Management and outcomes of patients transferred for rescue coronary angioplasty in acute myocardial infarction

Giuseppe Steffenino, Giorgio Baralis, Antonio Dellavalle, Eugenio La Scala, Federica Meinardi*, Franca Margaria*, Sara Goletto*, Fabrizio Rolfo*

*Cardiac Catheterization Unit, *Intensive Care Unit, S. Croce e Carle Hospital, Cuneo, Italy*

Key words:
Coronary angioplasty; Myocardial infarction; Reperfusion.

Background. **Rescue coronary angioplasty (PTCA), though recommended by the guidelines, is not regularly performed after failed lysis in patients with ST-elevation acute myocardial infarction (AMI), and data from large contemporary studies are not available. The outcomes of a recent series of consecutive patients in our Center are presented.**

Methods. **Between August 2000 and November 2003, 270 patients with AMI < 12 hours were referred to our cath lab for emergency PTCA: 117 (43%) for rescue PTCA after failed lysis, and 153 for primary or facilitated PTCA. The baseline, procedural and outcome data of all patients were prospectively collected, analyzed on an "intention-to-treat" basis and compared. Cineangiographic data were reviewed by three angiographers who were unaware of the clinical data.**

Results. **No significant differences were found between rescue PTCA and primary/facilitated PTCA patients as to: age, female gender, diabetes, hypertension, previous AMI, time from pain onset to the first emergency room admission, heart rate at admission, systolic blood pressure, number of leads with ST-segment elevation, total ST-segment deviation, collateral flow to the infarct-related artery, initial TIMI 2-3 flow, and three-vessel disease. Patients with rescue PTCA, as compared to primary/facilitated PTCA, had a longer time from pain onset to the cath lab (336 ± 196 vs 229 ± 155 min, p = 0.0001) and more frequently had an anterior AMI (52 vs 38%, p = 0.027), a higher Killip class (1.5 ± 0.98 vs 1.26 ± 0.7, p = 0.02), shock (11 vs 5%, p = 0.073), and intra-aortic balloon pump use (17 vs 8%, p = 0.048); fewer patients were in Killip class 1 (74 vs 85%, p = 0.043). PTCA was performed immediately in 78 vs 95% of patients (p = 0.0001); 8 vs 3 patients had PTCA of the infarct-related artery and 8 vs 1 had bypass surgery later during hospitalization. Patients with rescue PTCA, as compared to primary/facilitated PTCA, had a final TIMI 3 flow in 62 vs 76% of cases (p = 0.017), ≥ 70% ST-segment resolution in 36 vs 50% (p = 0.086), and both of the latter in 24 vs 45% (p = 0.006); the overall hospital mortality was 12 vs 6.5%, and 5.8 vs 3.4% when patients in shock on admission were not considered; reinfarction and stroke occurred in 0.9 vs 1.3% and in 2.6 vs 0% of the patients respectively.**

Conclusions. **Due to referral, rescue PTCA patients were admitted to the cath lab later after the onset of infarction, and had a higher risk profile, as compared to primary/facilitated PTCA patients; both recanalization and reperfusion were less satisfactory, as were the outcomes. Thrombolysis is often ineffective but, as long as it remains a widespread treatment, efforts should be made to improve reperfusion and survival in these patients, possibly by an earlier referral for rescue PTCA.**

(Ital Heart J 2004; 5 (10): 739-745)

Received March 18, 2004; revision received July 20, 2004; accepted July 23, 2004.

Address:

Dr. Giuseppe Steffenino

Laboratorio di Emodinamica Ospedale S. Croce e Carle Via M. Coppino, 26 12100 Cuneo E-mail: steffenino.g@ospedale.cuneo.it

Background

Coronary angioplasty (PTCA), though superior to thrombolysis (TT) in patients with ST-elevation acute myocardial infarction (AMI)[1,2], has substantial logistic limitations and is being offered only to a minority of patients in our country, where TT remains the most widespread reperfusion treatment[3]. Both failure of reperfusion and early reocclusion often occur after TT[4]. Rescue (R) PTCA is recommended by the current guidelines[5,6], but it is not regularly performed after failed TT[3], and data from large contemporary investigations are not available. In this paper, the characteristics and the outcomes of a consecutive series of patients referred to our Center for R-PTCA after failed TT are reviewed and compared to those of the other AMI patients treated with emergency PTCA during the same period.

