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Value of optical coherence tomography (OCT) in the management of borderline culprit lesions in patients with ST-segment elevation myocardial infarction (STEMI)

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ORIGINAL ARTICLE

Value of Optical Coherence Tomography in the Management of Borderline Culprit Lesions in Patients with ST-segment Elevation Myocardial Infarction

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Abstract

Background: **A nonnegligible portion of ST-segment elevation myocardial infarction (STEMI) patients are presented with nonobstructive lesions (30−70%). The underlying pathologies are not completely revealed. Usage of intravascular imaging, particularly optical coherence tomography (OCT) are crucial before the intervention for decision making and emphasizing on the common pathological measures.**

Aim: **Define guidance parameters and the value of OCT in the management of borderline culprit lesions in STEMI as well as compare the clinical outcomes of an OCT-guided versus angiographic-guided therapy regarding this group of acute coronary syndrome.**

Patients and methods: **A prospective study of 186 patients presented with STEMI and nonobstructive borderline lesions. These patients were divided into two arms determined by the usage of OCT before intervention for decision making (to stent or not stent). Follow up took place up to 6 months.**

Results: **The results of this research have shown that there are no statistical differences between the two groups (OCT and non-OCT) regarding the demographic data (average P~0.019). The average time of procedure was 33.4 min in the first group and 32.2 in the second. Increased use of dye was observed in the first group comparable to the second ($P = 0.005$). Stenting was less common in the OCT arm ($P = 0.003$). Six-months-follow up showed no statistical difference regarding all cause morbidity and mortality between the two groups except for revascularization ($P = 0.05$).**

Conclusion: **In evaluation of patients with STEMI, OCT should be used to establish underlying etiologies and mechanisms especially for borderline nonobstructive lesions.**

Keywords: Nonobstructive borderline lesions, Optical coherence tomography, Myocardial infarction

1. Introduction

Coronary artery disease (CAD) remains one of the leading causes of morbidity and mortality worldwide. Coronary angiography has been the gold standard for evaluating coronary anatomy since it was first performed by Sones and Shirey.[1]

Following a myocardial infarction, early return to normal coronary perfusion minimizes infract size, maintains left ventricular function, and lowers mortality. Reperfusion therapy's major goal is to maintain myocyte viability and, consequently, left ventricular function while also repairing the culprit epicardial vessel's patency.[2] However, the culprit vessel is only one part of the pathophysiological process of myocardial infarction.[3]

The ability of angiography's two-dimensional portrayal of coronary architecture to distinguish between intermediate lesions that require stenting and those that only require the proper medical

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treatment is restricted. The unhealthy reference vessel, foreshortening, tortuous vessels, calcification, eccentric lesions, and poor contrast opacification make this very clear. Treatment or observation of moderately severe lesions that are 40–70% severe has always been a difficult decision for interventional cardiologists. It has been suggested that these lesions are the source of acute myocardial infarctions, making them clinically significant. A pathology known as myocardial infarction with nonobstructive coronaries.[4]

Obstructive (>70%) CAD left untreated has been linked to a bad result, according to studies.[5] However, nonobstructive CAD is linked to normal survival, and early major cardiac MACE could come from unnecessary revascularization for stenosis that is not hemodynamically significant.[6] Therefore, it was widely accepted that this form of myocardial infarction required a more detailed evaluation than could be provided by a visual assessment, either noninvasively using MPI or PET scan or invasively using intracoronary imaging.

Noninvasive stress testing has good correlation with angiography in individuals with obstructive single-vessel CAD. However, noninvasive stress testing is less reliable to find ischemia-producing lesions in individuals with nonobstructive single-vessel CAD or multivessel disease.[7]

The gold standard for identifying flow limiting intermediate coronary stenosis is fractional flow reserve (FFR). The assumption used to calculate FFR is that myocardial resistance will be small and constant during the period of greatest hyperemia. In other words, it displays the percentage of blood flow that has been maintained despite stenosis. Dynamic changes in microvascular resistance and dysfunction occur in acute coronary syndrome (ACS) as a result of a number of variables, including an acute jump in filling pressures, downstream embolization into the microvasculature, the amount and duration of ischemia, and acute wall stress. Thus, maximal hyperemia is difficult to obtain and FFR is frequently overstated, especially in the culprit artery in ACS, at least theoretically.[8]

