The Zwolle global experience on primary percutaneous coronary intervention

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Timely restoration of antegrade blood flow in the infarct-related artery of patients with ST-segment elevation myocardial infarction (STEMI) results in myocardial salvage and improved survival. We describe the Zwolle approach with regard to prehospital phase, the first 15 min in hospital, initial pharmacological therapy, angiography, angioplasty, risk stratification, rehabilitation and secondary prevention. Confirmation of the diagnosis by 12-lead electrocardiography by either general practitioners or ambulance paramedics allows substantial reduction in the time-delay to first balloon inflation, as the hospital and the catheterization laboratory can be prepared in advance, and the emergency room and the coronary care unit with their unavoidable delays can be skipped on the way to acute angiography. In our setting all patients with STEMI are treated at the time of diagnosis (before or during transportation) with heparin (5000 IU) and aspirin (500 mg) intravenously, with additional oral bolus (300 mg) of clopidogrel and additional 5000 IU heparin at the time of angiography. Our attitude is that an optimal balloon angioplasty result should never be jeopardized just for somewhat lower rate of target vessel revascularization during the first year after the acute event. In particular, attention should be paid to side branches, which may be of more clinical relevance in this setting than with elective angioplasty. Additional mechanical devices, such as distal protection devices and/or thrombosuction, should be mostly used when relevant thrombotic material is visible, with concomitant higher risk of distal embolization, particularly in high-risk patients. Finally, the use of the Zwolle risk score may help to identify low-risk patients who could be safely discharged within 36-48 hours after primary angioplasty, with a significant reduction in the costs of hospitalization.

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Introduction

Timely restoration of antegrade blood flow in the infarct-related artery of patients with ST-segment elevation myocardial infarction (STEMI) results in myocardial salvage and improved survival[1,2]. Several studies[3-6] and a recent overview of 23 randomized trials[7] have shown that primary angioplasty is superior to thrombolysis in terms of mortality, reinfarction, and stroke. Given the superior efficacy and safety of primary angioplasty, this treatment is now preferred when logistics allow this approach.

As it has been shown for angioplasty therapy for stable and unstable angina[8], it is likely that the results of primary angioplasty will be in part dependent on the setting in which it is performed, and therefore the results from various hospitals may differ considerably[9]. Establishing and maintaining a proficient primary angioplasty program takes great institutional will and effort, and even institutions with a large experience in coronary angioplasty for stable and unstable angina will have something of a learning curve for primary angioplasty[10]. The main issues pertinent to the delivery of primary angioplasty therapy will be discussed following the sequence of events from the patient's perspective. Our approach will be described with regard to prehospital phase, the first 15 min in hospital, initial pharmacological therapy, angiography, angioplasty, risk stratification, rehabilitation, and secondary prevention.

Prehospital phase

Early recognition of STEMI and adequate response by general practitioners and ambulance service are of great importance, mainly for two reasons. First, mortality in the very early hours is substantial, and many patients die before adequate medical help has been sought and delivered. Secondly, although the results of primary angioplasty therapy are less time-dependent than the results of thrombolysis, in particular during the first few hours, saving time is saving muscle[11]. In fact, even though initial reports showed no impact of time delay on

outcome, our recent study showed that every minute of delay does count also in patients undergoing primary angioplasty for STEMI[12]. The impact of ischemic time has also been confirmed by other reports, particularly in high-risk patients[13-17]. In fact, both the American College of Cardiology/American Heart Association[18] and European Society of Cardiology[19] guidelines on STEMI suggest to start thrombolytic therapy when primary angioplasty cannot be performed within 90 min after diagnosis.

Confirmation of the diagnosis by 12-lead ECG by either general practitioners or ambulance paramedics allows substantial reduction in the time delay to first balloon inflation, as the hospital and the catheterization laboratory can be prepared in advance, and the emergency room and the coronary care unit with their unavoidable delays can be skipped on the way to acute angiography. Furthermore, it gives an important opportunity to start initial pharmacological therapy, and makes effective use of the transportation time in this regard. A primary angioplasty center must therefore develop additional specific training programs for general practitioners and ambulance services. Excellent communication with these first-line providers of care for patients with acute myocardial infarction is of paramount importance, as this will be among the main factors determining time to therapy. The On-TIME trial[20] showed the feasibility of in-ambulance diagnosis of STEMI and direct transportation to the cath lab, with complete skip of referral centers, emergency rooms or coronary care units[21]. This approach can significantly shorten ischemic time and thus may save "muscle" and improve long-term outcome.