Methods

In our Center, emergency PTCA has been the treatment of choice for high-risk patients with AMI since 1993. Patients with large (ST-segment deviation in > 4 leads), anterior, inferior + right ventricular, or recurrent AMI, as well as those with acute

left ventricular failure (Killip class > 2), are considered high-risk. Since August 2000, AMI patients admitted to our hospital who were candidates for PTCA have been treated with reteplase 10 U (facilitated PTCA) in cases when the angiography room was expected to be unavailable for at least 30 min. Coronary angiography was then performed as soon as possible, followed by PTCA in most cases. When the angiography room was expected to be available within 30 min, no thrombolytic drug was administered, and the patient was immediately transported to the cath lab (primary PTCA). A detailed description of our experience with primary and facilitated PTCA has been published separately[7].

Our Center is the only interventional cath lab in a large province, serving a population of about 500 000 inhabitants. Since July 2000, a cardiac surgical division has been active in our hospital, with 24/24 hour and 7/7 day coverage, and our around-the-clock program of emergency PTCA in AMI has also been offered to 6 nearby hospitals without interventional cardiology facilities (4 with a cardiac intensive care unit), to provide R-PTCA potentially in all cases of failed TT.

Between August 2000 and November 2003, 153 patients were admitted to our cath lab within 12 hours of the onset of AMI, to undergo facilitated PTCA (n = 80) or primary PTCA (n = 73); because in these patients PTCA was chosen as a reperfusion strategy from the very beginning, they were considered as a single group (P&F-PTCA). During the same period, 117 patients were referred to our cath lab for R-PTCA after failed TT. No definite protocol was followed by the nearby hospitals for the selection of patients to be referred for R-PTCA. In the patients included in this report, failed TT was diagnosed by the attending cardiologists as the persistence (or recurrence) of various degrees of ST-segment elevation within 12 hours of TT, most often accompanied by chest pain and/or signs of left ventricular failure.

The baseline, procedural and outcome data of all patients were prospectively collected as part of our quality assurance program, and were analyzed on an "intention-to-treat" basis (i.e., even when PTCA was not performed immediately or at all).

The femoral access was used for cardiac catheterization whenever possible. Heparin was administered during the interventional procedure, to achieve an activated clotting time ≥ 300 s. A left ventriculogram was not routinely performed. The use of thrombus aspiration systems (Rescue, Boston Scientific, Scimed, Maple Grove, MN, USA) and of glycoprotein IIb/IIIa inhibitors was at the operator's discretion. When glycoprotein IIb/IIIa inhibitors were used, activated clotting times between 230 and 270 s were considered satisfactory. Immediate PTCA was generally withheld when the coronary anatomy was very unfavorable and immediate bypass surgery was an option, or when the angiogram showed a TIMI 3 flow in the infarct-related artery (IRA) with a heavy thrombotic component, and at least 50% ST-segment resolution was apparent on the 12-lead ECG; in the latter case, elective myocardial revascularization, either with elective PTCA after treatment with heparin and ticlopidine ≥ 48 hours or with bypass surgery when indicated, was scheduled. Intra-aortic balloon counterpulsation was regularly used in patients with left ventricular failure, when the aorto-iliac anatomy was not unfavorable. Ticlopidine 500 mg/day *per os* and aspirin 100 to 250 mg/day were started within hours of stent implantation and continued for 1 month, and intravenous heparin was administered for 48 hours after the procedure. Femoral sheaths were generally removed 48 to 72 hours after the initial procedure.

A 12-lead ECG was recorded before and immediately (< 30 min) after the end of the initial procedure in all patients; ST-segment elevation and deviation in the initial ECG could be analyzed in 93 and 137 R-PTCA and P&F-PTCA patients, and in both ECG recordings in 87 and 129 patients respectively, who survived in the absence of pacemaker rhythm or left bundle branch block; ECG readings were computed both as the sum of ST-segment elevations and deviations. Cineangiographic data were reviewed by three angiographers who were unaware of the clinical and ECG data.

Statistical analysis. Univariate analysis of the clinical, ECG and angiographic characteristics was performed in both groups. The χ^2 test and the Student's t-test were used to compare proportions and means respectively. A p value of < 0.05 was considered as statistically significant.

