. It has been demonstrated that these later mechanisms might act as postoperative AF substrates [30].

According to Bell and O'Keefe, postoperative AF was seen in 25% of patients following CABG and was linked to higher mortality and postoperative stroke rates, longer hospital stays, and higher hospitalization costs [31]. After CABG, Kara et al [32]. discovered that there was a

significant prevalence of AF (19.2%), and they identified certain independent clinical markers.

According to Echahidi et al. [2], the MS was an independent predictor of postoperative AF and had a substantial impact on clinical outcomes following cardiac surgery. A strong connection between postoperative AF and increased waist circumference and/or C-reactive protein levels was shown by Girerd et al.33. The MS was listed by the authors as a separate risk factor for AF developing following CABG [32]. In this study, MS patients had a substantially greater risk of AF (20.9%) than MS-free participants (p 0.01) (data not shown).

Between CABG patients with and without MS, Gharipour et al.'s analysis of postoperative stroke incidence found no discernible difference. Although the rate of stroke was higher in MS patients in our study (6.3 vs 1.1%), there was no significant difference between the groups (p = 0.162). This could be explained by the carotid arteries being free of atherosclerotic plaque.

Carotid Doppler ultrasonography in our patients revealed mild stenosis (50–70%), which was deemed insufficient to cause hemodynamically important circumstances. While carotid stenosis is a significant risk factor for stroke during CABG surgery, other factors, such as aortic and carotid atherosclerosis (62%), intra cardiac thrombi (1%), hemorrhage (1%), hypo perfusion (11%), and other factors of unknown origin (25%), can also result in neurological events.35 In patients having CABG, the severity of carotid stenosis has been reported to be higher than 70% in 10% of cases, 50-70% in 9-22% of cases, and less than 50% in 80-91% of cases.35,36 It's interesting to note that 50–75% of stroke victims did not have carotid stenosis [37]. According to Lee et al.38, cerebral atherosclerosis was the primary cause of stroke, with extra cranial atherosclerotic processes having a much lower impact [39].

Notably, the MS had no effect on the pre-operative critical risk factors for mortality following CABG. Patients without MS, in contrast, required emergency surgeries more frequently than MS patients did. This is not unexpected considering that patients with MS typically undergo rigorous follow-up procedures to manage their hypertension, diabetes mellitus, and dyslipidemia - all of which are recognized to be underlying risk factors for coronary artery disease. Patients without MS are therefore more likely to require urgent, non-elective procedures if their coronary risk factors are not well managed.

The fact that variables exist that are known to raise death rates in MS patients may be a research restriction in and of itself. These include the presence of men, extensive coronary artery involvement, and prolonged cross-clamping. As a result, one constraint might be the impact of MS on death rates. The study's greatest flaw was its insufficient power to draw conclusions about certain of the outcomes, such as death.

Conventional pharmaceutical treatment approaches can only partially reduce some aspects of MS. It is generally recognized that the metabolic abnormalities seen in MS patients are not significantly affected by statins, ACE inhibitors, or beta-blockers [28].

Conclusion

Due to the high prevalence of cardiovascular risk factors in MS patients, the disease was linked to higher rates of morbidity in the early postoperative phase following CABG; nevertheless, its impact on early death rates was comparable to that observed in individuals without MS. The MS should be considered in the preoperative evaluation of CABG patients in light of the elevated postoperative morbidity rate.

