Safety, feasibility and efficacy of transradial primary angioplasty in patients with acute myocardial infarction

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Background. **In recent years the transradial approach has been increasingly employed as an alternative approach to percutaneous coronary intervention. The aim of this study was to investigate the safety, feasibility and efficacy of transradial primary angioplasty.**

Methods. **We studied 726 patients (552 males, 174 females, mean age 61.5 ± 12 years) with a diagnosis of acute myocardial infarction (< 12 hours after onset; Killip class 1-3) who underwent primary percutaneous coronary intervention. The transradial approach (group A) was used in 163 consecutive patients (126 males, 37 females, mean age 61.5 ± 12 years) with a negative Allen test by a single experienced operator. The transfemoral approach (group B) was used for vascular access in the remaining patients (n = 563).**

Results. **No significant differences in baseline characteristics were observed between the two groups. The radial access was achieved in all patients of group A, but 9 who were switched to either left radial (n = 7) or right femoral approaches (n = 2). The time of radial artery cannulation was in all cases < 2 min. The cannulation time (from skin anesthesia to the time of arterial cannulation) and the total procedure time (from patient arrival at the catheterization room to the completion of the procedure) did not significantly differ between group A and group B (1.7 ± 0.4 vs 1.6 ± 0.6 min, p = 0.8; 62 ± 23 vs 61 ± 22 min, p = 0.7, respectively). In 71.1% of cases of group A, a single catheter (Sones type I or II) was employed for diagnostic angiography of the right and left coronary arteries and of the left ventricle. Only balloon angioplasty was performed in 6.1% of group A patients vs 9.9% of group B patients (p = NS). The primary success rate was identical: 96.9% in the radial and 95.5% in the femoral group. There were no major bleeding complications in group A as opposed to 7 (1.2%) in group B (p = 0.04). In the radial group patients during the 30-day follow-up period there was no forearm ischemia or loss of the radial pulse. The total length of hospitalization was slightly shorter in the radial group, although this difference was not statistically significant (5.9 ± 2 vs 6.4 ± 2.8 days, p = 0.1).**

Conclusions. **Provided it is performed by experienced operators, the transradial approach can represent a safe and feasible method for performing primary angioplasty with similar results to those of the transfemoral approach.**

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Introduction

Early and complete reperfusion is the goal of acute myocardial infarction (AMI) therapy, and both thrombolysis and percutaneous coronary intervention (PCI) have been shown to yield good results[1]. In recent years, PCI has proved to be a safe and effective alternative to thrombolysis[2-6]. In AMI, the use of intense anticoagulation or antiplatelet therapy, such as IIb/IIIa receptor blockers, potentially increases the risk of bleeding complications during a PCI performed via the transfemoral route[7,8].

Recently, the transradial approach has been increasingly employed as an alternative means of performing elective diagnostic and interventional coronary procedures[9,10]. This approach was shown to be associated with a lower incidence of vascular access site complications and allows an earlier mobilization of the patients, with a reduced hospital stay and hospitalization costs[11]. The very low incidence of access site bleeding complications suggests the transradial approach as an interesting alternative to the femoral technique in AMI primary PCI, particularly when performed under an aggressive anticoagulation regimen[12-17].

Nevertheless, the possibility of employing the transradial approach also for primary PCI has not been thoroughly investigated so far. Therefore, we sought to investigate the safety, feasibility and efficacy of transradial primary PCI in patients with AMI.

Methods

Population. Between January 2000 and September 2002, 748 consecutive patients were admitted to our laboratory on an emergency basis because of AMI without cardiogenic shock, within 12 hours of the onset of chest pain. AMI was defined as typical chest pain lasting > 30 min, resistant to nitrates, with ST-segment elevation > 0.1 mV in the limb leads or > 0.2 mV in two or more chest leads. All patients gave their formal written consent before the procedure and were submitted to urgent coronary angiography. After coronary angiography was performed, 22 patients did not undergo further interventions because of infarct-related artery stenosis < 60% with TIMI flow grade 3; moreover, these patients showed markedly attenuated clinical signs of ischemia at the time of coronary angiography. The remaining 726 patients (552 males, 174 females, mean age 61.5 ± 12 years) underwent a primary PCI and form the basis of the present report. Exclusion criteria for the right transradial approach were an abnormal Allen test, previous coronary artery bypass grafting with both the right and left internal mammary arteries, chronic renal failure, absence of the radial pulse and previous brachial cut-down.