The first fifteen minutes in hospital

If a definitive diagnosis has not been made before arrival at the hospital, it is important that delays are avoided. A limited history and physical examination should be performed and 12-lead ECG should be made and interpreted within 5 to 10 min[18,19]. Blood tests may be drawn, but the results should not be waited for, a chest X-ray is unnecessary at this stage. The first responsibility of the emergency room physician is to contact the cath lab and to get the patient there as soon as possible.

Important organizational issues that determine the logistics are: who is in charge of patients with suspected cardiac symptoms in the emergency room?; who is in charge of the coronary care unit?; what type of nurses are staffing the emergency room? We have learnt that it is a great advantage if: 1) the coronary care unit is run by an interventional cardiologist; 2) the emergency room physicians are supervised by the head of the coronary care unit; and 3) coronary care unit, interventional cardiologists and emergency room nurses fall within the same organizational unit and therefore know each others' responsibilities.

Finally, a flexible attitude of cath lab staff and the interventional cardiologist in charge is a prerequisite. They should be prepared to charge their program at a moment's notice, postpone an elective case or get out of the bed in the middle of night, to do this job as quickly and proficiently as they can.

Initial pharmacological therapy

Adequate pain relief and sedation are essential, not only for humanitarian reasons, but in particular as the patient has to endure angiography and angioplasty[18,19]. Sublingual and intravenous nitroglycerine as well as intravenous beta-blockers, unless contraindicated, should be given in an effort to lower oxygen consumption and alleviate myocardial ischemia. High-dose intravenous heparin has been used in an attempt to increase the initial patency rates of the infarct-related artery with promising results[21]. However, a larger randomized trial[22] showed that a moderate dose of intravenous heparin (10 000 IU), without measurements of the activated clotting time, results in a comparable clinical outcome.

Thus, in our setting all patients with a STEMI are treated at the time of diagnosis (before or during transportation) with heparin (5000 IU) and aspirin (500 mg) intravenously, with additional oral bolus (300 mg) of clopidogrel and additional 5000 IU heparin at the time of angiography.

Still controversial is the additional pre-treatment with glycoprotein IIb/IIIa inhibitors. In the On-TIME trial[20], pre-treatment with tirofiban during transportation, despite benefits in terms of preprocedural TIMI 2 and 3 flow, was not associated with a reduction in infarct size and mortality. A major limitation of this study is the very short ischemic time and the relatively low-risk population. In fact, it is conceivable that the longer the transportation time and the higher the patient's risk profile, the more evident the benefits from early reperfusion[15-17]. Since a recent study at our Institution has shown the best antiplatelet aggregation inhibition with high-dose tirofiban[23], the results of the On-TIME II trial will clarify the benefits in outcome from additional early high-dose tirofiban administration in high-risk patients, in comparison with placebo. Recent data[24] have shown that abciximab is associated with a significant reduction in mortality, particularly when administered early[25]. The ongoing FINESSE trial[26] will potentially clarify this issue.

Angiography

Vascular access can be obtained by either the femoral, radial or brachial approach, but femoral access is generally preferred, in particular when the patient is electrically or hemodynamically unstable. Femoral ac-

cess allows the introduction of larger devices if necessary (intra-aortic balloon pump)[27,28]. However, recent studies have shown the feasibility of a radial approach in primary angioplasty for STEMI[29]. This approach may potentially help to reduce bleeding complications at the puncture site, particularly in elderly patients, and in those pretreated with thrombolysis or glycoprotein IIb/IIIa inhibitors. Five and 6F sheaths and catheters can be used. A low osmolar ionic contrast agent should be used to lower the risk of thromboembolic complications[30].

