Single-vessel versus multivessel PCI in patients with acute coronary syndrome and multivessel coronary artery disease

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Summary

Aims: Optimal management of patients with acute coronary syndromes (ACS) presenting with multivessel coronary artery disease (CAD) is controversial. We compared the outcome of three different treatment strategies: single-vessel (SV) PCI of the infarct-related artery only, multivessel PCI during the index procedure (MV_{index}) and staged multivessel PCI (MV_{staged}).

Methods and results: Between July 2007 and December 2008, 387 patients presented with ACS and multivessel CAD. In-hospital mortality was 2.4% for SV PCI, 1.9% for MV_{index} PCI and 0.8% for MV_{staged} PCI (p = 0.566). The in-hospital rate of myocardial infarction, acute stent thrombosis, cerebrovascular accident and unplanned revascularisation did not differ. MV_{index} PCI was associated with a higher rate of inguinal haematoma (0.5%, 9.4%, and 2.4% for SV PCI, MV_{index} PCI and MV_{staged} PCI respectively, p = 0.001). After 1 year death had occurred in 4.6% with SV PCI, in 4.0% with MV_{index} PCI and in 4.9% of the patients with MV_{staged} PCI (p = 0.966). Rates for major cardiovascular events including death, myocardial infarction, cerebrovascular accident and unplanned revascularisation were 13.1%, 12.1% and 13.4%, for SV PCI, MV_{index} PCI and MV_{staged} PCI respectively (p = 0.981).

Conclusion: Multivessel coronary artery PCI performed during the index procedure on presentation of the ACS was associated with a higher rate of inguinal haematoma. Long-term outcome of the three treatment strategies did not differ. Revascularisation of the infarct-related artery only might provide equal benefit to multivessel revascularisation, but needs to be determined prospectively in a larger patient population.

Key words: treatment strategy; acute coronary syndrome; multivessel disease; staged revascularisation; percutaneous coronary intervention

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Introduction

Patients with acute coronary syndrome (ACS) frequently present with angiographically-documented multivessel disease at the time of acute percutaneous coronary intervention (PCI). This has been associated with increased morbidity and mortality [1–3]. Current guidelines from the European Society of Cardiology (ESC) and the American College of Cardiology/American Heart Association (ACC/AHA) recommend PCI of the infarct-related artery (IRA) in patients who are haemodynamically stable. Multivessel revascularisation is encouraged in patients presenting in cardiogenic shock, especially if the stenotic vessel serves a large area of myocardium [4,5].

For several years past, progress in instrumental technology, stent design (in particular the introduction of drug-eluting stents) and the development of potent antiplatelet drugs has made an aggressive approach with multivessel revascularisation in ACS patients feasible and hence more attractive. Many interventionalists perform PCI of all angiographically relevant lesions either simultaneously at the time of the initial PCI or in a staged procedure. It is conceivable that the former approach, alleviating all areas of ischaemia, may be associated with a reduced incidence of adverse events at follow-up and thus also be more cost-effective [6]. On the other hand, early simultaneous multivessel PCI may result in an increased periprocedural risk due to a larger quantity of contrast dye, longer procedural time, ischaemia in non-infarcted myocardial regions and a higher risk of stent thrombosis [7]. In addition, treatment of clinically silent lesions is very possible. Unfortunately, data supporting either of these strategies are relatively sparse.

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Thus, optimal management of multivessel coronary artery disease in the context of an ACS treated by PCI remains uncertain. It was therefore the aim of this study to compare short- and long-term outcomes of single-vessel PCI, multivessel PCI during the index procedure, and staged multivessel revascularisation (either during the index hospitalisation or a second hospitalisation) in patients with ACS and multivessel coronary artery disease.