The right transradial approach was used in 163 patients (group A) by a single experienced operator (OV > 400 transradial diagnostic and interventional procedures per year). The transfemoral approach was used for vascular access in the remaining patients (group B, n = 563). Transfemoral procedures were performed by two different interventional cardiologists.

Arterial cannulation. Radial artery cannulation was performed with the right arm positioned beside the patient's body with the wrist hyperextended. After local anesthesia with 1 ml of 2% xylocaine and 1 ml of $NaHCO_3^-$, the radial artery was punctured with a 20G 1-piece metal needle and a 0.025" straight guidewire was inserted through the needle. Upon removal of the needle, a 23 cm long 6F sheath (Cordis Corporation, Miami, FL, USA) was placed over the guidewire. To reduce spasm and discomfort, an intra-arterial drug "cocktail" containing 200 μg of nitroglycerin, 5 mg of verapamil, 2 ml of $NaHCO_3^-$ and 2 ml of 2% xylocaine was delivered through the sheath. Diagnostic angiography was performed using 6F catheters (Cordis Corporation) and PCI using 6F guiding catheters manufactured by either Boston Scientific/Scimed (Maple Grove, MN, USA) or Medtronic (Maple Grove, MN, USA) and with inner lumen diameters of 0.064". Access to the right femoral artery was performed in the usual manner and was followed by insertion of a 6F sheath. Coronary angiography was performed using 6F diagnostic catheters (usually the Judkins type). All interventions were done using 6F guiding catheters.

Treatment. Before PCI all patients received aspirin, intravenous nitrates and a 5000 IU bolus of unfractionated heparin. During coronary angioplasty an adjunctive bolus of heparin was administered. The dose was determined on the basis of the patient's body weight (70 IU/kg) and of activated clotting time monitoring (therapeutic range 250-350 s). Glycoprotein IIb/IIIa inhibitors were administered as clinically indicated during the procedure. After the procedure no more heparin was given and the activated partial thromboplastin time was monitored for the following 12 hours. Patients who received a coronary stent were treated with aspirin 100 mg daily plus ticlopidine 250 mg twice a day for 1 month. Beta-blockers and angiotensin-converting enzyme inhibitors, if not contraindicated and well tolerated, were routinely administered to all patients. Angiographic success of primary PCI was defined as achievement of a residual stenosis < 30% of the lumen diameter with TIMI flow grade 2-3.

Sheath management. In the radial group, the arterial sheath was removed following completion of the procedure and hemostasis of the puncture site was achieved by a selective application of a gauzes pile with a compressive bandage supported by one tourniquet. Over the course of 30 min, the occlusive pressure of the tourniquet was gradually decreased, followed by application of a selective radial pressure bandage. Patients were then transferred to the coronary care unit.

In the femoral group, patients were transferred to the coronary care unit where the sheath was removed when the activated clotting time was < 180 s. Hemostasis was achieved using manual compression followed by a pressure bandage.

Patients referred from peripheral hospitals returned to the reference hospital immediately after the procedure had been successfully performed (transferred patients).

Clinical and metabolic data. All patients were screened for ECG changes; creatine kinase (CK) and CK-MB values were assessed every 6 hours during the first day and then every day before discharge unless clinical events prompted repeat measurements. Adverse clinical events (including death, ventricular arrhythmias, reinfarction, recurrent angina, target lesion revascularization and heart failure) were evaluated during the in-hospital follow-up.

Bleeding was defined according to the criteria of the Thrombolysis in Myocardial Infarction trial[18]; major bleeding was defined as a decrease in the hemoglobin basal level of 5 g/dl, intracranial hemorrhage or cardiac tamponade; minor bleeding was defined as a decrease in the hemoglobin basal level exceeding 3 g/dl from an identifiable site, spontaneous gross hematuria, hematemesis, hemoptysis or puncture site bleeding.

