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Safety and Efficacy of Modern Stents in Patients with Metabolic Syndrome

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Abstract: The impact of metabolic syndrome (MS) on stent performance and outcomes of patients underwent percutaneous coronary intervention (PCI), including stent implantation, had not yet been fully established. The aim of the present study was to investigate long-term safety and efficacy of 2nd generation DES vs. other stent types in MS patients underwent successful PCI for an acute coronary event. Descriptive epidemiology, angiographic characteristics and one-year clinical outcomes, including major adverse cardiovascular events (MACE) and target lesion revascularization (TLR) procedures were evaluated according to the stent type inserted for 204 patients. The occurrence of TLR (6.62% vs. 9.43%, $p = 0.50$) and the composite outcomes (20.52% vs. 24.52%, $p = 0.54$) did not differ significantly between patients having 2nd generation drug eluting stents (DES) or other stent types implanted at the index procedure. It seems that the PCI in acute coronary syndrome (ACS) is similarly efficient regardless of the stent type, suggesting that for the treatment of ACS in MS patients, all stent types show similar results, in terms of TLR or MACE.

Keywords: metabolic syndrome; percutaneous coronary intervention; stent type; target lesion revascularization

1. Introduction

Patients with metabolic syndrome (MS) are known to be at an increased risk for acute coronary events. MS represents a cluster of cardiovascular (c-v) risk factors comprising central obesity, high blood sugar, elevated blood pressure, hypertriglyceridemia (HTG) and low high-density lipoprotein cholesterol (hHDLc). Each component of MS is an independent risk factor for atherosclerotic coronary artery disease and their combination increases its severity [1].

Modern-day stenting procedures are considered the main technique for coronary revascularization, with excellent outcomes in terms of short and long-term mortality. A continuous evolution in the development of coronary stents have been observed in the last 10 years. Improvements have been made in the structural design, stents materials and drug-releasing mechanism [2–9]. Bare metal stents demonstrated improved angiographic and clinical outcomes over balloon angioplasty [10,11]. First-generation drug-eluting stents (DES) minimized neointimal hyperplasia and reduced repeat revascularization [12–14].

Subsequently, the second DES generation was designed to furthermore reduce stent thrombosis and restenosis rates [15]. The second-generation DES are now the predominant implanted stents.

Despite continuous innovation, the occurrence of stent failure due to stent thrombosis, neointimal hyperplasia and restenosis, in-stent neoatherosclerosis, or scaffold fracture still remains a challenge in the current era [16,17]. Metabolic syndrome encompasses many risk factors for stent failure. Diabetes and hypertension lead to more complicated coronary lesions and endothelial dysfunction consisting in vascular endothelial inflammation, damaged protein glycosylation and oxidation process, factors that can initiate the formation of coronary atherosclerotic plaque. Moreover, associated dyslipidemia stimulates inflammation, damages vascular endothelial cells and promotes deposition of cholesterol in the coronary artery wall [18].

However, there are sparse data on the influence of MS on the performance of different types of stents in real-life setting. In this study, we analyzed patients with acute coronary syndrome and MS who were subjected to percutaneous coronary intervention with different types of stent implantation. The aim of the present study was to investigate long-term safety and efficacy of 2nd generation DES vs. other stent types in MS patients underwent successful PCI for an acute coronary event.

2. Materials and Methods

2.1. Study Design and Population

Our study was a single center, observational study which enrolled prospectively 204 consecutive ACS patients with MS, who underwent successful PCI between 1 January and 31 December 2018 and followed up for one year at the Emergency Clinical Hospital of Oradea, Romania.

2.2. Data Collection and Processing

Our observational study used prospectively collected data of hospitalized patients who met all the following criteria: new diagnosed acute coronary syndrome, successful PCI revascularization procedure performed during hospital admission for the present ACS and metabolic syndrome.

The diagnosis of ACS was made on symptoms of myocardial ischemia along with electrocardiographic changes and cardiac biomarker (high sensitive troponin I) status. Based on these findings, patients were further diagnosed with non-ST segment elevation myocardial infarction (NSTEMI), ST-elevation myocardial infarction (STEMI) or unstable angina (UA) according to 2020 ESC Guidelines criteria for ACS definition [19].