Patients and methods

Patient population

The University Hospital Zurich, where this retrospective single-centre study was performed, is a tertiary referral clinic treating some 500 patients with ACS (i.e. unstable angina pectoris, non-ST elevation myocardial infarction [NSTEMI] and ST elevation myocardial infarction [STEMI]) per year. Between July 2007 and December 2008, 727 ACS patients were treated by primary PCI. Only patients with multivessel coronary artery disease (CAD) were eligible for this study. Multivessel CAD was defined as >50% diameter stenosis of at least two main coronary arteries (i.e. left anterior descending artery, left circumflex artery and right coronary artery) or their major branches [8–10]. The only exclusion criterion was presentation in cardiogenic shock at admission (Killip class IV). Treatment of multiple lesions in one major vessel during primary PCI was not an exclusion criterion. For analysis, patients were divided into three groups as follows: (1) single-vessel PCI (SV PCI), (2) multivessel PCI during the index procedure (MV_{index} PCI), and (3) staged multivessel PCI (MV_{staged} PCI). Due to the retrospective character of this study there were no predefined criteria for treatment selection. The study was approved by the local ethics committee and a waiver of consent was granted.

Definitions and endpoints

To group the coronary artery diseases into single-vessel and multivessel coronary diseases we used the definition of the coronary-artery-tree-segments based on the classification proposed by the American Heart Association and modified for the ARTS I and II trials [11, 12]. By this approach the three epicardial coronary arteries with their branches are divided into 16 segments.

Clinical and procedural data of our patients were collected from hospital records. Patients were also followed up in the out-hospital clinic or by phone interviews.

Adverse cardiovascular events included death, myocardial infarction, acute stent thrombosis, stroke, unplanned PCI or coronary artery bypass grafting and major bleeding. Major bleeding was defined as (a) inguinal haematoma ≥5 cm or requiring intervention, (b) retroperitoneal bleeding and (c) other bleeding such as intracranial or intraocular haemorrhage; any gastrointestinal haemorrhage; urogenital haemorrhage; a need for transfusion of packed red blood cells; a decrease in haemoglobin ≥4 g/dL; any other major bleeding. Additionally, peak creatinine was analysed as an in-hospital outcome parameter.

Endpoints at follow-up were death, myocardial infarction, stroke and the need for any unplanned revascularisation (i.e. target vessel revascularisation, target lesion revascularisation and coronary artery bypass grafting). We also analysed a combined endpoint including all the above events [13]. One year follow-up was available in 340 (88%) of the patients.

Statistical analysis

Statistical analysis was performed using SPSS 15 (SPSS Inc., Chicago, USA). If not otherwise indicated, data are presented as mean ± the standard deviation for continuous variables and as number and frequencies for categorical variables. Continuous variables were compared using student's t-test and categorical variables using the chi-square test and Fisher's exact test. Kaplan-Meier estimates were used to calculate 1-year outcome. They were compared using the log rank test. A cox regression analysis was performed to compare single-vessel and multivessel treatment. For all tests a two-sided $p < 0.05$ was considered statistically significant.

Results

Patients and procedures

Between July 2007 and January 2009, 727 patients presenting with ACS were treated at our clinic, of whom 409 (56%) presented with multivessel coronary disease. After exclusion of patients in cardiogenic shock at admission, a total of 387 patients were analysed. Of these, 209 patients were treated by SV PCI, 53 by MV_{index} PCI and the remaining 129 by MV_{staged} PCI. Forty-three (81%) of the patients undergoing MV_{index} PCI were considered completely revascularised. Staged revascularisation was carried out during the same hospitalisation in 20 (16%) of the patients. In the remaining patients elective revascularisation was performed during a second hospitalisation 1–12 weeks (median 4 weeks) after the index event.

Baseline characteristics of the three treatment groups are shown in table 1. Age, sex and prevalence of cardiovascular risk factors did not differ between the two groups. Patients with SV PCI presented more often with a history of prior PCI (19%, 9% and 7% for patients with SV PCI, MV_{index} PCI and MV_{staged} PCI respectively, $p = 0.006$).

Procedural characteristics are presented in table 2. Patients with MV_{index} revascularisation presented significantly more often with NSTEMI and unstable AP,

Table 1
Baseline characteristics.