Statistical analysis. Categorical data are presented as absolute values and percentages whereas continuous data are summarized as mean values ± SD. The χ^2 and Fisher's exact tests were used for comparison of categorical variables as appropriate. Comparison of continuous variables was performed by means of the Student's t-test or Wilcoxon rank-sum test as appropriate. P values < 0.05 were considered statistically significant.

Results

The baseline demographic and clinical characteristics are shown in table I. The mean age was the same in both groups and the majority of patients were males. The percentage of transferred patients was higher in the radial group (19.6 vs 12.7%, p = 0.04). The two groups did not significantly differ with regard to the prevalence of diabetes mellitus, the time elapsing from symptom onset to the first balloon inflation, the degree of ST-segment elevation at admission, and the prevalence of anterior infarction and left anterior descending coronary artery involvement.

Procedural data. The procedural outcomes in both groups are shown in table II. The primary success rate was high in both groups and not statistically different: 96.9% radial, 95.5% femoral; the percentage of TIMI 3 final flow was higher in the radial group (94.5 vs 90%, p = 0.04). Right radial access was achieved in all patients of group A, but 2 were switched to a right femoral approach and 7 to a left radial approach because no adequate guiding position could be obtained from the right radial artery. The time necessary for radial artery cannulation was in all cases < 2 min. The cannulation time (from skin anesthesia to the time of arterial cannulation) and the total procedure time (from patient arrival at the catheterization room to the completion of the procedure) did not significantly differ between group A and group B (1.7 ± 0.4 vs 1.6 ± 0.6 min, p = 0.8; 62 ± 23 vs 61 ± 22 min, p = 0.7, respectively). In 71.1% of cases of group A (n = 116) a single catheter (Sones type I or II; Cordis Corporation) was employed for diagnostic angiography of the right and left coronary arteries and of the left ventricle. Only balloon angioplasty was performed in 6.1% of group A patients vs 9.9% of group B patients (p = NS).

A slightly higher percentage of patients in the radial group received glycoprotein IIb/IIIa inhibitors, although this difference was not significant. A minority of patients received multiple stents, and the number of stents delivered was the same in both groups (average 1.3 stents per patient). The vessel distribution and lesion morphology were the same in both groups. The majority of patients had a complex lesion morphology.

Bleeding complications and follow-up. Severe hemorrhagic complications occurred in 7 patients of the femoral group (1.2%): 2 patients developed a hemorrhagic stroke at 10 and 14 hours after coronary angioplasty; one of these patients died. Two patients developed cardiac tamponade and 3 patients large hematomas at the puncture. These complications necessitated a longer length of hospitalization. None of these patients required surgical correction, although 2 required transfusion. No patient in the radial group developed a major bleeding complication. Access site bleeding occurred in 10 patients of the femoral group (1.7%) and in 1 patient of the radial group (0.6%, p = 0.3). Minor bleeding complications occurred in 7 patients of the femoral group (1.2%) and in 1 patient of the radial group (0.6%, p = NS; Fig. 1).

All patients of group A had a palpable radial artery following the procedure and no patient had symptoms or physical signs of hand ischemia. However, Doppler examination was not routinely performed and the incidence of asymptomatic radial artery occlusion could thus not be determined.

The clinical course was similar among the two groups (Table III). In-hospital death occurred in 1 pa-

Table I. Baseline patient characteristics.

Variable	Group A (n=163)	Group B (n=563)	p
Age (years)	61.5 ± 12	61.5 ± 12.6	0.8
Female	37 (22.7%)	137 (24.3%)	0.5
Smoke	69 (42.3%)	170 (30.1%)	0.02
Dyslipidemia	58 (35.6%)	152 (26.9%)	0.1
Hypertension	66 (40.5%)	199 (35.3%)	0.5
Diabetes	17 (10.4%)	63 (11.9%)	0.1
Previous AMI	7 (4.3%)	37 (6.6%)	0.2
Transferred patients	32 (19.6%)	72 (12.7%)	0.04
Killip class 1-2	154 (94.4%)	525 (93.1%)	0.1
Killip class 3	9 (5.6%)	38 (6.7%)	0.3
Time from onset (min)	4.3 ± 8.4	3.9 ± 5.6	0.4
Anterior AMI	81 (49.7%)	257 (45.6%)	0.4

AMI = acute myocardial infarction.