Results

There were no significant differences in the baseline historical characteristics of R-PTCA (n = 117) and P&F-PTCA patients (n = 153) (Table I), except for a trend to a younger age in the former (60 ± 12 vs 64 ± 13 years, p = 0.08).

The clinical and ECG picture at presentation (Table II) showed a similar time interval between symptom

Table I. Baseline historical characteristics.

	R-PTCA (n=117)	P&F-PTCA (n=153)	p
Age (years)	60 ± 12	64 ± 13	0.08
Females	20%	20%	NS
Diabetes mellitus	15%	16%	NS
Hypertension	55%	47%	NS
Previous CABG	0.9%	3%	NS
Previous PTCA	7%	11%	NS
Previous AMI	13%	15%	NS

AMI = acute myocardial infarction; CABG = coronary artery bypass graft; P&F = primary and facilitated; PTCA = coronary angioplasty; R = rescue.

Table II. Clinical and ECG picture at presentation.

	R-PTCA (n=117)	P&F-PTCA (n=153)	p
Interval between symptom onset and first emergency room admission (min)	139 ± 125, median 95	142 ± 135, median 90	NS
Interval between first emergency room admission and procedure (min)	197 ± 128, median 180, range 75-740	91 ± 73, median 70, range 20-240	0.0001
Interval between symptom onset and procedure (min)	336 ± 196, median 300, range 75-1340	229 ± 155, median 180, range 35-810	0.0001
Anterior AMI	52%	38%	0.027
No. leads with ↑ST*	5 ± 2	4 ± 2	NS
No. leads with ↑↓ST	7 ± 3	7 ± 3	NS
Sum of ST ↑ and ↓ (mm)	18 ± 13	17 ± 10	NS
Killip class 1	74%	85%	0.043
Killip class (mean)	1.5 ± 0.98	1.26 ± 0.7	0.02
Shock	11%	5%	0.073

AMI = acute myocardial infarction; P&F = primary and facilitated; PTCA = coronary angioplasty; R = rescue. * initial ST-segment elevation could not be assessed in 40 patients.

onset and first admission to the emergency room in both groups (139 ± 125 vs 142 ± 135 min, median 95 vs 90 min). R-PTCA patients had a significantly longer delay from the first emergency room to the cath lab (197 ± 128 vs 91 ± 73 min, median 180 vs 70 min, p = 0.0001), with a broader range (75-740 vs 20-240 min), mirrored by a longer total interval between symptom onset and procedure start (336 ± 196 vs 229 ± 155 min, median 300 vs 180 min, p = 0.0001). Previous full-dose TT with alteplase, reteplase and tenecteplase had been respectively administered to 65, 20 and 15% of R-PTCA patients. AMI was more often anterior in R-PTCA patients (52 vs 38%, p = 0.027) and, although overall, it was not more extensive as judged at ST-segment analysis, the left ventricular function was more markedly impaired in these patients, in terms of both a lower prevalence of Killip class 1 upon admission (74 vs 85%, p = 0.043), and a higher mean Killip class in their group (1.5 ± 0.98 vs 1.26 ± 0.7, p = 0.02). Cardiogenic shock on admission was present in 11 vs 5% of R-PTCA and P&F-PTCA patients respectively (p = 0.073). In the R-PTCA group, 3 patients were already intubated at the time of arrival to the cath lab, and another deceased in the cath lab before coronary angiography could be performed.

The angiographic findings and procedural data are listed in table III. Initial IRA patency was similar under all aspects in both groups, and a TIMI 2-3 flow was present in a similar proportion of cases (36 vs 34% in R-PTCA vs P&F-PTCA). The extent of coronary artery disease was also similar, with single-vessel involvement in about one half of cases. An intra-aortic balloon pump was used more often in R-PTCA patients (17 vs 8%), while glycoprotein IIb/IIIa inhibitors and thrombus aspiration systems were used only exceptionally (6 and 3% respectively).

It is of note that immediate R-PTCA was not performed after coronary angiography in 24 patients.

Table III. Angiographic findings and procedural data.

	R-PTCA (n=117)	P&F-PTCA (n=153)	p
Single-vessel CAD	50%	48%	NS
Three-vessel CAD	28%	30%	NS
Initial IRA TIMI 3 flow	13%	12%	NS
Initial IRA TIMI 2-3 flow	36%	34%	NS
Collateral supply to the IRA	52%	48%	NS
Immediate PTCA of the IRA	78%	95%	0.0001
Stent	87%	89%	NS
IABP	17%	8%	0.048
GP IIb/IIIa antagonists	6%	10%	NS
Thrombus aspiration	3%	7%	NS

CAD = coronary artery disease; GP = glycoprotein; IABP = intra-aortic balloon pump; IRA = infarct-related artery; P&F = primary and facilitated; PTCA = coronary angioplasty; R = rescue.