In order to make informed decisions, intravascular ultrasonography is used. This technology offers good imaging of both the vessel lumen and the surrounding vessel wall. However, as no one characteristic is pathognomonic, the intravascular ultrasonography diagnosis of thrombus is typically based on suspicion. Additionally, it has many limitations in terms of its sensitivity to intimal pathogenic events and comprehensive plaque examination.[9]

Other imaging techniques, such as cardiac MRI, angioscopy, superparamagnetic iron oxide, near-infrared spectroscopy, intravascular elastography, and others, have several limitations, technical challenges, and insufficient clinical applications.[10]

Optical coherence tomography (OCT) gives the tomographic or cross-sectional images of the coronary arteries that are promised, but infrequently delivered angiographically. These images include the lumen, vessel wall, plaque burden, plaque composition and distribution, and even perivascular structures. According to recent studies and reviews, this application can be utilized as a one-stop shop to provide answers to the common practice-related issues and enhance patient outcomes. Is this stenosis a serious issue? What lesion is the culprit? What does an uncommon or unclear angiographic lesion look like anatomically? What size and length of stent is ideal? What is the possibility of periprocedural myocardial infarction or distal embolization during stent implantation? An intervention has it been optimized? What caused this stent to restenose or thrombose?.[11]

2. Patients and methods

2.1. Study design and patients

A prospective observational control cohort study that had been done on a sample of patients presented with ACS and borderline (30–70%) non-obstructive lesions (assessed by traditional coronary angiography), that is, ST-segment elevation myocardial infarction (STEMI) and thrombus containing lesions including in-stent thrombosis (92.84%) or its equivalent (7.16%), that is, very high risk and high risk NTEMI, high risk unstable angina, De Winter's and Wellen's syndromes indicated for primary or early invasive PCI, who referred to Cath-Lab. Units, Cardiology Department, Al-Azhar University Hospitals, Cairo, Egypt and Cath-Lab. Unit, Cardiac Centre in Hail region, Hail, KSA.

2.2. Inclusion criteria

Age more than or equal to 18 years, STEMI or its equivalent, borderline lesion in coronary angiography.

2.3. Exclusion criteria

Creatinine clearance less than or equal to 30 ml/min/1.73 m^2, hypotension, shock, left ventricular ejection fraction less than or equal to 30%, unstable ventricular arrhythmias, inability to take dual antiplatelet therapy (both aspirin and a P2Y12 inhibitor) for at least 12 months, platelet count less than 50 000 cells/mm^3, planned use of any stent in a target vessel based on visual estimation, severe vessel tortuosity or calcification in a target vessel such that it is unlikely that the OCT catheter can be delivered. The target lesion is in the left main coronary artery (mid shaft and distal LM are no excluded). The target lesion is in a bypass graft conduit.

Eligible patients will be were divided into two groups according to the sight of the operator and the clinical situation of the case.

Group I: OCT-guided group (100% in Hail); the operator judges the lesion according to the feature of culprit lesions from OCT. If a stent is implanted, postoperative OCT examination is performed.

Group II: angiographic-guided group (64.5% in Egypt and 35.5% in Hail); patients undergoing conventional angiography and/or thrombus aspiration but do not undergo OCT. The operator judges the lesion according to the current treatment standard and decides to stent or not.

2.4. Methods

All patients will be subjected to full history taking with special emphasis on history of modifiable and nonmodifiable risk factors for CAD.

General and cardiac examination, Killip and PRECISE-dual antiplatelet therapy scores were calculated for most of patients.

ECG for topography and prediction of the culprit lesion.

Conventional two-dimensional transthoracic echocardiography during the primary presentation and period of follow up.

Full laboratory study per regarding the cardiac patients with emphasize on KFTs, cardiac biomarkers, lipid profile, CBC, INR, and ACT.

Primary or early invasive coronary angiography according to clinical situation of the patient. TIMI flow score and thrombus scores were calculated; target vessel revascularization was intended to be achieved.

Quantitative coronary angiography to assess the proportion of the narrowed segment decreasing the visual error.

OCT was accomplished in order to provide the data and criteria of these kind of lesions.

PCI; the deferred stent technique was the preferred approach. However, stents were implanted guided by the OCT assessment, the sight of the interventionist and the clinical scenario of every individual patient.

All patients were having clinical ± angiographic follow-up program including intracoronary imaging (if possible) in hospital and at regular intervals after discharge up to 6 months (telephone or outpatient visits were used).