Variable	Single-vessel PCI (n = 209)	Multivessel PCI index procedure (n = 53)	Multivessel PCI staged (n = 125)	p value
Age (years)	66 ± 12	64 ± 11	64 ± 12	0.476
Male sex	158 (76%)	38 (72%)	125 (82%)	0.208
Hypertension	119 (58%)	35 (67%)	75 (62%)	0.456
Diabetes	46 (22%)	8 (15%)	22 (18%)	0.418
Hypercholesterolaemia	91 (44%)	24 (46%)	46 (38%)	0.421
Current smoker	82 (40%)	27 (52%)	42 (34%)	0.222
Family history of CAD	57 (28%)	12 (23%)	37 (30%)	0.614
PVD	16 (8%)	6 (11%)	7 (6%)	0.412
Prior MI	45 (22%)	7 (13%)	15 (12%)	0.062
Prior CABG	19 (9%)	3 (6%)	5 (4%)	0.200
Prior PCI	40 (19%)	5 (9%)	9 (7%)	0.006
Prior CVA	4 (2%)	0 (0%)	1 (1%)	0.457
Creatinine (μmol/L)	95 ± 50	88 ± 22	90 ± 47	0.543

CAD: coronary artery disease; PVD: peripheral vascular disease; MI: myocardial infarction; CABG: coronary artery bypass grafting; PCI: percutaneous coronary intervention; CVA: cerebrovascular accident.

Table 2
Procedural characteristics of the primary intervention.

Variable	Single-vessel PCI (n = 209)	Multivessel PCI index procedure (n = 53)	Multivessel PCI staged (n = 125)	p value
Type of ACS				
STEMI	125 (60%)	18 (34%)	75 (60%)	0.002
NSTEMI	63 (30%)	26 (49%)	43 (34%)	0.034
Unstable AP	21 (10%)	9 (17%)	7 (6%)	0.058
Three vessel disease	83 (40%)	22 (42%)	48 (38%)	0.925
Left main stenosis ≥50%	13 (6%)	10 (19%)	5 (4%)	0.002
CTO of LAD	19 (9%)	6 (11%)	13 (10%)	0.857
CTO of CX	12 (6%)	2 (4%)	5 (4%)	0.712
CTO of RCA	31 (15%)	5 (9%)	8 (6%)	0.056
Ejection fraction (%)	52 ± 14	53 ± 12	53 ± 9	0.822
Systolic BP (mm Hg)	126 ± 25	124 ± 24	123 ± 24	0.658
Diastolic BP (mm Hg)	69 ± 13	70 ± 12	70 ± 13	0.884
Medication before angiography				
Aspirin	209 (100%)	53 (100%)	125 (100%)	N/A
Clopidogrel	106 (51%)	27 (51%)	77 (62%)	0.135
Heparin	143 (68%)	34 (64%)	86 (69%)	0.813
Low molecular weight heparin	47 (23%)	11 (21%)	29 (23%)	0.938
Medication for PCI				
Heparin	94 (45%)	29 (55%)	57 (46%)	0.433
Heparin and GpIIb/IIIa	79 (38%)	16 (30%)	45 (36%)	0.588
Bivalirudin	35 (17%)	8 (15%)	23 (18%)	0.853
Number of stents	1.69 ± 1.43	2.10 ± 0.77	1.47 ± 0.63	0.005
DES use	134 (64%)	38 (72%)	76 (61%)	0.282
Total stent length (mm)	32 ± 18	44 ± 20	30 ± 14	<0.001
IABP use	18 (9%)	11 (21%)	10 (8%)	0.021

ACS: acute coronary syndrome; STEMI: ST segment elevation myocardial infarction; NSTEMI: non-ST segment elevation myocardial infarction; AP: angina pectoris; CTO: chronic total occlusion; LAD: left anterior descending; CX: circumflex; RCA: right coronary artery; BP: blood pressure; DES: drug eluting stent; IABP: intra-aortic balloon pump.

and less often with STEMI. However, an IABP was inserted more frequently in patients with MV_{index} PCI. As expected, a larger number of stents were also used in such patients and total stent length was more than in SV PCI and MV_{staged} PCI patients. Antithrombotic medication before angiography and for PCI did not differ between the treatment groups.