Three patients had a completely occluded IRA with an excellent collateral supply, and 12 had a TIMI 3 flow, with a satisfactory ST-segment resolution in all; in 9 patients, the IRA flow was suboptimal (TIMI ≤ 2 flow), either in the presence of a stenosis deemed not amenable to PTCA, or in the absence of any discrete and severe stenosis. Elective PTCA of the IRA and emergency or elective bypass surgery were performed during admission in 8 and 8 cases respectively in the R-PTCA group. Immediate PTCA was withheld in 8 P&F-PTCA patients with a satisfactory reperfusion, and elective PTCA of the IRA and bypass surgery were performed in 3 and 3 cases respectively.

The post-procedural angiographic and ECG data are listed in table IV. All indicators of IRA recanalization and of myocardial reperfusion were less favorable in the R-PTCA group, with a lower incidence of final TIMI 3 flow (62 vs 76%), a definite trend toward less frequent ≥ 70% ST-segment resolution (36 vs 50% of cases, p = 0.086), and a poorer overall reperfusion out-

Table IV. Post-procedural angiographic and ECG data.

	R-PTCA (n=117)	P&F-PTCA (n=153)	p
Final IRA TIMI 3 flow*	62%	76%	0.017
Final IRA TIMI 2-3 flow	88%	93%	NS
Distal embolization	11%	11%	NS
Resolution ↑ST < 50%**	42.5%	33.9%	NS
Resolution ↑ST ≥ 50% < 70%	21.3%	16.5%	NS
Resolution ↑ST ≥ 70%	36.2%	49.6%	0.086
Final IRA TIMI 3 flow + resolution ↑ST ≥ 50%	40%	55%	0.058
Final IRA TIMI 3 flow + resolution ↑ST ≥ 70%	24%	45%	0.006

IRA = infarct-related artery; P&F = primary and facilitated; PTCA = coronary angioplasty; R = rescue. * 1 patient died before coronary angiography could be performed; ** in 54 patients, final ST-segment resolution could not be assessed.

come (final TIMI 3 flow and ≥ 70% ST-segment resolution in 24 vs 45% of patients, p = 0.006).

When only the patients actually treated with immediate R-PTCA and P&F-PTCA were considered, a post-procedural TIMI 3 flow in the IRA was achieved in 68 and 71% of cases respectively.

The in-hospital outcomes for all patients are detailed in table V. The difference in overall mortality between R-PTCA and P&F-PTCA (12 vs 6.5%) did not attain statistical significance, and appeared consistent with the higher incidence of cardiogenic shock on admission in the former group. One patient in the R-PTCA group and 2 in the P&F-PTCA group, in whom immediate PTCA had been withheld due to a patent IRA and ST-segment resolution, had reinfarction before the planned PTCA and underwent emergency PTCA.

Of the 24 patients in the R-PTCA group in whom coronary angiography had been performed and immediate PTCA had not, 4 with a TIMI grade 2-3 IRA patency died before day 4 due to irreversible heart failure, one before and another after emergency bypass surgery; 3 of these patients were in shock at the time of admission; 15 patients were discharged uneventfully after elective PTCA of the IRA (8 patients), or after bypass surgery (7 patients); 2 were scheduled for elective bypass surgery after discharge and 3 were discharged on medical treatment alone. In all, 4 patients (17%) died out of 24 in whom R-PTCA was not – for any reason – immediately performed after coronary angiography, vs none out of 8 in whom immediate P&F-PTCA was withheld. The mortality in patients actually treated with immediate R-PTCA and P&F-PTCA was, therefore, 10 and 6.9%, respectively.

Table V. In-hospital outcomes.

	R-PTCA (n=117)	P&F-PTCA (n=153)	p
MB peak (U/l)	388 ± 282	317 ± 246	0.03
LVEF (days 2-11) (%)	48 ± 9	49 ± 9	NS
Death	12%	6.5%	NS
Death (shock excluded)	5.8%	3.4%	NS
Reinfarction	0.9%	1.3%	NS
Stroke	2.6%	0	NS

LVEF = left ventricular ejection fraction; MB = MB isoenzyme of creatine kinase; P&F = primary and facilitated; PTCA = coronary angioplasty; R = rescue.