Angiography of the non-infarct-related artery should be performed first to allow identification of multivessel disease and collateral flow to the infarct zone. Contrast ventriculography is only necessary to help to determine the infarct-related artery if this is uncertain based on information of the ECG and the coronary angiography, and can usually be avoided. In general, we perform angiography of the infarct-related artery with a 6F angioplasty guiding catheter, in order to be able to proceed immediately with angioplasty if indicated. In case of relevant thrombotic material in the infarct-related artery, we change for a 7F guiding catheter in order to use a thrombosuction device. During this phase the interventional cardiologist must try to give answers to the following questions:

• can I identify the infarct-related artery with certainty and will I be able to get it open? (if not, ask for help, do not try to be a hero);

• consider a conservative approach when there is spontaneous reperfusion or a small myocardial territory at risk, and consider bypass surgery if clinically indicated; either acutely or following initial stabilization;

• if the decision to go for angioplasty is taken, do you need venous access, temporary pacing, or intra-aortic balloon pumping? In particular, during recanalization of the right coronary artery, bradycardia and hypotension may occur and may necessitate large amounts of intravenous fluids, 0.5-2.0 mg atropine or even pressure therapy. The interventional cardiologist who is not prepared to handle this type of complications, but let him-herself be surprised by these sudden events, may even lose patients[31].

Angioplasty

After passing the wire, it is often possible to have a first impression of the distal vessel following intracoronary nitrates. Balloon sizing should be adequate – at least 1:1 balloon-to-artery ratio. This mandates repeated bolus doses of intracoronary nitrates in order to avoid serious underestimation of the true vessel size. We perform one or two balloon inflations of 2-3 min, usually with pressures of 8-12 atm. Over-the-wire balloon may be used for distal injection of adenosine, papaverine or calcium-antagonist before deflation, in order to prevent the reperfusion injury.

Optimal angiographic visualization of the lesion in multiple projections, as well as the distal vessel, is necessary to assess the results and define the need for further balloon inflations or stenting. The operator should strive for an optimal result with < 30% residual stenosis and TIMI 3 flow, as well as evidence of myocardial reperfusion[32-34]. If there is a significant residual stenosis or if there is angiographic evidence of major dissection, stenting should be considered. If an adequate vessel lumen is evident in multiple projections, dissections can be left without a stent, provided that reliability of angiographic result is shown by repeating one or two worst view after waiting 5 min. After initial angioplasty, the presence of relevant residual thrombotic material, with the presence of good flow (TIMI 3 flow), may represent an acceptable result, and additional balloon angioplasty (risk of distal embolization) or stenting ("stent the plaque and not the thrombus or the vessel") may not be needed. Since TIMI 3 flow represents the best thrombolytic therapy, after additional therapy with glycoprotein IIb/IIIa inhibitors, the lesion can be followed-up by predischarge angiography to see if the thrombus has been dissolved. In case of no-reflow phenomenon, before starting a "blind" inflation in the distal coronary bed or repeated movements of the balloon with a potential "cleaning effect" of intracoronary thrombus, a probing catheter may be advanced distally to the lesion for selective injection of adenosine (2 mg) or papaverine (15 mg).

With rare exceptions, the goal of primary angioplasty is to dilate the infarct-related artery. Multiple lesions in the infarct-related artery can, and sometimes should, be dilated but dilating a non-infarct-related artery during the acute hours of myocardial infarction jeopardizes too much myocardium. Any complication in approaching the non-culprit artery may have serious consequences on the outcome. We tend to dilate all significant lesion (diameter stenosis > 50%) in the infarct-related artery, with the sole exception of concomitant lesions that seem to carry a very high risk of complications. TIMI 3 flow in the infarct-related artery should not be put at risk for a somewhat less severe distal stenosis.

Stenting

It should be stressed that stenting has so far been shown to be superior to balloon angioplasty only in selected patients[35-45], without no benefits in terms of mortality and reinfarction. In fact, the results of all previous trials may have been biased by the strict patient selection, due to exclusion criteria and randomization after initial angiography or balloon dilation. In order to overcome this potential limitation, and to evaluate the role of routine stenting in unselected patients, a total of 1683 consecutive STEMI patients have been randomized to balloon or stenting before angiography, without

any exclusion criteria[46]. Stenting did not show any superiority in comparison with balloon angioplasty, in terms of combined death and/or reinfarction and major adverse cardiac events.