Table II. Procedural and angiographic characteristics.

Variable	Group A (n=163)	Group B (n=563)	p
IRA (LAD)	78 (47.8%)	259 (46%)	0.8
GP IIb/IIIa	42 (25.7%)	112 (20%)	0.2
Cannulation time (min)	1.7 ± 0.4	1.6 ± 0.6	0.8
Procedure time (min)	62 ± 23	61 ± 22	0.7
TIMI 0/1 flow pre	106 (65%)	405 (71.9%)	0.04
TIMI 2 flow final	4 (2.4%)	31 (5.5%)	0.1
TIMI 3 flow final	154 (94.5%)	507 (90%)	0.04
Stent rate	1.15 ± 0.4	1.1 ± 0.6	0.8
2/3 diseased vessels	68 (41.7%)	275 (48.8%)	0.08
LVEF (%)	49.2 ± 7.7	49.7 ± 8.7	0.5

GP = glycoprotein; IRA = infarct-related artery; LAD = left anterior descending coronary artery; LVEF = left ventricular ejection fraction.

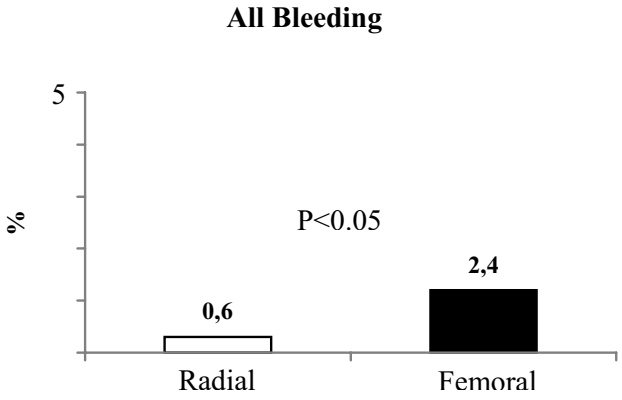

Figure 1. *Bleeding complications occurred in 14 patients of the femoral group (2.4%) and in 1 patient of the radial group (0.6%).*

Table III. In-hospital follow-up.

Variable	Group A (n=163)	Group B (n=563)	p
Creatine kinase (U/l)	2100 ± 2028	2027 ± 1816	0.7
Hospitalization (days)	5.9 ± 2	6.4 ± 2.8	0.1
Minor bleeding	1 (0.6%)	7 (1.2%)	0.09
Major bleeding	0	7 (1.2%)	0.04
Access site bleeding	1 (0.6%)	10 (1.7%)	0.3
Death	1 (0.6%)	10 (1.7%)	0.3
Stroke	1 (0.6%)	5 (0.8%)	0.8
Re-infarction	0	2 (0.3%)	0.2
Ischemic TVR	3 (1.8%)	7 (1.2%)	0.3
Heart failure	7 (4.3%)	9 (1.5%)	0.09

TVR = target vessel revascularization.

tient of the radial group (0.6%) and in 10 patients (1.7%) of the femoral group (p = 0.3). One patient of group A and another of group B presented with post-infarction angina; 1 patient of group A and 4 of group B presented with life-threatening ventricular arrhythmias. The two groups were also similar with regard to the development of Q waves, as well as with regard to peak creatinephosphokinase and CK-MB release.

The total length of hospitalization was slightly shorter in the radial group, although this difference was not statistically significant (5.9 ± 2 vs 6.4 ± 2.8 days, p = 0.1).