Non-hemorrhagic stroke occurred in 3 R-PTCA patients; bleeding complications requiring transfusion occurred in 2 R-PTCA patients. Bleeding at the vascular access site occurred in 8 patients in each group, with no need for transfusions or surgical repair.

Overall, when the patients in the two groups were considered together (Table VI), shock upon admission, a longer time interval from pain onset to the beginning of coronary angiography, a final IRA TIMI flow < 3 and a final ST-segment resolution < 50% or non-assessable, were all significantly associated with in-hospital death at univariate analysis. The proportions of patients who died among those with shock, with a final IRA TIMI flow < 3, and with final ST-segment resolution < 50% or non-assessable, were similar in both the R-PTCA and P&F-PTCA groups (62 vs 71%, 14 vs 19% and 14 vs 14%).

Discussion

Observational data from this small, consecutive series of patients show that during a period of time lasting 3 years the number of patients transported from nearby hospitals to our referral Center for R-PTCA was extremely small. This seems consistent with data from a recent national survey covering 90% of Italian coronary care units: overall, about 50% of patients with AMI receive TT, but only 10% of the latter undergo subsequent R-PTCA[3].

In the absence of strict regional or local protocols, it is unclear how often efforts were made to identify evidence of failed reperfusion after TT in the nearby coronary care units, how – and how timely – this diagnosis was made, and on the basis of which criteria some of these patients were transferred to our Center. The time interval between arrival to the first emergency room on admission and the start of the cardiac catheterization procedure in our cath lab shows an extreme dispersion in our R-PTCA patients, which is only partially accounted for by variations in ambulance travel times (30 to 60 min). Although the exact time TT was initiated was not recorded in all cases, this wide range of intervals probably reflects variable delays in the diagnosis of TT failure, as well as in the logistics of patient transfer. It is also likely that patients referred for the treatment of failed reperfusion were those with a perceived higher risk if untreated/higher potential benefit from R-PTCA. In fact, our R-PTCA patients tended to be

Table VI. Univariate analysis of in-hospital death for the whole population (n = 270).

	Dead (n=24)	Discharged alive (n=246)	Total (n=270)	p
Age (years)	65 ± 12	62 ± 12	63 ± 11	NS
Females	5	49	54	NS
Previous AMI	5	33	38	NS
Anterior AMI	10	109	119	NS
No. leads with ↑ST on admission*	4.1 ± 1.5	4.7 ± 2	4.6 ± 2	NS
Shock on admission	13	7	20	0.0001
Single-vessel CAD**	9	121	130	NS
Time from pain onset to procedure start (min)	361 ± 220	268 ± 177	290 ± 180	0.027
Final ST-segment resolution < 50% or non-assessable***	20	123	143	0.004
Final TIMI grade < 3 or non-assessable flow in the IRA**	14	68	82	0.004

AMI = acute myocardial infarction; CAD = coronary artery disease; IRA = infarct-related artery; P&F = primary and facilitated; PTCA = coronary angioplasty; R = rescue. * initial ST-segment elevation could not be assessed in 40 patients; ** 1 patient died before coronary angiography could be performed; *** final ST-segment resolution could not be assessed in 54 patients.

younger than our P&F-PTCA patients and, despite a similar extension of ST-segment deviation on the initial ECG, more often had anterior AMI and signs of left ventricular failure; 11% were in shock at the time of admission, and 3 were intubated.

Immediate R-PTCA was withheld for clinical or angiographic reasons in about 20% of our patients, as compared to about 5% P&F-PTCA. This is not unusual in patients referred to an interventional center after failed TT, and has been well documented in a previous intention-to-treat-based report[8]. Possibly also as a result of this policy, both IRA patency and myocardial perfusion status in the acute phase were less satisfactory in our patients, as were their in-hospital outcomes.