In-hospital outcome

In-hospital outcome is shown in table 3. In-hospital mortality was 2.4 % for patients with SV PCI, 1.9% for patients with MV_{index} PCI and 0.8% for patients with MV_{staged} PCI (p = 0.566). Thus, in-hospital mortality for multivessel revascularisation (MV_{index} and MV_{staged} PCI) was 1.1% (p = 0.351 compared to single-vessel revascularisation). Myocardial infarction occurred in 1.4%, 0% and 1.6% for SV PCI, MV_{index} PCI and MV_{staged} PCI respectively, p = 1.000. Acute stent thrombosis occurred in two patients with SV PCI, two with MV_{staged} PCI and none with MV_{index} PCI respectively, p = 0.798. While no cerebrovascular accidents occurred in the patients with SV PCI or MV_{index} PCI, cerebrovascular accidents occurred in 2 patients with MV_{staged} PCI. The rate for unplanned PCI and need for coronary artery bypass grafting did not differ. Peak creatinine was not higher in patients undergoing MV_{index} PCI. In the subgroup of patients presenting with STEMI, in-hospital mortality was 3/125 (2.4%), 1/18 (5.6%) and 0/75 (0%) for patients treated by SV PCI, MV_{index} PCI and MV_{staged} PCI respectively, p = 0.222. Significantly more patients presented with an inguinal haematoma after undergoing MV_{index} PCI (0.5%, 9.4% and 2.4% for SV PCI, MV_{index} PCI and MV_{staged} PCI respectively, p = 0.001). Possible causes of inguinal haematoma in MV_{index} PCI patients included need for an intra-aortic balloon pump (IABP) in 2 patients, use of a Gp2b3a inhibitor for 12 h after PCI in 1 patient. One patient already presented with inguinal haematoma after diagnostic catheterisation in the referring hospital. In one patient no specific reason for inguinal haematoma could be found.

None of the patients in the MV_{staged} PCI group had an adverse cardiovascular event within 30 days of staged revascularisation.

As shown in table 2, a total of 28 patients presented with left main stenosis ≥ 50%. These patients were more often treated with MV_{index} PCI. In-hospital

Table 3
In-hospital outcome.

Variable	Single-vessel PCI (n = 209)	Multivessel PCI index procedure (n = 53)	Multivessel PCI staged (n = 129)	p value
Death	5 (2.4%)	1 (1.9%)	1 (0.8%)	0.566
Myocardial infarction	3 (1.4%)	0 (0%)	2 (1.6%)	1.000
Acute stent thrombosis	2 (1.0%)	0 (0%)	2 (1.6%)	0.798
CVA	0 (0%)	0 (0%)	2 (1.6%)	0.211
Unplanned PCI	1 (0.5%)	1 (1.9%)	2 (1.6%)	0.457
CABG	3 (1.4%)	0 (0%)	0 (0%)	0.548
Major bleeding	8 (3.8%)	6 (11.3%)	5 (4.0%)	0.068
Inguinal haematoma	1 (0.5%)	5 (9.4%)	3 (2.4%)	0.001
Retroperitoneal bleeding	3 (1.4%)	0 (0%)	0 (0%)	0.276
Other bleeding	4 (1.9%)	1 (1.9%)	2 (1.6%)	0.978
Peak creatinine (µmol/L)	111 ± 78	97 ± 35	101 ± 74	0.403

CVA: cerebrovascular accident; PCI: percutaneous coronary intervention; CABG: coronary artery bypass grafting.

Table 4
Kaplan Meier estimates of 1-year outcome.

Variable	Single-vessel PCI	Multivessel PCI index procedure	Multivessel PCI staged	p value
Death	8 (4.6%)	2 (4.0%)	4 (4.9%)	0.966
Myocardial infarction	4 (2.5%)	1 (3.4%)	2 (1.6%)	0.924
CVA	0 (0%)	0 (0%)	1 (1.2%)	0.126
Unplanned revascularisation	21 (13.2%)	3 (8.1%)	8 (9.4%)	0.525
Combined endpoint	21 (13.1%)	5 (12.1%)	12 (13.4%)	0.981

CVA: cerebrovascular accident. Data in parentheses represent Kaplan-Meier estimates for 1-year event rate. P values indicate overall comparison using the log-rank test.

mortality (7.1% vs. 1.4%, p = 0.028), the rates of unplanned CABG (7.1% vs. 0.3%, p = 0.014) and of major bleeding (14.3% vs. 4.2%, p = 0.040) were higher in these patients. Rates of CVI, MI and unplanned PCI did not differ.

Long-term outcome

Kaplan-Meier estimates of event rate at one-year follow-up are reported in table 4. Mortality and adverse event rates did not differ between treatment strategies. Mortality was 4.6%, 4.0% and 4.9% for patients with SV, MV_{index} and MV_{staged} PCI respectively, p = 0.966. Cumulative event rate including death and major cardiovascular events was 13.1%, 12.1% and 13.4% for patients with SV, MV_{index} and MV_{staged} PCI respectively, p = 0.981. Cumulative event rate is also shown in figure 1.