Thus, our attitude is that an optimal balloon angioplasty result should never be jeopardized just for somewhat lower rate of target vessel revascularization during the first year after the acute event. In particular, attention should be paid to side branches, which may be of more clinical relevance in this setting than with elective angioplasty. This also goes for the need for long stents to cover the lesion, as this predisposes to in-stent restenosis and to the life-threatening consequences of the rare event of subacute stent thrombosis. In our experience, almost all sudden occlusion of infarct-related arteries after balloon angioplasty occur in hospital, and can usually be managed, but subacute stent thrombosis, although rare, may occur later after discharge with dramatic consequences. All stented patients should be treated with aspirin and additional antiplatelet therapy for 4 weeks. At our institution all patients receive clopidogrel for at least 1 month after the procedure, since clopidogrel has been shown as much affective as ticlopidine, with better safety profile[47,48]. Even though the benefits of drug-eluting stents on restenosis have been shown[49,50], only few and non-randomized data are available on the efficacy and safety of drug-eluting stents in primary angioplasty[51]. In fact, the delayed re-endothelialization may be associated with higher rates of subacute thrombosis, with negative impact on outcome. Again, one should realize that stenting has not been shown to reduce mortality, as compared to balloon angioplasty.

Distal protection device and thrombosuction

Our previous report[52] has shown that distal embolization is observed in up to 16% of STEMI patients, with a significant negative impact on long-term survival. Thus, additional use of distal protection and thrombosuction devices may be expected to further improve the outcome. However, data from the EMERALD trial[53] have shown no benefits from distal protection devices. Small randomized trials have shown benefits from thrombosuction in patients with evidence of intracoronary thrombus[54]. According to these initial reports, it seems that these devices should be mostly used when relevant thrombotic material is visible, with concomitant higher risk of distal embolization, particularly in high-risk patients[33].

Risk stratification, rehabilitation and secondary prevention

When the care of patients with acute myocardial infarction is in the hands of interventional cardiologists, it is crucial that they pay as meticulous attention to further management as to the initial procedure; some of the most important aspects are therefore briefly delineated here. Based on the available clinical data, the angiographic findings and the 12-lead ECG[18,19,32-34,55] after the primary angioplasty procedure, the risk of the individual patient can be estimated reliably, and further management can be tailored accordingly. In high-risk patients, intra-aortic balloon pumping may be considered[27,28]. During the first days, it is appropriate to assess left ventricular function by echocardiography or radionuclide ventriculography[18,19]. In our approach, most of the patients will have early sheath removal 1-3 hours after primary angioplasty procedure, with low-molecular heparin for 1-2 days. Angiotensin-converting enzyme inhibition is given to patients with depressed left ventricular function, and most patients have diet counseling and start with a cholesterol lowering agent (statin)[18,19]. In particular, as patients are now discharged after 2-3 days, the outpatient rehabilitation program has become an integral part of infarct patient management, including many aspects of secondary prevention, such as smoking cessation and weight reduction.

A recent study[55] has shown that almost 60% of patients, identified as low-risk by the Zwolle risk score, could be safely discharged within 36-48 hours after primary angioplasty, with a significant reduction in the costs of hospitalization. A prospective study at our institution will test the feasibility of a very early discharge (36 hours) after primary angioplasty.

In patients with multivessel disease, the need for additional revascularization procedures should be assessed. Signs and symptoms of recurrent ischemia must be carefully sought after, during the few in-hospital days and in particular during visits to the outpatient clinic. The general practitioner of the patients may play a central role in this monitoring process. In our setting, thallium scintigraphy is often the preferred non-invasive test for restenosis and recurrent ischemia.

References

1. An international randomized trial comparing four thrombolytic strategies for acute myocardial infarction. The GUSTO investigators. N Engl J Med 1993; 329: 673-82.
2. The effects of tissue plasminogen activator, streptokinase, or both on coronary-artery patency, ventricular function, and survival after acute myocardial infarction. The GUSTO Angiographic Investigators. N Engl J Med 1993; 329: 1615-22.
3. Grines CL, Browne KF, Marco J, et al. A comparison of immediate angioplasty with thrombolytic therapy for acute myocardial infarction. The Primary Angioplasty in Myocardial Infarction Study Group. N Engl J Med 1993; 328: 673-9.
4. Zijlstra F, de Boer MJ, Hoorntje JC, et al. A comparison of immediate coronary angioplasty with intravenous streptokinase in acute myocardial infarction. N Engl J Med 1993; 328: 680-4.
5. Zijlstra F, Hoorntje JC, de Boer MJ, et al. Long-term benefit of primary angioplasty as compared with thrombolytic