The percutaneous coronary intervention was performed with standard methods. The drugs, type of devices, intervention techniques including stenting techniques and type of stents used during the percutaneous coronary procedure were determined by experienced operators. In coronary angiography, angiographic parameters were measured: location of the lesion, stenosis severity, thrombus, calcifications, and TIMI flow grade. More than 70% diameter stenosis of any coronary artery was considered significant disease. The type of stent used for implantation during the procedure were chosen according to the operator's decision or stent availability. Stents were chosen from BMS (Vision or Driver stent), first-generation DES (Sirolimus-eluting stent (SES)) or second-generation DES (Everolimus-eluting stent (EES), zotarolimus-eluting stent (ZES) and biolimus-eluting stent (BES)). According to this, patients were further divided into two large groups: first group included patients with 2nd generation DES inserted and second group included patients with other stents implanted, such as 1st generation DES and BMS. In patients with multiple stent implantation, the stent was implanted to the culprit lesion, or the more severe stenosis was taken into consideration.

A successful percutaneous coronary intervention was defined as stent implantation in the most severe stenosis with a residual lesion under 30% and no major c-v complications, such as death, acute myocardial infarction, emergency coronary revascularization surgery or new angioplasty.

Metabolic syndrome was defined, according The International Diabetes Federation (IDF) consensus, as central obesity (assumed at body mass index (BMI) over 30 kg/m^2) and any two of the following criteria: hypertension (HTN): systolic blood pressure ≥130 or diastolic blood pressure ≥85 mm Hg, or treatment for previously diagnosed HTN, fasting plasma glucose over 100 mg/dL or previously diagnosed diabetes, raised triglycerides: >150mg/dL, low HDL cholesterol: <40 mg/dL in males, <50 mg/dL in females, or treatment for these lipid abnormalities [20].

Demographic characteristics including age, sex, body mass index, information on underlying diseases, patient clinical profile on emergency department presentation, laboratory tests, echocardiographic parameters and discharge guideline medication were recorded. Killip Kimball classification was assessed in each patient enrolled. The third class was considered equivalent to acute pulmonary edema and the last stage equivalent to cardiogenic shock.

2.3. Follow-Up and Outcomes

All the patients included in the study were routinely followed up for one year after the coronary event. Information on patient evolution was obtained from medical records of the enrolling center and phone contact. If no information was available, data on vital status was obtained from other providers of the National Health Care System.

All major clinical events, including all-cause death, any recurrent ACS, stroke and major bleeding were recorded.

Repeat angiography was symptom-driven and performed in the setting of an ACS. Revascularization was considered indicated in patients with symptom-driven angiograms that revealed >70% diameter stenosis of any coronary lesion. Revascularization of the originally treated index lesion was considered target lesion revascularization (TLR). Revascularization of any other lesions was considered non-TLR. Patients with recurrent acute coronary syndrome and conservative/noninvasive treatment approach (e.g., no coronary angiography performed for the re-ACS or patients who underwent coronary angiography for the re-ACS but no PCI) were defined as No-Revascularization (No-R). Additionally, planned documented staged procedures were not considered TLR or non-TRL.

Deaths were categorized as cardiac unless a clear non-cardiac cause was identified. Sudden death, cardiogenic shock, and malignant ventricular arrhythmias were the main causes of cardiac death. Stroke was diagnosed using imagistic investigations and major bleeding was defined as symptomatic bleeding associated with decrease in hemoglobin.

2.4. Statistics

Demographic and clinical characteristics of study participants were analyzed using descriptive statistics. Differences in variables were analyzed using the chi-square test, while Student's t test was used to compare mean values. A value of $p < 0.05$ was considered statistically significant.

3. Results

From 1 January 2018 to 31 December 2018, a total of 204 patients with metabolic syndrome who underwent successful PCI were enrolled in the study. Different types of stents were used for implantation during the PCI procedure according to the operator's decision or stent availability. From the total of 204 patients, 2nd generation DES were used in 151 patients, and other stents comprising BMS and 1st generation DES were used in 53 patients.

3.1. Baseline Characteristics

The mean age of patients enrolled was 61.16 ± 11.04 with the preponderance of men (n = 142; 69.60%). Baseline characteristics were similar between groups, with no statistically differences in terms of age, underlying cardiovascular diseases or cardiovascular risk factors. Table 1 summarizes the baseline characteristics of the cohort, according to the stent type inserted.