Table 5 compares long-term outcome between single-vessel revascularisation and multivessel revascularisation (MV, including MV_{index} and MV_{staged} PCI). Mortality was the same in SV and MV PCI (HR 0.90, 95% CI 0.31–2.59). Cumulative event rate did not differ (HR 1.06, 95% CI = 0.57 – 1.97).

Discussion

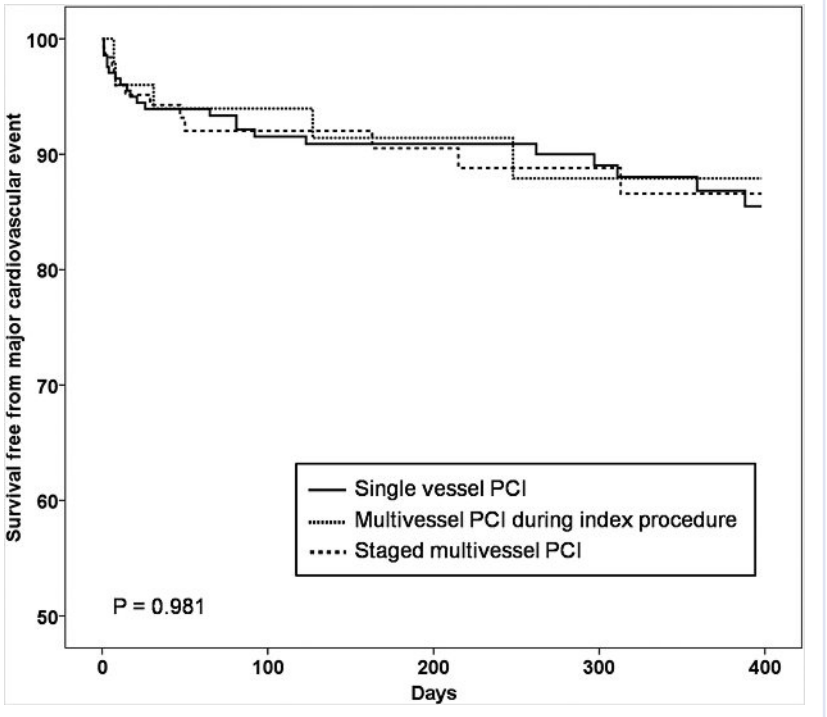
In the present study we compared three different treatment strategies: (1) single-vessel treatment of the IRA only, (2) multivessel revascularisation during the index procedure and (3) staged multivessel revascularisation. Inguinal haematoma was significantly more frequent in patients undergoing MV_{index} PCI. However, in two of these patients inguinal haematoma was associated with use of an IABP, and an IABP was significantly more often inserted in patients undergoing MV_{index} PCI. Otherwise, short- and long-term mortality and the rate of major adverse cardiovascular events were similar in all three treatment groups. In-hospital mortality in patients treated with multivessel PCI was indeed as low as 1.1% and compared well with the 2.4% rate in patients treated by single-vessel revascularisation. The low in-hospital mortality of all treatment groups may be explained at least in part by the exclusion of patients presenting in cardiogenic shock. This may have limited the power of this study to detect differences between groups. On the other hand, the combined event rate during the first year was relatively high, probably due to the presence of multivessel disease and hence selection of a patient population at high risk of future adverse cardiovascular events. Peak creatinine was not higher in patients undergoing MV revascularisation during the index procedure.

Table 5
Cox-regression analysis of multivessel PCI (during the index procedure or staged) compared to single-vessel PCI.

Endpoint	Hazard ratio	95% CI	p value
Death	0.90	0.31–2.59	0.841
Myocardial infarction	0.752	0.179–3.155	0.697
Unplanned revascularisation	0.675	0.34–1.34	0.260
Combined endpoint	1.059	0.571–1.965	0.855

CI: confidence interval

Figure 1
Kaplan-Meier estimates of survival free from major cardiovascular events in patients with multivessel coronary artery disease according to treatment strategy.