Discussion

The present study demonstrates that a transradial primary PCI in patients with AMI can be performed safely and efficaciously by interventional cardiologists who are familiar with the transradial approach. In this prospective study, radial access was achieved in all patients by a single experienced operator; only in 9 patients was it necessary to switch to either a left radial or femoral approach, because of tortuosity of the brachycephalic artery; moreover, the mean cannulation time and total procedural time did not differ between the transradial and transfemoral approaches. The cannulation time was in all cases < 2 min. The primary success rate was almost the same, regardless of whether the procedure was performed via the radial or femoral approach. No procedure performed through the radial artery was associated with inadequate support of the guiding catheter, despite the fact that most guiding catheters are not designed for the right radial approach. Good backup support for the right coronary artery could be achieved by means of multipurpose and Amplatz left 1-2 guiding catheters. For the left main coronary artery, Extra backup 4 or Amplatz left 2 guiding catheters are suggested. Venous bypass grafts can usually be cannulated with multipurpose and Judkins right catheters. The primary success rate was high in both groups and not statistically different. Major vascular complications occurred more frequently after transfemoral angioplasty and were absent after transradial PCI. However, the incidence of major bleeding complications after the use of 6F guiding catheters by the femoral approach was still low. The clinical course was similar both for the radial and femoral groups; the length of hospitalization was slightly shorter in the radial group although this difference was not statistically significant; finally, the number of transferred patients was significantly higher in the radial group.

Our results are consistent with those of recent studies on transradial primary PCI for AMI in selected patients[12-17]. Ochiai et al.[13] reported that radial artery puncture was achieved within 15 min in all patients and within 5 min in 79% of the patients. However, the times required to achieve vascular access in the transradial and transfemoral groups were not compared. In the study by Kim et al.[16] the cannulation time was < 10 min in the majority of patients (only in 1 patient was it not possible to gain access to the radial artery) and just as in the study by Louvard et al.[17] and in our study, the mean cannulation time and total procedural time did not differ between the transradial and transfemoral approaches. In our series the cannulation time was shorter than in previously reported studies probably because in our study the cannulation time did not include the arm preparation time.

In the present study, the incidence of access site bleeding complications in the femoral group was 1.7%, which is as low as has been reported in the literature in a controlled study of patients with AMI. Johnson et al.[19] reported an incidence of vascular complications of 2.4% out of 1579 PCI procedures performed using the femoral and brachial techniques. Popma et al.[20] reported a 5.9% incidence of vascular complications after 1413 PCI procedures with different techniques; the highest incidence was observed after coronary stenting (14%).

Indeed, in this paper only one access site bleeding complication was encountered in the radial group (0.6%). The safety of the transradial approach is main-

ly determined by the favorable anatomic relations of the radial artery to its surrounding structures. No major veins or nerves are located near the artery, minimizing the chance of injury to these structures. Thrombotic or traumatic arterial occlusion does not endanger the viability of the hand if an adequate collateral blood supply from the ulnar artery is present. The superficial location of the radial artery allows easy hemostasis, and the use of a mechanical compression device minimizes utilization of personnel[21,22]. An additional advantage of the radial approach is the passive achievement of hemostasis by a pressure device or by a pressure bandage, reducing the workload of nursing and medical staff.

In this study 142 patients (87.1%) received one or more stents in the infarct-related artery and direct stenting was attempted in 101 patients (61.9%). Stenting via the radial route is technically more challenging. However, almost all recently designed stents can be delivered through 6F guiding catheters. Therefore, stent embolism or dislodgment was not encountered in our series and in no case did we fail to deliver the stent. These results are consistent with those of previous studies including smaller numbers of patients and in which it was concluded that in hemodynamically stable patients primary stenting or PCI can be performed expeditiously and safely using the transradial approach[13,16].

Previous papers concluded that the total hospital costs were lower for the radial group as compared to the femoral group[10,11]; our study partially confirms this datum but we did not find any statistically significant difference between the two groups, probably because only patients with AMI were included and although the transradial group patients, who were at relatively low risk, were allowed to ambulate the day after the procedure.