Due to both the small number of patients in each group, and to the bias inherent to R-PTCA patient referral, statistical workup with multivariate analysis was thought to be of limited significance in our patient series. Considering our population as a whole, however, univariate analysis showed that the presence of shock at the time of admission, of an abnormal (TIMI flow < 3) final flow in the IRA, and of a poor (< 50%) or non-assessable final ST-segment resolution at ECG, were all significantly associated with in-hospital death, as was a longer time delay from symptom onset to the beginning of the invasive procedure. This is consistent with previous data from larger studies of reperfusion treatment in AMI[9-12]. Overall, our in-hospital mortality of 8.9% was consistent with the 8-9% reported in two single-center databases of consecutive patients with very similar baseline characteristics[13,14].

Our data may be of interest because they reflect a host of open questions.

Effectiveness of rescue coronary angioplasty. In patients with AMI, irrespective of which TT is used, early and complete restoration of the IRA patency and myocardial perfusion is the major determinant of their 30-day mortality[15,16]. Even with the use of newer drugs with an improved lytic power, failure of reperfusion still occurs in about 20 to 30% of patients[17]. Despite some validated criteria, such as ≥ 50% ST-segment resolution[18], the diagnosis of failed TT may not be straightforward in many cases, and the management is unclear[19,20]. Although for R-PTCA some benefit has been shown in most[8,21-24] but not all[25,26] reports, studies in the pre-stent era have failed to document a clear-cut benefit in terms of survival[23,27]. Evidence from randomized trials using contemporary PTCA technology is not available.

Adjunctive drug treatment during coronary angioplasty. The use of abciximab has been shown to be beneficial before or during P-PTCA, and – together with stents – is considered by some as the new standard for this treatment[28]. Due to concern regarding possible hemorrhagic complications[29], adjunctive treatment with glycoprotein IIb/IIIa inhibitors is not often used during R-PTCA in patients who have received full-dose TT in the preceding hours, although data from a small randomized study have shown that abciximab may substantially improve myocardial reperfusion in these patients, with acceptable risks[30].

Delay in diagnosis and referral. In most reports, a long delay in patient referral, a severely impaired left ventricular function, and a very poor outcome in case of persistent failure of reperfusion, are all recurrent features of R-PTCA patients[23,26,31]; these aspects appear to be linked together. Patient transfer to an interventional center for "intentional R-PTCA" immediately after TT has been proposed, and the outcomes of this strategy have been reported to be similar to those of primary PTCA[32-35]. Data from a very large database of patients in the American College of Cardiology National Cardiovascular Data Registry show that transferred patients who received previous TT had better outcomes following PTCA than those who did not[36].

Conclusive remarks. Despite the recognized superiority of primary PTCA[1,2], due to logistic limitations, TT

is – and will remain for some years to come – the most frequently used reperfusion treatment in patients with AMI, in our country as well as in many others. On the one hand, considering both the logistic burden and the costs of emergency transfer and of unplanned interventions in these patients, proof of the efficacy of R-PTCA as currently used (i.e., for the treatment of failed TT) is urgently needed from trials. On the other hand, efforts to improve both myocardial reperfusion and survival in these patients should be encouraged. The risk/benefit profile of adjunctive treatment with abciximab during R-PTCA in patients who have received full-dose TT should be investigated in larger numbers of patients. Shortening the delay to R-PTCA is likely to have a strong impact on survival, at least in high-risk patients in whom TT has not been effective. In contrast with both the current "wait for complications" attitude, and the often recommended "watchful wait" attitude, this approach would require prompt transfer to the interventional center during TT or immediately after it, without wasting time in any assessment of reperfusion. In this case, "intentional R-PTCA" would assume the same significance as "facilitated PTCA". A strategy of "inject-and-transfer", with full-dose tenecteplase, appeared superior to tenecteplase + conditional transfer in case of failed reperfusion, in a recently reported randomized trial in Canada (LeMay M. Results of the CAPITAL-AMI randomized trial. Scientific Session of the American College of Cardiology, New Orleans, LA, USA, unpublished data); this strategy is also being tested in the CARESS randomized trial including high-risk patients, with the use of half-dose reteplase plus abciximab. There is reason to hope that in the near future, patients for whom TT has been – for any reason – the initial reperfusion treatment are no longer left on their own, nor managed as sons of a lesser god.

Acknowledgments

We are grateful to Mrs. Cinzia Renaudo for her help with the collection of data.