Comparison to previous studies

Current guidelines recommend single vessel PCI of the IRA only in haemodynamically stable patients [4, 5]. There is ongoing debate as to whether or not complete revascularisation may improve prognosis in patients presenting with an

acute coronary syndrome, since by this approach all areas of potential ischaemia are effectively treated. A recent metaanalysis has suggested that elective revascularisation may improve outcome in patients with recent myocardial infarction, but not in patients without such an event [14]. Furthermore, use of drug eluting stents has led to lower rates of revascularisation and mortality in patients with acute myocardial infarction [15–17].

A number of retrospective studies comparing single-vessel and multivessel treatment of patients with myocardial infarction have been published. Most of the studies have compared outcome of SV and MV_{index} PCI [18–22] only. A few studies have included patients treated by MV_{staged} PCI [23–26]. Altogether, the conclusions of these studies were inhomogeneous: indeed, in Corpus et al. [23], reporting on patients with prior myocardial infarction treated in early 2000, multivessel PCI was associated with higher rates of reinfarction, revascularisation and major adverse cardiac events at 1-year follow-up. They concluded that in patients with multivessel disease PCI should be restricted to the infarct-related artery. However, the majority of these patients were treated with bare metal stents. Rigattieri et al. [24] reported in 2008 that multivessel, staged PCI was associated with a lower incidence of adverse events at follow-up (9.3% vs 23.9%, P = 0.037), but this strategy was associated with a higher incidence of in-hospital major adverse cardiac events. In contrast, evaluation of the combined endpoint at one year did not show any difference between multivessel, staged PCI and single-vessel PCI, which is in line with our results. Han et al. [25] used drug-eluting stents in more than 90% of their patients and found no difference in major adverse cardiovascular events or mortality during a 12-month follow-up. However, the rate of recurrent angina and depressed left ventricular ejection fraction was lower in patients undergoing multivessel revascularisation with the second intervention performed 7–15 days after the index procedure. Finally, Hannan et al. [26] recently reported increased in-hospital mortality in patients undergoing multivessel revascularisation during the index procedure but lower 12-month mortality in patients with MV_{staged} PCI performed within 60 days of the index procedure, including during the index admission.

Overall, 218 patients in this study presented with ST elevation myocardial infarction. Only 18 (8%) were treated by multivessel PCI. This is in line with a recent state-of-the art paper suggesting that default strategy in patients with ST elevation myocardial infarction and multivessel disease should be single vessel PCI [27].

Clinical relevance

Clinical practice and several studies have highlighted the fact that multivessel disease is frequently present in patients presenting with ACS. In previously published series of patients with acute myocardial infarction, multivessel CAD was found in about 40–50% of the cases [28, 29]. In our study the rates of multivessel disease tended to be even higher and were 52%, 63% and 58% for patients with STEMI, NSTEMI and unstable angina pectoris respectively. It is therefore important to define an optimal treatment strategy in such patients. The results of the present study suggest that multivessel PCI in patients presenting with ACS is safe but does not outperform single-vessel revascularisation during a 1-year follow-up. However, as no additional hospitalisation is required, multivessel PCI during the index procedure may be cost-effective compared to staged multivessel PCI.

Limitations

This is a retrospective non-randomised single-centre study without predefined criteria for treatment selection. Moreover, coronary lesions were classified on the basis of the respective operator's visual estimation, which involves uncertainty. Tests for the detection of ischaemia such as pressure wires or scintigraphy were not routinely used. Also, the number of patients included in this study was small and confidence intervals were relatively wide. Finally, the follow-up time of one year was relatively short and may lead to underestimation of the benefits of multivessel revascularisation [19]. Indeed, one year of follow-up may not be long enough to show differences in outcome of a disease that may take decades to develop its complications [30], particularly in patients receiving optimal medical care.

Conclusion

We conclude, with respect to the limitations of this study, that multivessel PCI in patients with ACS did not outperform single-vessel revascularisation during a 1-year follow-up. Multivessel PCI during the index procedure was associated with a higher rate of inguinal haematoma. Prospective, randomised trials including a larger patient population and long-term follow-up are needed to determine the optimal treatment strategy in patients with ACS and multivessel disease.

References

1 Sorajja P, Gersh BJ, Cox DA, McLaughlin MG, Zimetbaum P, Costantini C, et al. Impact of multivessel disease on reperfusion success and clinical outcomes in patients undergoing primary percutaneous coronary intervention for acute myocardial infarction. Eur Heart J. 2007; 28:1709–16.