therapy for acute myocardial infarction. N Engl J Med 1999; 341: 1413-9.
6. de Boer MJ, Ottervanger JP, van't Hof AW, et al. Reperfusion therapy in elderly patients with acute myocardial infarction: a randomized comparison of primary angioplasty and thrombolytic therapy. J Am Coll Cardiol 2002; 39: 1723-8.
7. Keeley EC, Boura JA, Grines CL. Primary angioplasty versus intravenous thrombolytic therapy for acute myocardial infarction: a quantitative review of 23 randomised trials. Lancet 2003; 361: 13-20.
8. Kimmel SE, Berlin JA, Laskey WK. The relationship between coronary angioplasty procedure volume and major complications. JAMA 1995; 274: 1137-42.
9. Christian TF, O'Keefe JH, DeWood MA, et al. Intercenter variability in outcome for patients treated with direct coronary angioplasty during acute myocardial infarction. Am Heart J 1998; 135 (Part 1): 310-7.
10. Caputo RP, Ho KK, Stoler RC, et al. Effect of continuous quality improvement analysis on the delivery of primary percutaneous transluminal coronary angioplasty for acute myocardial infarction. Am J Cardiol 1997; 79: 1159-64.
11. O'Neill WW, de Boer MJ, Gibbons RJ, et al. Lessons from the pooled outcome of the PAMI, ZWOLLE and Mayo Clinic randomized trials of primary angioplasty versus thrombolytic therapy of acute myocardial infarction. J Invasive Cardiol 1998; 10 (Suppl A): 4A-10A.
12. De Luca G, Suryapranata H, Ottervanger JP, et al. Time delay to treatment and mortality in primary angioplasty for acute myocardial infarction: every minute of delay counts. Circulation 2004; 109: 1223-5.
13. Stone GW, Cox D, Garcia E, et al. Normal flow (TIMI-3) before mechanical reperfusion therapy is an independent determinant of survival in acute myocardial infarction: analysis from the primary angioplasty in myocardial infarction trials. Circulation 2001; 104: 624-6.
14. De Luca G, van't Hof AW, de Boer MJ, et al. Time-to-treatment significantly affects the extent of ST-segment resolution and myocardial blush in patients with acute myocardial infarction treated by primary angioplasty. Eur Heart J 2004; 25: 1009-13.
15. Antoniucci D, Valenti R, Migliorini A, et al. Relation of time to treatment and mortality in patients with acute myocardial infarction undergoing primary coronary angioplasty. Am J Cardiol 2002; 89: 1248-52.
16. De Luca G, Ernst N, Zijlstra F, et al. Preprocedural TIMI flow and mortality in patients with acute myocardial infarction treated by primary angioplasty. J Am Coll Cardiol 2004; 43: 1363-7.
17. De Luca G, Suryapranata H, Zijlstra F, et al. Symptom-onset-to-balloon time and mortality in patients with acute myocardial infarction treated by primary angioplasty. J Am Coll Cardiol 2003; 42: 991-7.
18. Antman EM, Anbe DT, Armstrong PW, et al. ACC/AHA guidelines for the management of patients with ST-elevation myocardial infarction. A report of the American College of Cardiology/American Heart Association Task Force on Practice Guidelines (Committee to revise the 1999 guidelines for the management of patients with acute myocardial infarction). J Am Coll Cardiol 2004; 44: E1-E211.
19. Van de Werf F, Ardissino D, Betriu A, et al. Management of acute myocardial infarction in patients presenting with ST-segment elevation. The Task Force on the Management of Acute Myocardial Infarction of the European Society of Cardiology. Eur Heart J 2003; 24: 28-66.
20. van't Hof AW, Ernst N, de Boer MJ, et al. Facilitation of primary coronary angioplasty by early start of a glycoprotein IIb/IIIa inhibitor: results of the Ongoing Tirofiban in Myocardial Infarction Evaluation (On-TIME) trial. Eur Heart J 2004; 25: 837-46.