References

1. Alberti KG, Eckel RH, Grundy SM, Zimmet PZ, Cleeman JI, et al. (2009). Harmonizing the metabolic syndrome: a joint in terim statement of the International Diabetes Federation Task Force on Epidemiology and Prevention; National Heart, Lung, and Blood Institute; American Heart Association; World Heart Federation; International Atherosclerosis Society; and International Association for the Study of Obesity. Circulation. 120(16):1640–1645.
2. Echahidi N, Pibarot P, Després J-P, Daigle J-M, Mohty D, et al. (2007). Metabolic syndrome increases operative mortality in patients undergoing coronary artery bypass grafting surgery. *J Am CollCardiol.* 50(9):843–851.
3. Benozzi S, Ordonez F, Polini N, Alvarez C, Selles J, et al. (2009). Insulinresistance and metabolic syndrome in patients with coronary heart disease defined by angiography. Medicina (B Aires) 69(2):221–228.
4. Mehta NN KP, Martin SS, St Clair C, Schwartz S, Iqbal N, et al. (2011). Usefulness of insulin resistance estimation and the metabolic syndrome in predicting coronary atherosclerosis in type 2 diabetes mellitus. *Am J Cardiol.* 107(3):406–411.
5. Vonbank A, Saely CH, Rein P, Beer S, Breuss J, et al. (2011). Insulin resistance is associated with the metabolic syndrome and is not directly linked to coronary artery disease. Clin Chim Acta. 412(11-12):1003–1007.
6. (2002). National Cholesterol Education Program (NCEP) Expert Panel on Detection, Evaluation, Adults and Treatment of High Blood Cholesterol in Adults (Adult Treatment Panel III): Third Report of the National Cholesterol Education Program (NCEP) Expert Panel on Detection, Evaluation, and Treatment of High Blood Cholesterol in Adult (Adult Treatment Panel III) final report. Circulation. 106(25):3143–3421.
7. Ford ES. (2005). Prevalence of the metabolic syndrome defined by the international diabetes federation among adults in theU.S. Diabetes Care. 28(11):2745–2749.
8. Edmunds LH. (1998). Inflammatory response to cardiopulmonary bypass. Ann Thorac Surg. 66(Suppl 5):12–16.
9. Després JP. (2011). Health consequences of visceral obesity. Ann Med. 33(8):534–541.
10. Brackbill ML, Sytsma CS, Sykes K. (2009). Perioperative outcomes of coronary artery bypass grafting: effects of metabolic syndrome and patient's sex. Am *J Crit Care.* 18(18):468–473.
11. Swart MJ, De Jager WH, Kemp JT, Nel PJ, Van Staden SL, et al. (2012). The effect of the metabolic syndrome on the risk and outcome of coronary artery bypass graft surgery. Cardiovasc J Afr. 23(7):400–404.
12. Ozyazicioglu A, Yalcinkaya S, Vural AH, Yumun G, Bozkurt O. (2010). Effects of metabolic syndrome on early mortality and morbidity in coronary artery bypass graft patients. J Int Med Res. 38(1):202–207.
13. Isomaa B, Almgren P, Tuomi T, Forsén B, Lahti K, et al. (2001). Cardiovascular morbidity and mortality associated with the metabolic syndrome. Diabetes Care. 24(4):683–689.
14. Lakka HM, Laaksonen DE, Lakka TA, Niskanen LK, Kumpusola E, et al. (2002). The metabolic syndrome and total and cardiovascular disease mortality in middle-aged men. J Am Med Assoc. 288(21):2709–2716.
15. Hu G, Qiao Q, Tuomilehto J, Balkau B, Borch-Johnsen K, et al. (2004). Prevalence of the metabolic syndrome and its relation to all-cause and cardiovascular mortality in nondiabetic European men and women. Arch Intern Med. 164(10):1066–1076.
16. Onat A, Sansoy V. (2002). Metabolic syndrome. Major culprit in coronary disease among Turks: its pevalence and impact on coronary risk. Türk Kardiyol Dern Arş 30(1):8–15.
17. Kajimoto K, Miyauchi K, Kasai T, Yanagisawa N, Yamamoto T, et al. (2009). Metabolic syndrome is an independent risk factor stroke and acute renal failure after coronary artery bypass grafting. *J Thorac Cardiovasc Surg.* 137(3):658–663.