2 Timóteo AT, Fiarresga A, Feliciano J, Ferreira R, Gonçalves JM, Ferreira L, et al. Importance of complex additional stenosis after primary angioplasty for acute myocardial infarction in medium-term prognosis. Rev Port Cardiol. 2004;23:853–64.

3 Tarantini G, Napodano M, Gasparetto N, Favaretto E, Marra MP, Cacciavillani L, et al. Impact of multivessel coronary artery disease on early ischemic injury, late clinical outcome, and remodeling in patients with acute myocardial infarction treated by primary coronary angioplasty. Coron Artery Dis 2010;21(2):78–86.

4 Silber S, Albertsson P, Avilés FF, Camici PG, Colombo A, Hamm C, et al. Task Force for Percutaneous Coronary Interventions of the European Society of Cardiology. Guidelines for Percutaneous Coronary Interventions. The Task Force for Percutaneous Coronary Interventions of the European Society of Cardiology. Eur Heart J 2005;26:804–847.

5 Smith SC Jr, Feldman TE, Hirshfeld JW Jr, Jacobs AK, Kern MJ, King SB 3rd, et al. American College of Cardiology/American Heart Association Task Force on Practice Guidelines; ACC/AHA/SCAI Writing Committee to Update the 2001 Guidelines for Percutaneous Coronary Intervention. ACC/AHA/SCAI 2005 guideline update for percutaneous coronary intervention: a report of the American College of Cardiology/American Heart Association Task force on Practice Guidelines (ACC/AHA/SCAI Writing Committee to Update the 2001 Guidelines for Percutaneous Coronary Intervention). J Am Coll Cardiol 2006;47:e1–121.

6 Palmer ND, Causer JP, Ramsdale DR, Perry RA. Effect of completeness of revascularization on clinical outcome in patients with multivessel disease presenting with unstable angina who undergo percutaneous coronary intervention. J Invasive Cardiol. 2004;16:185–8.

7 Shishehbor MH, Topol EJ, Mukherjee D, Hu T, Cohen DJ, Stone GW, et al. TARGET Investigators. Outcome of multivessel coronary intervention in the contemporary percutaneous revascularization era. Am J Cardiol. 2006;97:1585–90.

8 Tsuiki K, Ohta I, Oguma M, Yamaguchi S, Tono-oka I, Yasui S. Significant stenosis of coronary arteries in patients with single and multiple vessel diseases without previous myocardial infarction. Jpn Circ J. 1991;55:427–36.

9 Schweiger MJ, Stanek E, Iwakoshi K, Hafer JG, Jacob A, Tullner W, et al. Comparison of visual estimate with digital caliper measurement of coronary artery stenosis. Cathet Cardiovasc Diagn. 1987;13:239–44.

10 Leaman DM, Brower RW, Meester GT, Serruys P, van den Brand M. Coronary artery atherosclerosis: severity of the disease, severity of angina pectoris and compromised left ventricular function. Circulation. 1981;63:285–99.

11 Austen WG, Edwards JE, Frye RL, Gensini GG, Gott VL, Griffith LS, et al. A reporting system on patients evaluated for coronary artery disease. Report of the Ad Hoc Committee for Grading of Coronary Artery Disease, Council on Cardiovascular Surgery, American Heart Association. Circulation. 1975;51:5–40.

12 Serruys PW, Unger F, van Hout BA, van den Brand MJ, van Herwerden LA, van Es GA, et al. The ARTS study (Arterial Revascularization Therapies Study). Semin Interv Cardiol. 1999;4:209–19.

13 Myocardial infarction redefined – a consensus document of The Joint European Society of Cardiology/American College of Cardiology Committee for the redefinition of myocardial infarction. Eur Heart J. 2000; 21:1502–13.

14 Katritsis DG, Ioannidis JPA. Percutaneous Coronary Intervention Versus Conservative Therapy in Nonacute Coronary Artery Disease: A Meta-Analysis. Circulation 2005;111:2906–2912.

15 Hannan EL, Racz MJ, McCallister BD, Ryan TJ, Arani DT, Isom OW, et al. A comparison of three-year survival after coronary artery bypass graft surgery and percutaneous transluminal coronary angioplasty. J Am Coll Cardiol 1999;33:63–72.