21. Verheugt FW, Liem A, Zijlstra F, et al. High dose bolus heparin as initial therapy before primary angioplasty for acute myocardial infarction: results of the Heparin in Early Patency (HEAP) pilot study. J Am Coll Cardiol 1998; 31: 289-93.
22. Liem A, Zijlstra F, Ottervanger JP, et al. High dose heparin as pretreatment for primary angioplasty in acute myocardial infarction: the Heparin in Early Patency (HEAP) randomized trial. J Am Coll Cardiol 2000; 35: 600-4.
23. Ernst NM, Suryapranata H, Miedema K, et al. Achieved platelet aggregation inhibition after different antiplatelet regimens during percutaneous coronary intervention for ST-segment elevation myocardial infarction. J Am Coll Cardiol 2004; 44: 1187-93.
24. De Luca G, Suryapranata H, Stone GW, et al. Abciximab as adjunctive therapy to reperfusion in acute ST-segment elevation myocardial infarction: a meta-analysis of randomized trials. JAMA 2005; 193: 1759-65.
25. Montalescot G, Barragan P, Wittemberg O, et al. Platelet glycoprotein IIb/IIIa inhibition with coronary stenting for acute myocardial infarction. N Engl J Med 2001; 344: 1895-903.
26. Ellis SG, Armstrong P, Betriu A, et al. Facilitated percutaneous coronary intervention versus primary percutaneous coronary intervention: design and rationale of the Facilitated Intervention with Enhanced Reperfusion Speed to Stop Events (FINESSE) trial. Am Heart J 2004; 147: E16.
27. van't Hof AW, Liem AL, de Boer MJ, et al. A randomized comparison of intra-aortic balloon pumping after primary coronary angioplasty in high risk patients with acute myocardial infarction. Eur Heart J 1999; 20: 659-65.
28. Stone GW, Marsalese D, Brodie BR, et al. A prospective, randomized evaluation of prophylactic intraaortic balloon counterpulsation in high-risk patients with acute myocardial infarction treated with primary angioplasty. Second Primary Angioplasty in Myocardial Infarction (PAMI-II) Trial Investigators. J Am Coll Cardiol 1997; 29: 1459-67.
29. Philippe F, Larrazet F, Meziane T, et al. Comparison of transradial vs transfemoral approach in the treatment of acute myocardial infarction with primary angioplasty and abciximab. Catheter Cardiovasc Interv 2004; 61: 67-73.
30. Grines CL, Schreiber TL, Savas V, et al. A randomized trial of low osmolar ionic versus nonionic contrast media in patients with myocardial infarction or unstable angina undergoing percutaneous transluminal coronary angioplasty. J Am Coll Cardiol 1996; 27: 1381-6.
31. Gacioch GM, Topol EJ. Sudden paradoxic clinical deterioration during angioplasty of the occluded right coronary artery in acute myocardial infarction. J Am Coll Cardiol 1989; 14: 1202-9.
32. van't Hof AW, Liem A, Suryapranata H, et al. Angiographic assessment of myocardial reperfusion in patients treated with primary angioplasty for acute myocardial infarction: myocardial blush grade. Zwolle Myocardial Infarction Study Group. Circulation 1998; 97: 2302-6.
33. De Luca G, van't Hof AW, de Boer MJ, et al. Impaired myocardial perfusion is a major explanation of the poor outcome observed in patients undergoing primary angioplasty for ST-segment-elevation myocardial infarction and signs of heart failure. Circulation 2004; 109: 958-61.
34. van't Hof AW, Liem A, de Boer MJ, Zijlstra F. Clinical value of 12-lead electrocardiogram after successful reperfusion therapy for acute myocardial infarction. Zwolle Myocardial Infarction Study Group. Lancet 1997; 350: 615-9.
35. Suryapranata H, van't Hof A, Hoorntje JC, et al. Randomised comparison of coronary stenting with balloon an-