2.5. Ethical considerations

Before enrollment, patients were fully informed of the details of the study protocol that was approved by Al-Azhar University ethical committee regulations. Written informed consent was obtained from all participating patients.

2.6. Statistical analysis

Using the Statistical Program for Social Science (SPSS) (IBM, Chicago, IL, USA) the data was analyzed. The numerical variables were expressed as the mean ± SD and statistically analyzed. A P value less than 0.05 was considered statistically significant, and P value more than 0.05 was considered statistically nonsignificant. P value less than 0.001 is considered a highly statistically significant value.

3. Results

The current prospective study included a total of 186 patients undergone primary or early invasive PCI for ACS in Cath-Labs, Cardiology Department, Al-Azhar University Hospitals, Cairo, Egypt and Cath-Lab. Unit, Cardiac Centre in Hail region, Hail, KSA from January 2019 to December 2022 (Table 1).

Table 1 shows no statistical deference regarding the baseline demographic data between the two groups except for obesity and menopausal females which were recruited more in the non-OCT group. Family history of CAD was statistically higher in OCT group. P value more than 0.05 is considered nonsignificant.

Regarding angiography-guided group (93 patients) compared to OCT-guided group (95 patients, the data of two of them had been lost); the average age was 41.2 ± 0.77 compared with 40.85 ± 0.76 in OCT-group. Females represented 33.3 versus 31.18%. The average age of the first group was 41.2 ± 7.4 compared with 40.85 ± 7.3 of the second group. The majority of both groups (73.1 vs. 74.2 %) were presented in hemodynamic stable condition, that is, Killip I. Twenty-five (26.9%) versus 30 (32.26%) patients were presented by AWMI according to the ECG definitions. Mean EF before (%) was 46.1 ± 10.1 in the first group versus 50.6 ± 11.01 in the OCT-group. Average area stenosis by quantitative coronary angiography (%) was 49.2 ± 10.3

Table 1. Comparison among studied groups regarding the baseline demographic data.

Variables	No-OCT (%)	OCT (%)	*P* value
Age (years)	41.2 ± 7.4	40.85 ± 7.3	0.7
Females	33.3	31.18	0.4
HTN	41.9	22.58	0.2
DM	37.6	25.81	0.2
Smokers	37.6	23.66	0.03
BMI >30	40.9	6.45	0.001
Dyslipidemia	37.6	37.63	0.5
Menopause	54.8	6.9	0.001
Previous MI	24.7	17.2	0.1
Previous PCI	18.3	20.43	0.5
Previous CABG	0	0	–
Family history	31.2	43.01	0.06
Killip 0	0	4.3	0.1
Killip I	73.12	69.9	0.3
Killip II	11.8	16.13	0.8
Killip III	8.6	8.6	0.2
Killip IV	6.45	1.1	0.7
AWMI, EXT. AWMI.	26.9	32.26	0.3
ASWM	9.7	13.98	0.7
Inferior, IWMI, IPWM	33.3	34.41	0.4
PWMI, Posterior	9.7	2.15	0.3
Lateral	12.9	5.38	0.3
NSTEMI	7.5	8.6	0.4
LM	0	3.23	0.2
UA, ACS	0	0	–
EF before (%)	46.1 ± 10.1	50.6 ± 11.01	0.4
Thrombolytics	8.6	13.98	0.2

Table 2. Comparison between the studied groups as regarding angiographic findings.

Variables	No-OCT (%)	OCT (%)	*P* value
Diseased vessel 1	70.97	91.4	0.2
Diseased vessel 2	22.58	8.6	0.002
Diseased vessel 3	9.68	3.2	0.001
Stenosis by QCA	49.2 ± 10.3	50.22 ± 14.4	0.4
Stenosis by OCT	0	47.8 ± 12.3	–
TIMI flow (pre) 0	1.1	1.1	0.5
TIMI flow (pre) 1	1.1	1.1	0.5
TIMI flow (pre) 2	5.4	5.4	0.5
TIMI flow (pre) 3	92.5	92.5	0.5
Aspiration device	15.1	0	–
Stenting	43.01	38.8	0.3
Contrast (ml)	157 ± 112.2	134.4 ± 64.7	0.009
Procedure time (min.)	32.2 ± 13.6	33.4 ± 15.5	0.4
TIMI flow (post) 0	2.15	0	–
TIMI flow (post) 1	0	0	–
TIMI flow (post) 2	3.2	0	–
TIMI flow (post) 3	94.6	100	0.2
GP IIb/IIIa	15.1	1.1	0.001