Table 1. Baseline characteristics of patients according to stent type inserted.

Clinical Factors	2nd Generation DES (n = 151)	Other Stents (n = 53)	p-Value
Age (year), mean ± SD	60.53 ± 10.65	62.94 ± 11.81	0.17
<50, n (%)	20 (13.24)	11 (20.75)	0.19
50–69, n (%)	98 (64.90)	27 (50.94)	0.07
≥70, n (%)	33 (21.85)	15 (28.30)	0.34
Female, n (%)	45 (29.80)	17 (32.07)	0.76
Male, n (%)	106 (70.19)	36 (67.92)	0.76
BMI (kg/m^2), mean ± SD	33.68 ± 4.11	33.18 ± 3.19	0.42
Obesity, n (%)	151 (100)	53 (100)	
Hypertension, n (%)	135 (89.40)	51 (96.22)	0.13
Diabetes, n (%)	57 (37.74)	25 (47.16)	0.23
Low HDL-C, n (%)	130 (86.09)	42 (79.24)	0.24
Hypertriglyceridemia, n (%)	98 (64.90)	26 (49.05)	0.04
Prior ischemic heart disease, (n) %	27 (17.88)	13 (24.52)	0.30
Prior MI, n (%)	13 (8.60)	8 (15.09)	0.18
Prior CABG, n (%)	2 (1.32)	1 (1.88)	0.77
Prior PCI, n (%)	15 (9.93)	7 (13.20)	0.51
Prior stroke/TIA, n (%)	4 (2.64)	0	0.23

Abbreviations: DES, drug eluting stent; SD, standard deviation; BMI, *Body mass index*; MI, myocardial infarction; CABG, coronary artery bypass graft; PCI, percutaneous coronary intervention; TIA, transient ischemic attack.

3.2. Prevalence of Metabolic Syndrome Components and Their Most Frequent Combinations

All the patients included in the study fulfilled the criteria for MS according to the International Diabetes Federation consensus. The prevalence of the individual components of MS was 91.17% (n = 186) for raised blood pressure, 40.19% (n = 82) for diabetes mellitus, 84.31% (n = 172) for low HDL-C, 60.78% (n = 124) for high TG levels and 100% for obesity, as central obesity assumed at body mass index (BMI) over 30 kg/m^2 was the main criteria for MS diagnosis. We observed a higher prevalence of both hypertension and diabetes in patients underwent BMS and 1st generation DES stenting (96.22% and 47.16%, respectively), meanwhile dyslipidemia, comprising low HDL-C and hypertriglyceridemia, was most frequent in patients with 2nd generation DES implant (86.09% and 64.90%, respectively). There were no statistically differences between groups concerning MS components profile. However, fewer patients who underwent 2nd generation DES stenting had all five MS components present, comparing to patients with other stents implanted (17.21% vs. 18.86%). The most frequent combinations of MS components according to stent type used in patient's angioplasty are shown in Table 2.

3.3. Diagnosis and Presentation

Patients with MS were more likely to present with STEMI than NSTEMI or UA (48.52% vs. 27.94% vs. 23.52%). Overall, 73.73% of STEMI patients underwent 2nd generation DES stenting, while other stents were less used in patients presenting with ACS. Characteristics of patient's presentation at emergency department are described in Table 3. Patients presenting with cardiogenic shock, acute pulmonary edema or cardiopulmonary arrest on arrival had more chance of 2nd generation DES stenting than 1st generation DES or BMS stenting (78.94% vs. 21.05%). There was no statistically significant difference concerning the time to PCI between groups. Over 39.21% of patients underwent coronary stenting in less than 120 min. Moreover, almost equal proportion of patients underwent PCI in less than 2 h in both groups (39.07% vs. 39.62%). Echocardiography was assessed in all patients enrolled and echocardiographic measurements are summarized in Table 3. Laboratory findings and lipid levels of patients undergoing coronary stenting are shown in Table 4.

Table 2. Most frequent combinations of the metabolic syndrome components.