References

1. Weaver WD, Simes RJ, Betriu A, et al. Comparison of primary coronary angioplasty and intravenous thrombolytic therapy for acute myocardial infarction: a quantitative review. JAMA 1997; 278: 2093-8.
2. 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.
3. Di Chiara A, Chiarella F, Savonitto S, et al, for the BLITZ Investigators. Epidemiology of acute myocardial infarction in the Italian CCU network: the BLITZ study. Eur Heart J 2003; 24: 1616-29.
4. The GUSTO Angiographic Investigators. The effects of tissue plasminogen activator, streptokinase, or both on coronary-artery patency, ventricular function, and survival after acute myocardial infarction. N Engl J Med 1993; 329: 1615-22.
5. Smith SC Jr, Dove JT, Jacobs AK, et al. ACC/AHA guidelines for percutaneous coronary intervention: executive summary. A report of the American College of Cardiology/American Heart Association Task Force on Practice Guidelines (Committee to revise the 1993 guidelines for percutaneous transluminal coronary angioplasty) endorsed by the Society for Cardiac Angiography and Interventions. Circulation 2001; 103: 3019-41.
6. Van de Werf F, Ardissino D, Betriu A, et al. Management of acute myocardial infarction in patients presenting with ST-segment elevation: a report of the Task Force on the management of acute myocardial infarction of the European Society of Cardiology. Eur Heart J 2003; 24: 28-66.
7. La Scala E, Steffenino G, Dellavalle A, et al. Half-dose thrombolysis to begin with, when immediate coronary angioplasty in acute myocardial infarction is not possible. Ital Heart J 2004; 5: 678-83.
8. Sutton AG, Campbell PG, Grech ED, et al. Failure of thrombolysis: experience with a policy of early angiography and rescue angioplasty for electrocardiographic evidence of failed thrombolysis. Heart 2000; 84: 197-204.
9. Schroeder R, Wegscheider K, Schroeder K, Dissmann R, Meyer-Sabellek W. Extent of early ST segment elevation resolution: a strong predictor of outcome in patients with acute myocardial infarction and a sensitive measure to compare thrombolytic regimens. A substudy of the International Joint Efficacy Comparison of Thrombolytics (INJECT) trial. J Am Coll Cardiol 1995; 26: 1657-64.
10. Mehta RH, Harjai KJ, Cox D, et al, for the Primary Angioplasty in Myocardial Infarction (PAMI) Investigators. Clinical and angiographic correlates and outcomes of suboptimal coronary flow in patients with acute myocardial infarction undergoing primary percutaneous coronary intervention. J Am Coll Cardiol 2003; 42: 1739-46.
11. De Luca G, Suryapranata H, Otterwanger JP, Antman EM. Time delay to treatment and mortality in primary angioplasty for acute myocardial infarction. Every minute of delay counts. Circulation 2004; 109: 1223-5.
12. Brodie B, Costantini C, Aymong E, et al. Relationship between time to reperfusion, ST-segment resolution, myocardial blush scores and mortality with primary percutaneous coronary intervention for acute myocardial infarction. Results from the CADILLAC trial. (abstr) J Am Coll Cardiol 2004; 43 (Suppl A): 303A.
13. Balachandran KP, Miller J, Pell AC, Vallance BD, Oldroyd KG. Rescue percutaneous coronary intervention for failed thrombolysis: results from a district general hospital. Postgrad Med J 2002; 78: 330-4.
14. Sengottuvel G, Lefevre T, Louvard Y, et al. Evolution of percutaneous coronary intervention in acute myocardial infarction: insights from a large single center database. (abstr) J Am Coll Cardiol 2004; 43 (Suppl A): 60A.
15. Simes RJ, Topol EJ, Holmes DR Jr, et al. Link between the angiographic substudy and mortality outcomes in a large randomized trial of myocardial reperfusion. Importance of early and complete infarct artery reperfusion. GUSTO-I Investigators. Circulation 1995; 91: 1923-8.
16. Gibson CM, Cannon CP, Murphy SA, et al. Relationship of TIMI myocardial perfusion grade to mortality after administration of thrombolytic drugs. Circulation 2000; 101: 125-30.
17. Antman EM, Gibson CM, de Lemos JA, et al. Combination reperfusion therapy with abciximab and reduced dose reteplase: results from TIMI 14. The Thrombolysis in Myocardial Infarction (TIMI) 14 Investigators. Eur Heart J 2000; 21: 1944-53.