versus 50.22 ± 14.4 comparable to 47.9 ± 12.3 by OCT. 92.5% versus 92.5% were in TIMI III coronary flow. Average volume of contrast (ml) used was 157 ± 112.2 versus 134.4 ± 64.7 and the average procedure time (min.) was 32.2 ± 13.6 versus 33.4 ± 15.5. Nearly, all the procedures in the two groups (94.6 vs. 100%) terminated in TIMI III flow (Table 2).

Table 2 shows: no statistically significant difference ($P > 0.05$) between studied groups as regard area stenosis, TIMI flow and procedure time. Statistically significant difference ($P < 0.05$) between studied groups as regard number of diseased vessels, amount of contrast use and usage of IV GPIIb/IIIa inhibitors.

Indeed, in-hospital outcome measures (primary end point); all-cause mortality was 7.5 versus 1.1%, stroke was 5.4 versus 1.1%, revascularization was 9.7 versus 2.15%, CIN occurred in 6.45 versus 15.1%, minor bleeding was 8.6 versus 19.4%, major bleeding was 7.5 versus 8.6%, arrhythmia happened in 11.8 versus 5.4%, angina took place in 20.4 versus 21.5%, cardiogenic shock was 10.75 versus 3.2%, stent thrombosis was 5.4 versus 0% and in-hospital re-infarction was 11.8 versus 4.3%. while 6-month outcome measures (secondary end point); were 2.15 versus 1.1% cardiac death, 3.2 versus 2.15% noncardiac death, 5.4 versus 12.9% TLR, 8.6 versus 10.8% TVR, 50.5 versus 0% impaired EF, 2.15 versus 1.1% STEMI and 8.6 versus 16.1% UA/non-ST-segment elevation myocardial infarction (NSTEMI), 1.1 versus 0% referred for CABG. Follow up achieved according to the study protocol in 90.3% in the first group compared with 93.5% in the second group (Figs. 1 and 2).

4. Discussion

The clinical patterns and presentations of atherosclerosis, a multifactorial disease, can vary. They can include little or no symptoms, single-vessel or multiple-vessel disease, or an asymptomatic sudden cardiac death from a coronary obstructive or non-obstructive lesion. The long-standing goal of CAD treatment is to eliminate its unpleasant side effects

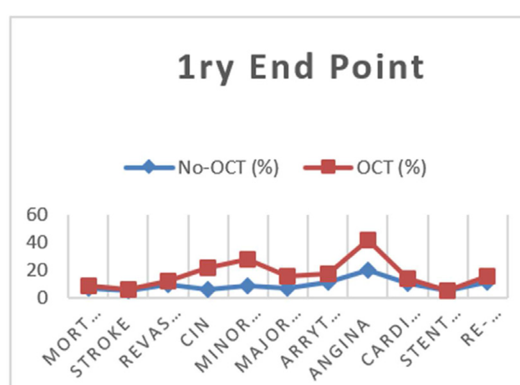

Fig. 1. Comparisons between studied groups regarding predischarge follow up (primary end point). CIN and minor bleeding were higher in OCT group while all other 1ry end points took place with higher incidence in the non-OCT group.

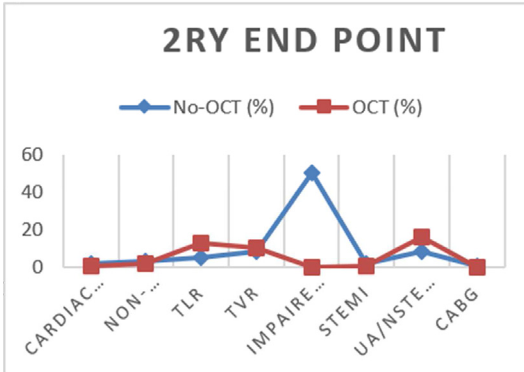

Fig. 2. Comparisons between studied groups regarding 6-month follow up (secondary end point). OCT group represented more with ischemia which required higher incidence of target lesion revascularization. The non-OCT group shows higher incidence of impaired systolic function.

of mortality and disability, which are primarily consequences of ACSs.[12]