MS Components	2nd Generation DES (*n* = 151)	Other Stents (*n* = 53)	*p*-Value
Triads, *n* (%)			
BMI + HDLc + DM	1 (0.66)	0	0.55
BMI + HTg + HDLc	11 (7.28)	2 (3.77)	0.37
BMI + HTN + DM	3 (1.98)	7 (13.20)	0.00
BMI + HTN + HDLc	33 (21.85)	12 (22.64)	0.91
BMI + HTN + HTg	11 (7.28)	4 (7.54)	0.95
Tetrads, *n* (%)			
BMI + HTg + HDLc + DM	4 (2.64)	0	0.23
BMI + HTN + HDLc + DM	16 (10.59)	8 (15.09)	0.38
BMI + HTN + HTg + DM	7 (4.63)	0	0.11
BMI + HTN + HTg + HDLc	39 (25.82)	10 (18.86)	0.31
With all the components, *n* (%)			
BMI + HTN + HTg + HDLc + DM	26 (17.21)	10 (18.86)	0.79

Abbreviations: Des, drug eluting stent; MS, metabolic syndrome; BMI, body mass index over 30 kg/m^2; DM, diabetes mellitus; HDLc, low high-density lipoprotein cholesterol; HTg, hypertriglyceridemia; HTN, hypertension.

Table 3. Initial diagnosis and presentation.

Variable	2nd Generation DES (*n* = 151)	Other Stents (*n* = 53)	*p*-Value
Initial diagnosis			
STEMI, *n* (%)	73 (48.34)	26 (49.05)	0.93
NSTEMI, *n* (%)	46 (30.46)	11 (20.75)	0.18
UA, *n* (%)	32 (21.19)	16 (30.18)	0.19
Presentation			
Onset to balloon time (h), mean ± SD	47.39 ± 57.74	49.63 ± 59.07	0.81
Door to balloon time (h), mean ± SD	33.09 ± 49.84	31.67 ± 47.32	0.86
≤120 min from door to balloon, *n* (%)	59 (39.07)	21 (39.62)	0.94
120–180 min from door to balloon, *n* (%)	7 (4.63)	1 (1.88)	0.38
Killip class I, *n* (%)	95 (62.91)	30 (56.60)	0.94
Killip class II, *n* (%)	46 (30.46)	21 (39.62)	0.22
Acute pulmonary edema, (%)	9 (5.96)	2 (3.77)	0.54
Cardiogenic shock, *n* (%)	1 (0.66)	0	0.55
Cardiopulmonary arrest on arrival, *n* (%)	5 (3.31)	2 (3.77)	0.87
Ejection fraction, (%),mean ± SD	50.68 ± 10.30	51 ± 10.03	0.84
EF > 50%, *n* (%)	73 (48.34)	27 (50.94)	0.75
EF = 40–50%, *n* (%)	58 (38.41)	21 (39.62)	0.88
EF < 40%, *n* (%)	20 (13.24)	5 (9.43)	0.47
Diastolic dysfunction, *n* (%)	61 (40.39)	24 (45.28)	0.54
Wall motion abnormality, *n* (%)	83 (54.96)	29 (54.71)	0.98

Abbreviations: DES, drug eluting stent; SD, standard deviation; NSTEMI, non-ST-segment elevation myocardial infarction; STEMI, ST-segment elevation myocardial infarction; UA, unstable angina; EF, ejection fraction.

3.4. Angiographic Characteristics

The baseline angiographic and lesion characteristics of the study population are summarized in Table 5. The angiographic profile revealed higher preponderance of multivessel disease in MS patients (58.82%), comparing to single vessel disease observed in 41.18% of enrolled patients. However, the presence of involvement of more than one vessel was 62.91% of patients who underwent 2nd generation DES stenting versus 47.16 of patients with other type of stents implanted. As regards ACS-related artery location (i.e., culprit vessel), left main coronary artery involvement was found more common in 2nd generation

DES group, meanwhile other stents were more frequently inserted into the right coronary artery. More lesion and stents characteristics are described in Table 5.

Table 4. Laboratory tests.