16 Mauri L, Silbaugh TS, Garg P, Wolf RE, Zelevinsky K, Lovett A, et al. Drug-eluting or bare-metal stents for acute myocardial infarction. N Engl J Med 2008;359:1330–42.

17 Kastrati A, Dibra A, Spaulding C, Laarman GJ, Menichelli M, Valgimigli M et al. Meta-analysis of randomized trials on drug-eluting stents vs. bare-metal stents in patients with acute myocardial infarction. Eur Heart J 2007;28:2706 –13.

18 Brener SJ, Milford-Beland S, Roe MT, Bhatt DL, Weintraub WS, Brindis RG. American College of Cardiology National Cardiovascular Database Registry. Culprit-only or multivessel revascularization in patients with acute coronary syndromes: an American College of Cardiology National Cardiovascular Database Registry report. Am Heart J. 2008;155:140–6.

19 Kong JA, Chou ET, Minutello M, Wong SC, Hong MK. Safety of single versus multi-vessel angioplasty for patients with acute myocardial infarction and multi-vessel coronary artery disease: report from the New York State Angioplasty Registry. Coronary Artery Disease 2006;17: 71–75.

20 Khattab AA, Abdel-Wahab M, Röther C, Liska B, Toelg R, Kassner G, et al. Multi-vessel stenting during primary percutaneous coronary intervention for acute myocardial infarction. A single-center experience. Clin Res Cardiol 97;32–38.

21 Qarawani D, Nahir M, Abboud M, Hazanov Y, Hasin Y. Culprit only versus complete coronary revascularization during primary PCI. Int J Cardiol 2008;123:288–292.

22 Roe MT, Cura FA, Joski PS, Garcia E, Guetta V, Kereiakes DJ, et al. Initial Experience With Multivessel Percutaneous Coronary Intervention During Mechanical Reperfusion for Acute Myocardial Infarction. Am J Cardiol 2001;88:170–173.

23 Corpus RA, House JA, Marso SP, Grantham JA, Huber KC Jr, Laster SB, et al. Multivessel percutaneous coronary intervention in patients with multivessel disease and acute myocardial infarction. Am Heart J. 2004;148:493–500.

24 Rigattieri S, Biondi-Zoccai G, Silvestri P, Di Russo C, Musto C, Ferraiuolo G, et al. Management of multivessel coronary disease after ST elevation myocardial infarction treated by primary angioplasty. J Interv Cardiol. 2008;21:1–7.

25 Han YL, Wang B, Wang XZ, Li Y, Wang SL, Jing QM, et al. Comparative effects of percutaneous coronary intervention for infarct-related artery only or for both infarct- and non-infarctrelated arteries in patients with ST-elevation myocardial infarction and multi-vessel disease. Chin Med J. 2008;121:2384–7.

26 Hannan EL, Samadashvili Z, Walford G, Holmes DR, Jacobs AK, Stamato NJ, et al. Culprit Vessel Percutaneous Coronary Intervention Versus Multivessel and Staged Percutaneous Coronary Intervention for ST-Segment Elevation Myocardial Infarction Patients With Multivessel Disease. J Am Coll Cardiol Intv. 2010;3:22–31.

27 Widimsky P, Holmes DR. How to treat patients with ST-elevation acute myocardial infarction and multi-vessel disease? Eur Heart J. 2011;32: 396–403.

28 Mohamad T, Bernal JM, Kondur A, Hari P, Nelson K, Niraj A, et al. Coronary Revascularization Strategy for ST Elevation Myocardial Infarction with Multivessel Disease: Experience and Results at 1-Year Follow-Up. Am J Ther. 2010 Jan 4. [Epub ahead of print].

29 Jaski BE, Cohen JD, Trausch J, Marsh DG, Bail GR, Overlie PA, et al. Outcome of urgent percutaneous transluminal coronary angioplasty in acute myocardial infarction: comparison of single-vessel versus multivessel coronary artery disease. Am Heart J. 1992;124:1427–33.

30 Katritsis DG, Meier B. Percutaneous Coronary Intervention for Stable Coronary Artery Disease. J Am Coll Cardiol 2008;52:889–93.