gioplasty in selected patients with acute myocardial infarction. Circulation 1998; 97: 2502-5.
36. Suryapranata H, Ottervanger JP, Nibbering E, et al. Long-term outcome and cost-effectiveness of stenting versus balloon angioplasty for acute myocardial infarction. Heart 2001; 85: 667-71.
37. Antoniucci D, Santoro GM, Bolognese L, et al. A clinical trial comparing primary stenting of the infarct-related artery with optimal primary angioplasty for acute myocardial infarction: results from the Florence Randomized Elective Stenting in Acute Coronary Occlusion (FRESCO) trial. J Am Coll Cardiol 1998; 31: 1234-9.
38. Rodriguez A, Bernardi V, Fernandez M, et al. In-hospital and late results of coronary stents versus conventional balloon angioplasty in acute myocardial infarction (GRAMI trial). Am J Cardiol 1998; 81: 1286-91.
39. Saito S, Hosokawa G, Tanaka S, Takamura S. Primary stent implantation is superior to balloon angioplasty in acute myocardial infarction: final results of the Primary Angioplasty versus Stent Implantation in Acute Myocardial Infarction (PASTA) trial. PASTA Trial Investigators. Catheter Cardiovasc Interv 1999; 48: 262-8.
40. Grines CL, Cox DA, Stone GW, et al. Coronary angioplasty with or without stent implantation for acute myocardial infarction. Stent Primary Angioplasty in Myocardial Infarction Study Group. N Engl J Med 1999; 341: 1949-56.
41. Scheller B, Hennen N, Severin-Kneib S, et al. Follow-up of the PSAAMI study population (Primary Stenting vs Angioplasty in Acute Myocardial Infarction). (abstr) J Am Coll Cardiol 1999: 33 (Suppl A): 29A.
42. Millard L, Hamon M, Khalife K, et al. A comparison of systematic stenting and conventional balloon angioplasty during primary percutaneous transluminal coronary angioplasty for acute myocardial infarction. STENTIM-2 Investigators. J Am Coll Cardiol 2000; 35: 1729-36.
43. Stone G, Grined CL, Cox AD, et al, for the Controlled Abciximab and Device Investigation to Lower Late Angioplasty Complications (CADILLAC) Investigators. Comparison of angioplasty with stenting with or without abciximab, in acute myocardial infarction. N Engl J Med 2002; 346: 957-66.
44. Stone GW, Brodie BR, Griffin JJ, et al. Clinical and angiographic follow-up after primary stenting in acute myocardial infarction. The Primary Angioplasty in Myocardial Infarction (PAMI) Stent Pilot Trial. Circulation 1999; 99: 1548-54.
45. Zhu MM, Feit A, Chadow H, Alam M, Kwam T, Clark LT. Primary stent implantation compared with primary balloon angioplasty for acute myocardial infarction: a meta-analysis of randomized clinical trials. Am J Cardiol 2001; 88: 297-301.
46. Suryapranata H, De Luca G, van't Hof AW, et al. Is routine stenting for acute myocardial infarction superior to balloon angioplasty? A randomised comparison in a large cohort of unselected patients. Heart 2005; 91: 641-5.
47. Bhatt DL, Bertrand ME, Berger PB, et al. Meta-analysis of randomized and registry comparisons of ticlopidine with clopidogrel after stenting. J Am Coll Cardiol 2002; 39: 9-14.
48. De Luca G, Suryapranata H, van't Hof AW, et al. Comparison between ticlopidine and clopidogrel in patients with ST-segment elevation myocardial infarction treated with coronary stenting. Thromb Haemost 2004; 91: 1084-9.
49. Moses JW, Leon MB, Popma JJ, et al. Sirolimus-eluting stents versus standard stents in patients with stenosis in a native coronary artery. N Engl J Med 2003; 349: 1315-23.
50. Stone GW, Ellis SG, Cox DA, et al. A polymer-based, paclitaxel-eluting stent in patients with coronary artery disease. N Engl J Med 2004; 350: 221-31.
51. Lemos PA, Saia F, Hofma SH, et al. Short- and long-term clinical benefit of sirolimus-eluting stents compared to conventional bare stents for patients with acute myocardial infarction. J Am Coll Cardiol 2004; 43: 704-8.
52. Henriques JP, Zijlstra F, Ottervanger JP, et al. Incidence and clinical significance of distal embolisation during primary angioplasty for acute myocardial infarction. Eur Heart J 2002; 23: 1112-7.
53. Stone GW, Webb J, Cox DA, et al, for the Enhanced Myocardial Efficacy and Recovery by Aspiration of Liberated Debris (EMERALD) Investigators. Distal microcirculatory protection during percutaneous coronary intervention in acute ST-segment elevation myocardial infarction: a randomized controlled trial. JAMA 2005; 293: 1063-72.
54. Napodano M, Pasquetto G, Sacca S, et al. Intracoronary thrombectomy improves myocardial reperfusion in patients undergoing direct angioplasty for acute myocardial infarction. J Am Coll Cardiol 2003; 42: 1395-402.
55. De Luca G, Suryapranata H, van't Hof AW, et al. Prognostic assessment of patients with acute myocardial infarction treated with primary angioplasty: implications for early discharge. Circulation 2004; 109: 2737-43.