Variable, Mean ± SD	2nd Generation DES (n = 151)	Other Stents (n = 53)	p-Value
WBC (10^9/L)	10.93 ± 3.56	11.13 ± 4.02	0.73
Creatinine (mg/dL)	1.03 ± 0.41	1.07 ± 0.67	0.61
GFR (mL/min/1.73 m^2)	75.05 ± 22.19	75.35 ± 23.75	0.93
CRP (mg/dL)	2.43 ± 4.03	2.60 ± 4.07	0.79
GGT (mg/dL)	48.81 ± 37.54	50.62 ± 56	0.79
Total cholesterol (mg/dL)	194.59 ± 50.60	184.66 ± 47.18	0.21
Triglyceride (mg/dL)	225 ± 199.28	187.94 ± 157.39	0.22
LDL (mg/dL)	126.09 ± 53.75	115.62 ± 43.35	0.20
HDL (mg/dL)	35.11 ± 7.01	36.34 ± 8.27	0.30
Non-HDL cholesterol (mg/dL)	159.48 ± 48.96	148.32 ± 45.56	0.15
Cholesterol/HDL cholesterol	5.67 ± 1.65	5.25 ± 1.52	0.11
LDL cholesterol/HDL cholesterol	3.70 ± 1.77	3.23 ± 1.35	0.08
Triglycerides/HDL cholesterol	6.88 ± 7.05	5.83 ± 5.99	0.33

Abbreviations: DES, drug eluting stent; SD, standard deviation; WBC, white blood cells; GFR, glomerular filtration rate; CRP, C-reactive protein; GGT, gamma-glutamyl transferase; LDL, low-density lipoprotein; HDL, high-density lipoprotein.

Table 5. Baseline angiographic characteristics of patients underwent PCI.

Angiographic Characteristics	2nd Generation DES (n = 151)	Other Stents (n = 53)	p-Value
Treated vessel: LM, n (%)	2 (1.32)	0	0.40
Treated vessel: LAD, n (%)	68 (45.03)	23 (43.39)	0.84
Treated vessel: LCX, n (%)	37 (24.50)	7 (13.20)	0.09
Treated vessel: RCA, n (%)	43 (28.47)	21 (39.62)	0.13
Treated vessel: CABG graft, n (%)	1 (0.66)	0	0.55
Single-vessel disease, n (%)	57 (37.74)	27 (50.94)	0.09
Multivessel disease, n (%)	95 (62.91)	25 (47.16)	0.05
Prior PCI in the index segments, n (%)	3 (1.98)	2 (3.77)	0.47
Culprit lesion stenosis severity, (%), mean ± SD	94.05 ± 7.52	95.69 ± 14.87	0.30
Thrombus aspiration, n (%)	18 (11.92)	9 (16.98)	0.35
Ostial lesion, n (%)	26 (17.21)	5 (9.43)	0.18
TiMI 0–1 flow, n (%)	91 (60.26)	37 (69.81)	0.22
TIMi 2 flow, n (%)	57 (37.74)	16 (30.18)	0.32
TIMI 3 flow, n (%)	3 (1.98)	0	0.30
Calcified lesion, n (%)	22 (14.56)	9 (16.98)	0.67
Lenght stent per lesion (mm), mean ± SD	3.01 ± 0.45	3.10 ± 0.51	0.23
Lesion severity			
Type A, n (%)	75 (49.66)	11 (20.75)	0.00
Type B, n (%)	68 (45.03)	37 (69.81)	0.00
Type C, n (%)	8 (5.29)	5 (9.43)	0.29
Stent diameter (mm), mean ± SD	22.76 ± 6.93	22.32 ± 7.18	0.69
Number of stents per procedure, median (25th and 75th interquartile)	1 (1:2)	1 (1:2)	-
Maximal inflation pressure (atm), mean ± SD	16.56 ± 3.94	16.26 ± 3.89	0.6328
Predilation, n (%)	82(54.30)	23(43.39)	0.63

Abbreviations: DES, drug eluting stent; SD, standard deviation; ACS, acute coronary syndrome; LM, left main; LAD, left anterior descending artery; LCX, left circumflex artery RCA; CABG, coronary artery bypass graft; TIMI, thrombolysis in myocardial infarction; ATM, standard atmosphere pressure unit.