An important criticism of the radial approach is that it is not suitable for every patient. However, several reports attest the use of the transradial approach in virtually all clinical situations[23-25]; in our study the PCI was performed in almost all patients (98.5%). Of course, patient selection before the procedure, on the basis of the clinical status (Killip class < 4) and of the anatomic characteristics of the radial artery (normal Allen test), is very important.

Study limitations. A main limitation of the present study is the absence of randomization; another limitation is the lack of follow-up Doppler information on the patency of the radial artery through which the procedure was performed. Although no patient in the present study had an absent pulse or symptoms suggesting vascular ischemia of the hand, it is likely that asymptomatic radial artery occlusion occurred in a small percentage of patients. Previous series have demonstrated the incidence of asymptomatic radial artery occlusion in the 3-5% range, but the benign nature of this problem has been emphasized[26,27].

The need for the use of small guide catheters (6F) has been felt to be a significant limitation of the transradial approach in case of lesions requiring complex devices (e.g. thrombus removal or distal protection) or techniques (kissing balloon). However, with experience and the recent continued miniaturization of interventional devices, this is no longer a serious drawback. Indeed, in the present study no patient crossed over to the femoral approach for these reasons.

Finally the large experience of the single operator (OV) with the transradial route (> 1400 PCI by the transradial approach) may limit the possibility of transferring our results to less experienced, low-volume centers and operators.

In conclusion, provided it is employed by experienced operators, the transradial approach may represent a safe and feasible technique for performing primary PCI with similar results and a slight trend toward less bleeding complications as compared to the transfemoral approach; it is especially useful for hemodynamically stable patients who do not require a second vascular access site for intra-aortic balloon pumping.

References

1. Simoons ML, Serruys PW, van den Brand M, et al. Early thrombolysis in acute myocardial infarction: limitation of infarct size and improved survival. J Am Coll Cardiol 1986; 7: 717-28.
2. Zijlstra F, de Boer MJ, Hoorntje JC, Reiffers S, Reiber JH, Suryapranata H. A comparison of immediate coronary angioplasty with intravenous streptokinase in acute myocardial infarction. N Engl J Med 1993; 328: 680-4.
3. Grines CL, Browne KF, Marco J, et al, for the Primary Angioplasty in Myocardial Infarction Study Group. A comparison of immediate angioplasty with thrombolytic therapy for acute myocardial infarction. N Engl J Med 1993; 328: 673-9.
4. Gibbons RJ, Holmes DR, Reeder GS, Bailey KR, Hopfenspirger MR, Gersh BJ. Immediate angioplasty compared with the administration of a thrombolytic agent followed by conservative treatment for myocardial infarction. The Mayo Coronary Care Unit and Catheterization Laboratory Groups. N Engl J Med 1993; 328: 685-91.
5. The Global Use of Strategies to Open Occluded Coronary Arteries in Acute Coronary Syndromes (GUSTO IIb) Angioplasty Substudy Investigators. A clinical trial comparing primary coronary angioplasty with tissue plasminogen activator for acute myocardial infarction. N Engl J Med 1997; 336: 1621-8.
6. Lange RA, Cigarroa J, Hillis LD. Thrombolysis versus primary percutaneous transluminal coronary angioplasty for acute myocardial infarction. Cardiology Review 1999; 7: 77-82.
7. Blankenship JC, Hellkamp AS, Aguirre FV, Demko SL, Topol EJ, Califf RM, for the EPIC Investigators. Vascular access site complications after percutaneous coronary intervention with abciximab in the Evaluation of c7E3 for the Prevention of Ischemic Complications (EPIC) trial. Am J Cardiol 1998; 81: 36-40.
8. Brener SJ, Barr LA, Burchenal JE, et al, on behalf of the ReoPro and Primary PTCA Organization and Randomized Tri-