According to studies, the survival and complication outcomes for STEMI patients with borderline lesions on coronary angiography and obstructive lesions are nearly identical. But the use of stents in this case raises a number of problems.[13]

Although interventional cardiologists welcome better imaging and more knowledge of non-obstructive coronary lesions, they face a clinical dilemma on the subsequent management patients who presented with STEMI and nonobstructive borderline lesions. Our study was a prospective study dedicated as a decision maker guidance regarding this group of patients. The purpose of the present study was to compare short-term (in-hospital) outcomes as well as MACCE at 6 months in ACS patients with borderline CAD that were treated percutaneously guided by the *ad hoc* intravascular OCT tool as compared with those that were treated percutaneously without the usage of OCT depending on the operator visual assessment of the coronary status in a group of Egyptian and non-Egyptian patients enrolled from two centers (double-centered study), it included 186 patients with ACS, divided into two groups according to the usage of OCT: group I: 93 patients with borderline lesion ACS and no-OCT and group II: 93 patients with ACS in which OCT was used. The study was intended to emphasize on the demographic data and on the angiographic findings in this group of patients, as well as on the common OCT findings.

Depending on the observed population and the definition employed, 5−15% of patients who report with acute STEMI or NSTEMI have MI with borderline lesions.[14] This was nearly the same portion of the presenting patients to the study two Cath-labs.

In this study, females are on the lesser sides. They represent a round one third of the patients. This is not matching with a lot of studies in which females represent the higher potion of this group of MI ranging between 26% and 52%.[15] The author referred this to political and traditional issues as well as miss-diagnosis of young menstruating women who are presenting with chest pain.

Both primary and secondary end points of the two studied groups come in agreement with Bainey et al.[16] where short-term mortality, stroke, revascularization, re-infarction, cardiogenic shock, impaired left ventricular functions were less common in the OCT group. However, CIN and major bleeding were higher because of relatively prolonger procedure time and higher volumes of contrast in the second arm.

The frequently gained OCT findings; average area stenosis (%) was 47.04 ± 12.4. Vessel wall dissection occurred in 31.2% of the cases. Plaques were presented in almost all the patients (91.4%). Lipid rich (fatty) plaques were 55.91%, fibrotic plaques 81.72%, necrotic tissue was found in 20.43% of the plaques, mixed plaques were 40.86%. Plaques ruptured in 33.4% where ruptured plaque with blood flow (antegrade rupture) were 17.2% that mostly lead to NSTEMI, while ruptured plaque against blood flow (retrograde rupture) were 16.13% that frequently lead to STEMI. The average intimal thickness (μm) was 144.4 ± 110.16. TCFA (<65 μm) was found in 11.83%. Red thrombi represented 19.35% while white thrombus represented 13.98%. Calcium nodules; one of the accused pathologies in ACS, were found in 11.83%. Stenting took place in 35.48% with reported good stent apposition and expansion in almost all-cases. Stent related-complications were reported in only 2.15% that treated properly according the patient condition and the operator sight. This agreed to Bryniarski et al.[17] (Fig. 3).

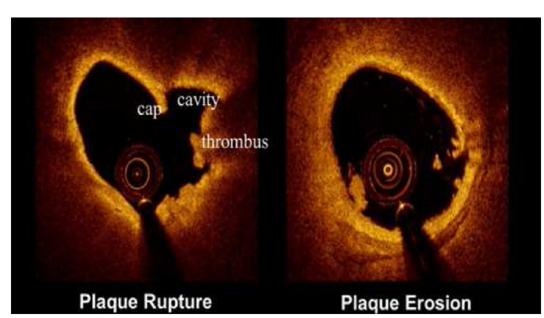

Fig. 3. OCT identified the STEMI culprit lesion's morphology and underlying pathology in two different patients presented with STEMI and borderline culprit lesions. OCT, optical coherence tomography; STEMI, ST-segment elevation myocardial infarction.

4.1. Conclusion

MI with nonobstructive lesions should not be considered as a benign condition and should receive same attention as MI-CAD. Based on available evidence in literature, it is reasonable to consider antiplatelets, statins, ACE inhibitors for those patients and individualize the treatment based on the underlying mechanisms. The study recommends the usage of intravascular imaging particularly OCT as a one-stop shop to establish etiology and mechanism especially for borderline lesions.

Conflicts of interest

There are no conflicts of interest.

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