18. Yilmaz MB, Guray U, Guray Y, Biyikoglu SF, Tandogan I, et al. (2006). Metabolic syndrome negatively impacts early patency of saphenous vein grafts. Coron Artery Dis. 17(1):41–44.
19. Bardakçı H, Demirdaş E, Bahar İ, Vural K, Yay K, et al. (2007). Metabolic syndrome and coronary artery bypass surgery. Turkish J thorac Cardiovasc Surg. 15(3):187–191.
20. Ardeshiri M, Faritus Z, Ojaghi-Haghighi Z, Bakhshandeh H, Kargar F, et al. (2014). Impact of metabolic syndrome on mortality and morbidity after coronary artery bypass grafting surgery. Res Cardiovasc Med. 3(3): e20270–e20270.
21. Bundy JK, Gonzalez VR, Barnard BM, Harnard BM, Hardy RJ, et al. (2006). Gender risk differences for surgical site infections among a primary coronary artery bypass graft surgery cohort: 1995-1998. Am *J Infect* Control. 34(3):114–121.
22. Moulton MJ, Creswell LL, Mackey ME, Cox JL, Rosenboom M. (1996). Obesity is not a risk factor for significant adverse outcomes after cardiac surgery. Circulation. 94(9):1187–1192.
23. Kopelman PG. (1984). Clinical complication of obesity. Clin Endocrinol Metab. 13(3):613–634.
24. Kim SK, Hur KY, Choi YK, Kim SW, Chung JH, et al. (2010). The relationship between lung function and metabolic syndrome in obese and non-obese korean adult males. Korean Diabetes J. 34(4):253–260.
25. Bagheri J, Rezakhanloo F, Valeshabad AK, Bagheri A. (2014). Effects of body mass index on the early surgical outcomes after coronary artery bypass grafting. Turkish J Thorac Cardiovasc Surg. 22(2):253–259.
26. Hansel B, Giral P, Nobecourt E, Chantepie S, Bruckert E, et al. (2004). Metabolic syndrome is associated with elevated oxidative stress and dysfunctional dense high-density lipoprotein particles displaying impaired antioxidative activity. *J Clin Endocrinol Metab.* 89:10–4963.
27. Hutley L, Prins JB. (2005). Fat as an endocrine organ: relationship to the metabolic syndrome. Am J Med Sci. 330(6):280–289.
28. Echaidi N, Mohty D, Pibarot P, Despres JP, O'Hara G, et al. (2007). Obesity and metabolic syndrome are independent risk factors for atrial fibrillation after coronary artery bypass graft surgery. Circulation. 116(11):1213–1219.
29. Fuster V, Ryden LE, Asinger RW, Cannom DS, Crijns HJ, et al. (2001). ACC/AHA/ESC guidelines for the management of patients with atrial fibrillation. A report of the American College of Cardiology/American Heart Association Task Force on Practice Guidelines and the European Society of Cardiology Committee for Practice Guidelines and Policy Conferences (Committee to develop guidelines for the management of patients with atrial fibrillation) developed in collaboration with the North American Society of Pacing and Electrophysiology. *Eur Heart J.* 22(20):1852–1923.
30. Spach MS, Dolber PC, Heidlage JF. (1988). Influence of the passive anisotropic properties on directional differences in propagation following modification of the sodium conductance in human atrial muscle. A model of reentry based on anisotropic discontinuous propagation. Circ Res. 62(4):811–832.
31. Bell DS, O'Keefe JH. (2009). Metabolic syndrome and postoperative atrial fibrillation. *Eur Heart J*.30(10):1167–1168.
32. Kara H, Önem G, Gökşin İ, Kestelli M, Özsöyler İ, et al. (2003). Risk factors in atrial fıbrillation after coronary artery bypass surgery. Turkish *J Thorac Cardio Surg*. 2003;11(1):14–19.
33. Girerd N, Pibarot P, Fournier D, Daleau p, Voisine P, et al. (2009). Middle-aged men with increased waist circumference and elevated C-reactive protein level are at higher risk for postoperative atrial fibrillation following coronary artery bypass grafting surgery. *Eur Heart J.* 30(10):1270–1278.
34. Gharipour M, Sadeghi MM, Sadeghi M, Farhmand N, Sadeghi PM. (2015). Detrimental predictive effect of metabolic syndrome on postoperative complications in patients who undergoing coronary artery bypass grafting. Acta Biomed. 86(1):89–91.
35. Likosky DS, Marrin CA, Caplan LR, Baribeau YR, Morton JR, et al. (2003). Determination of etiologic mechanisms of strokes secondary to coronary artery bypass graft surgery. Stroke. 34(12):2830–2834.
36. Venkatachalam S, Shishehbor MH. (2011). Management of carotid disease in patients undergoing coronary artery bypass surgery: is it time to change our approach? Curr Opin Cardiol. 226(6):480–487.
37. Li Y, Walicki D, Mathiesen C, Jenny D, Li Q, et al. (2009). Strokes after cardiac surgery and relationship to carotid stenosis. Arch Neurol. 66(9):1091–1096.
38. Lee EJ, Choi KH, Ryu JS, Jeon SB, Lee SW, et al. (2011). Stroke risk after coronary artery bypass graft surgery and extent of cerebral artery atherosclerosis. *J Am Coll Cardiol*. 57(18):1811–1818.
39. Özkan, S., Özdemir, F., Uğur, O., Demirtunç, R., Balci, A. Y., et al. (2017). The effects of the metabolic syndrome on coronary artery bypass grafting surgery. *Cardiovascular journal of Africa*, 28(1), 48–53.

DOI:10.31579/2692-9759/114