al (RAPPORT) Investigators. Randomized, placebo-controlled trial of platelet glycoprotein IIb/IIIa blockade with primary angioplasty for acute myocardial infarction. Circulation 1998; 98: 734-41.
9. Kiemeneij F, Laarman GJ. Percutaneous transradial approach for coronary Palmaz-Schatz stent implantation. Am Heart J 1994; 128: 167-74.
10. Kiemeneij F, Laarman GH, Odekerken D, Slagboom T, van der Wieken R. A randomized comparison of percutaneous transluminal coronary angioplasty by the radial, brachial and femoral approaches: the access study. J Am Coll Cardiol 1997; 29: 1269-75.
11. Mann T, Cubeddu G, Bowen J, et al. Stenting in acute coronary syndromes: a comparison of radial versus femoral access sites. J Am Coll Cardiol 1998; 32: 572-6.
12. Steg G, Aubry P. Radial access for primary PTCA in patients with acute myocardial infarction and contraindication to or impossible femoral access. Cathet Cardiovasc Diagn 1996; 39: 424-6.
13. Ochiai M, Isshiki T, Toyoizumi H, et al. Efficacy of transradial primary stenting in patients with acute myocardial infarction. Am J Cardiol 1999; 83: 966-8.
14. Delarche N, Idir M, Estrade G, Leblay M. Direct angioplasty for acute myocardial infarction in elderly patients using transradial approach. Am J Geriatr Cardiol 1999; 8: 32-5.
15. Mathias DW, Bigler L. Transradial coronary angioplasty and stent implantation in acute myocardial infarction: initial experience. J Invasive Cardiol 2000; 12: 547-9.
16. Kim MH, Cha KS, Kim HJ, Kim SG, Kim JS. Primary stenting for acute myocardial infarction via the transradial approach: a safe and useful alternative to the transfemoral approach. J Invasive Cardiol 2000; 12: 292-6.
17. Louvard Y, Ludwig J, Lefevre T, et al. Transradial approach for coronary angioplasty in the setting of acute myocardial infarction: a dual-center registry. Catheter Cardiovasc Interv 2002; 55: 206-11.
18. Chesebro JH, Knatterud G, Roberts R, et al. Thrombolysis in Myocardial Infarction (TIMI) trial, phase I: a comparison between intravenous tissue plasminogen activator and streptokinase. Clinical findings through hospital discharge. Circulation 1987; 76: 142-54.
19. Johnson LW, Esente P, Giambartolomei A, et al. Peripheral vascular complications of coronary angioplasty by the femoral and brachial techniques. Cathet Cardiovasc Diagn 1994; 31: 165-72.
20. Popma JJ, Satler LF, Pichard AD, et al. Vascular complications after balloon and new device angioplasty. Circulation 1993; 88 (Part 1): 1569-78.
21. Arnold AM. Hemostasis after radial artery cardiac catheterization. J Invasive Cardiol 1996; 8 (Suppl D): 26D-29D.
22. Chatelain P, Arceo A, Rombaut E, Verin V, Urban P. New device for compression of the radial artery after diagnostic and interventional cardiac procedures. Cathet Cardiovasc Diagn 1997; 40: 297-300.
23. Wu CJ, Lo PH, Chang KC, Fu M, Lau KW, Hung JS. Transradial coronary angiography and angioplasty in Chinese patients. Cathet Cardiovasc Diagn 1997; 40: 159-63.
24. Mann JT III, Cubeddu G, Schneider JE, Arrowood M. Right radial access for PTCA: a prospective study demonstrates reduced complications and hospital charges. J Invasive Cardiol 1996; 8 (Suppl D): 40D-44D.
25. Marco J, Fajadet J, Cassagneau B, Jordan C. Transradial coronary stenting: a passing fad or widespread use in the future? J Invasive Cardiol 1996; 8 (Suppl E): 16E-21E.
26. Stella PR, Kiemeneij F, Laarman GH, Odekerken D, Slagboom T, van der Wieken R. Incidence and outcome of radial artery occlusion following transradial artery coronary angioplasty. Cathet Cardiovasc Diagn 1997; 40: 156-8.
27. Benit E, Missault L, Eeman T, et al. Brachial, radial, or femoral approach for elective Palmaz-Schatz implantation: a randomized comparison. Cathet Cardiovasc Diagn 1997; 41: 124-30.