18. Oude Ophuis AJ, Bar FW, Vermeer F, et al. Angiographic assessment of prospectively determined non-invasive reperfusion indices in acute myocardial infarction. Heart 2000; 84: 164-70.
19. Kovac JD, Gershlick AH. How should we detect and manage failed thrombolysis? Eur Heart J 2001; 22: 450-7.
20. de Belder MA. Acute myocardial infarction: failed thrombolysis. Heart 2001; 85: 104-12.
21. The CORAMI Study Group. Outcome of attempted rescue coronary angioplasty after failed thrombolysis for acute myocardial infarction. Am J Cardiol 1994; 74: 172-4.
22. Gimelli G, Kalra A, Sabatine MS, Jang IK. Primary versus rescue percutaneous coronary intervention in patients with acute myocardial infarction. Acta Cardiol 2000; 55: 187-92.
23. Ross AM, Lundergan CF, Rohrbeck SC, et al. Rescue angioplasty after failed thrombolysis: technical and clinical outcomes in a large thrombolysis trial. GUSTO-1 Angiographic Investigators. Global Utilization of Streptokinase and Tissue Plasminogen Activator for Occluded Coronary Arteries. J Am Coll Cardiol 1998; 31: 1511-7.
24. Bar F, Vainer J, Stevenhagen J, et al. Ten-year experience with early angioplasty in 759 patients with acute myocardial infarction. J Am Coll Cardiol 2000; 36: 51-8.
25. McKendall GR, Forman S, Sopko G, Braunwald E, Williams DO. Value of rescue percutaneous transluminal coronary angioplasty following unsuccessful thrombolytic therapy in patients with acute myocardial infarction. Thrombolysis in Myocardial Infarction Investigators. Am J Cardiol 1995; 76: 1108-11.
26. Gibson CM, Cannon CP, Greene RM, et al. Rescue angioplasty in the Thrombolysis in Myocardial Infarction (TIMI) 4 Trial. Am J Cardiol 1997; 80: 21-6.
27. Ellis SG, Da Silva ER, Spaulding CM, Nobuyoshi M, Weiner B, Talley JD. Review of immediate angioplasty after fibrinolytic therapy for acute myocardial infarction: insights from RESCUE I, RESCUE II, and other contemporary clinical experiences. Am Heart J 2000; 139: 1046-53.
28. Topol EJ, Neumann FJ, Montalescot G. A preferred reperfusion strategy for acute myocardial infarction. J Am Coll Cardiol 2003; 42: 1886-9.
29. Ali A, Rehan A, Ganji J, et al. Eptifibatide and risk of bleeding after failed thrombolysis. J Invasive Cardiol 2004; 16: 20-2.
30. Petronio AS, Musumeci G, Limbruno U, et al. Abciximab improves 6-month clinical outcome after rescue coronary angioplasty. Am Heart J 2002; 143: 334-41.
31. Gorfinkel HJ, Berger SM, Klaus AP, et al. Rescue angioplasty in failed thrombolysis in acute myocardial infarction: a community hospital experience. J Invasive Cardiol 1997; 9: 83-7.
32. Vermeer F, Oude Ophuis AJ, vd Berg EJ, et al. Prospective randomized comparison between thrombolysis, rescue PTCA, and primary PTCA in patients with extensive myocardial infarction admitted to a hospital without PTCA facilities: a safety and feasibility study. Heart 1999; 82: 426-31.
33. Juliard JM, Himbert D, Cristofini P, et al. A matched comparison of the combination of prehospital thrombolysis and standby rescue angioplasty with primary angioplasty. Am J Cardiol 1999; 83: 305-10.
34. Oude Ophuis TJ, Bar FW, Vermeer F, et al. Early referral for intentional rescue PTCA after initiation of thrombolytic therapy in patients admitted to a community hospital because of a large acute myocardial infarction. Am Heart J 1999; 137: 846-53.
35. Polonski L, Gasior M, Wasilewski J, et al. Outcomes of primary coronary angioplasty and angioplasty after initial thrombolysis in the treatment of 374 consecutive patients with acute myocardial infarction. Am Heart J 2003; 145: 855-61.
36. O'Neill DP, Hui PY, Yee RR, et al. Beneficial effects of combined thrombolytic therapy and percutaneous coronary angioplasty in transfer patients with ST-segment elevation myocardial infarction: a report from the ACC-NCDR. (abstr) J Am Coll Cardiol 2004; 43 (Suppl A): 304A.