3.5. Medication at Discharge

Over 50% of study participants received all five guideline-recommended medications (i.e., *acetylsalicylic acid*, purinergic receptor P2Y12 inhibitors, β-blocker, angiotensin-converting enzyme inhibitor (ACE-I) or angiotensin II receptor blocker (ARB), and statin) at hospital discharge (Table 6). No significant differences were observed between groups regarding administration of aspirin ($p = 0.96$), clopidogrel ($p = 0.51$), ticagrelor ($p = 0.44$) or their combination, beta-blockers ($p = 0.46$), ACEI or ARB ($p = 0.87$ and $p = 0.81$, respectively) and statins ($p = 0.44$).

Table 6. Medication at discharge.

Medication at Discharge	2nd Generation DES ($n = 151$)	Other Stents ($n = 53$)	p-Value
Acetylsalicylic Acid (A), n (%)	148 (98.01)	52 (98.11)	0.96
Clopidogrel (C), n (%)	29 (19.20)	8 (15.09)	0.51
Ticagrelor (T), n (%)	121 (80.13)	45 (84.90)	0.44
DAPT, A + C, n (%)	27 (17.88)	8 (15.09)	0.64
DAPT, A + T, n (%)	120 (79.47)	44 (83.01)	0.58
Beta blocker, n (%)	115 (76.15)	43 (81.13)	0.46
Statin, n (%)	150 (99.33)	52 (98.11)	0.44
ACEI, n (%)	118 (78.14)	42 (79.24)	0.87
ARB, n (%)	10 (6.62)	3 (5.66)	0.81

Abbreviations: DES, drug eluting stent; DAPT, dual antiplatelet therapy; ACEI, angiotensin-converting enzyme inhibitor; ARB, angiotensin II receptor blocker.

3.6. Clinical Outcomes

Patients were followed up for one year from the index ACS. The cumulative incidences for MACE and each of its components are shown in Table 7. MACE had occurred in 20.52% versus 24.52% of patients underwent 2nd generation DES and other stents placement procedures, respectively. From the total, 4.41% of all patients enrolled died within one year of the acute coronary event, and 3.43% of deaths were due to cardiac diseases. There were no significantly differences in terms of death rates between groups. Graphical representation of the leading causes of cardiac deaths in each group is shown in Figure 1.

Table 7. One-year clinical outcomes.

Clinical Outcomes at 12 Months	2nd Generation DES ($n = 151$)	Other Stents ($n = 53$)	p-Value
MACE	31 (20.52)	13 (24.52)	0.54
All-cause mortality	5 (3.31)	4 (7.54)	0.20
Cardiac mortality	3 (1.98)	4 (7.54)	0.05
TLR	10 (6.62)	5 (9.43)	0.50
Non-TLR	8 (5.29)	2 (3.77)	0.66
No-R	8 (5.29)	2 (3.77)	0.66
Coronary event-free survivor	128 (84.76)	45 (84.90)	0.60
Stroke	3 (1.98)	1 (1.88)	0.96
Bleeding events	5 (3.31)	2 (3.77)	0.87

Abbreviations: DES, drug eluting stent; MACE, major adverse cardiac events; TLR, target lesion revascularization; Non-TLR, non-target lesion revascularization; No-R, no-revascularization.

Ischemic driven TLR was performed in 7.35% of all patients, with no statistically significant differences in new revascularizations between the 2nd generation DES and the other stents cohorts ($p > 0.05$). Despite these results, most patients requiring TLR had bare metal stents and 1st generation DES implanted at the index procedure (9.43%). On the other hand, higher rates of non-TLR were recorded in the 2nd generation DES group.

Cerebrovascular ischemic events and bleeding events are described in Table 7.

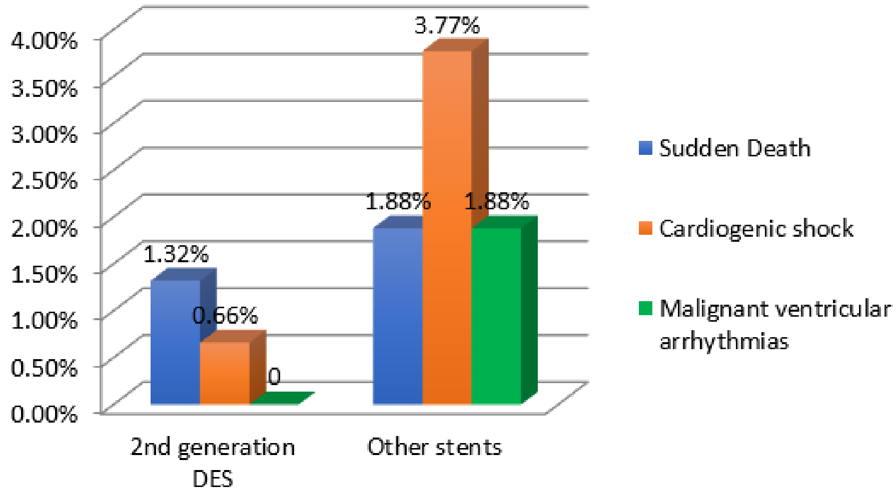

Figure 1. Leading causes of cardiac deaths in patients according to stent type inserted.

4. Discussion

MS is a major public health problem of the 21st century. MS was previously associated with an increased risk of coronary artery disease and c-v mortality. However, the impact of metabolic syndrome on stent performance in patients undergoing PCI is not yet clear. Moreover, there are few data on the influence of MS on the performance of different stent types in acute and real-life setting.

Various factors can be responsible for stent failure, starting with stent characteristics and ending with the patient's response to stent injury. The possible mechanisms were related to mechanical factors (nonuniform stent strut distribution, stent underexpansion, stent fracture, nonuniform drug elution), technical factors (stent gap, barotrauma outside stented segment, residual uncovered atherosclerotic plaques) and biological factors (hypersensitivity, drug resistance) [21–24]. In addition, the individual's response to stent placement is also decisive when it comes to evaluating the risk of restenosis. MS encompasses many risk factors for in-stent restenosis, and diabetes was specifically identified as a powerful determinant of neointimal hyperplasia [25,26].

This prospective follow-up study provides information on descriptive epidemiology, angiographic characteristics and outcomes of MS patients presenting with ACS to our specialized cardiac center. Furthermore, a comparative analysis of subjects with MS was made according to different types of stent used in patient's angioplasty.

We observed similar demographic profiles to the prior reports, in terms of mean age and gender preponderance of metabolic syndrome patients presenting with ACS [27]. Patients with 2nd generation DES stenting were 2 years younger than patients with other stents implanted and the prevalence of MS in male patients presenting with ACS was higher when compared with overall cohort, regardless of the stent type. Among the individual components of MS, raised blood pressure and low HDL-C were more common, besides central obesity, which was the main criteria for MS definition used in our study. A higher prevalence of diabetes (40.19%) was seen in our study when compared with prior studies (29.4–40%) [28,29].

Most patients had three or four MS factors; meanwhile, quintuple association comprising all five MS components (BMI > 30 kg/m^2 + HTN + HTg + HDLc + DM) was most frequent in patients with other stents than 2nd generation DES inserted (18.86% vs. 17.21%). Prior studies have shown that MS does not increase c-v risk more than the sum of its components [30,31]. According to this, our study recorded worse outcomes in terms of cardiac mortality in patients with other stents implanted, but no statistically significant differences were observed in terms of MACE or TLRs when comparing to the 2nd generation DES group. These results suggest that the number of MS components is not as important as their individual atherogenic effect.

As other studies showed [32], the prevalence of multi-vessel disease was overall greater in MS patients compared to single vessel disease (58.82% vs. 41.18%). This demonstrates the strong association between MS and coronary artery disease. When comparing patients according to stent type implanted, multi-vessel disease was predominant in patients with 2nd generation DES inserted (62.91%), whereas similar percentages of single and multi-vessel disease were observed in patients with other stents implanted. In contrast, complex coronary lesions defined by severe stenosis, total occlusion, type C lesion along with acute thrombus, excepting ostial lesion, were more frequently seen in patients undergoing PCI with 1st generation DES or bare metal stenting than in patients with second-generation stent placement. However, patients having ostial lesions were more likely to undergo 2nd generation DES stenting. These results suggest that coronary lesion characteristics are more important than the overall extent of coronary atherosclerosis (i.e., single, double, triple vessel coronary artery disease) when it comes to establishing prognosis. Thus, the complexity of culprit lesions of patients enrolled can explain the higher rates of MACE in patients with 1st generation DES or bare metal stenting. However, the results were not statistically significant.

Our study showed similar outcomes in patients with metabolic syndrome regardless of the stent type. We found that stent type in the presence of MS had no significant impact on all-cause mortality or TLR. Despite the well-known benefits of 2nd generation DES, there is no clear evidence of different stent type performance in patients with MS in the settings of an acute coronary syndrome. However, studies comparing stents have been conducted in patients with DM. Results from the Massachusetts Data Analysis Center Registry showed reduced mortality, repeat revascularization rates and myocardial infarction in patients with DES stenting compared to BMS. Nevertheless, the study had several limitations, the data was observational and did not include angiographic characteristics [33]. These findings are in contrast with our results and could be explained by the differences in methodology, acute settings and follow up period. Instead, a meta-analysis of 10 randomized trials comparing DES to BMS in DM patients, associated DES with lower rate of TLR but no differences compared to BMS regarding MACE or mortality during one year of follow-up [34]. Moreover, one of the latest trials comparing DES to BMS, that followed over 9000 patients for 6 years, showed similar results between patients receiving DES and those receiving BMS in terms of mortality, although there was a lower rate of TLR in the DES group [35]. Our study revealed similar results in terms of mortality and MACE when comparing 2nd generation DES to other stents including BMS and 1st generation DES. Additionally, an expected trend toward increased risk of ischemic-driven TLR procedures was observed in patients with 1st generation DES and bare metal stent implantation. However, the results were not statistically significant.

Few trials comparing 1st vs. 2nd generation of DES in diabetes patients with ACS resulted in no convincing differences in safety and efficacy outcomes [36,37], whereas a large meta-analysis in patients with DM and coronary artery disease showed increased beneficial effect of everolimus-eluting stents over 1st generation DES in terms of TLR, myocardial infarction and stent thrombosis, but no differences in all-cause and cardiac mortality. Moreover, for zotarolimus-eluting stents, the rates for TLR were significantly higher compared to 1st generation DES and no significant difference in the rates of MACE and cardiac mortality was observed [38]. Our research revealed no significant differences in terms of efficacy between groups, despite the fact that a trend towards reduction in TLR was observed in 2nd generation DES patients. All these findings were not statistically significant because of the low number of coronary events and revascularization procedures on follow-up. Additionally, our study had a relatively short follow-up period of 1 year, and this may be the reason why we did not detect a statistically significant association between stent type and TLR in the presence of MS. Instead, lower rates of cardiac mortality were recorded in 2nd generation DES patients, demonstrating a better safety profile of this type of stents. However, all-cause mortality and MACE did not differ between groups.

Smaller studies conducted on patients with metabolic syndrome comparing BMS to DES revealed lower rates of restenosis and adverse cardiovascular events in patients underwent DES stenting [39,40]. In contrast to our research, other studies included patients with both stable and unstable coronary disease; furthermore, some reports excluded patients with ST segment elevation ACS. The acute setting may influence stenting techniques, microvascular obstruction and outcomes. All in all, our data study demonstrated similar safety and efficacy profile of different stent types inserted in MS patients, although we observed a trend towards reduction in TLR procedures and mortality rates in patients having 2nd generation DES implanted at the index procedure. These results suggest that PCI using any stent type in parallel with intensive medical therapy for ACS and risk factors might be an effective therapeutic method in MS patients undergoing PCI and stent placement [41–43].

5. Limitation of Study

The present research has several limitations. Firstly, BMI was used instead of waist circumference to define metabolic syndrome. However, according the IDF consensus, central obesity can be assumed at BMI over 30 kg/m^2. Secondly, our study data was collected from an observational study. Thirdly, we only followed up enrolled patients for 12 months; an extended follow-up should be made for more accurate results.

6. Conclusions

In real-world metabolic syndrome population undergoing PCI and stenting, stent type is neither associated with TLR nor with the combined end point. There was no significant difference in the rates of TLR for up to 1 year of follow-up in patients with MS receiving 2nd generation DES compared with other stents. These results suggest that reperfusion therapy using PCI with stenting is equally beneficial in ACS patients with metabolic syndrome. Several limitations must be considered in this research, and future studies with larger sample size and longer follow-up are needed. Additionally, performance of third generation stents need to be evaluated in MS patients, as recent studies demonstrated its improved effectiveness [44,45].

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