

Transradial Approach for Percutaneous Coronary Stenting in the Treatment of Acute Myocardial Infarction

Luis S. Díaz de la Llera, Juan A. Fournier Andray, Silvia Gómez Moreno, Eduardo Arana Rueda, Mónica Fernández Quero, José A. Pérez Fernández-Cortacero, and Sara Ballesteros Prada

Unidad de Cardiología Intervencionista, Servicio de Cardiología, Hospital General Universitario Virgen del Rocío, Sevilla, Spain.

Introduction and objective. Treatment of acute myocardial infarction by percutaneous coronary intervention with stenting leads to excellent immediate clinical results and a good prognosis. The aim of this study was to compare in this selected population the safety and effectiveness of radial artery access versus femoral artery access.

Patients and method. Between May 2001 and June 2003, 162 consecutive patients with acute myocardial infarction < 12 hours treated by percutaneous stenting were included in an observational study. The radial artery approach was used in 103 patients, and the femoral artery approach in the remaining 59 patients. The success of the procedure, incidence of major adverse cardiac events and local puncture complications were compared in patients treated with the radial artery versus the femoral artery approach.

Results. Fluoroscopy time (22.4 [15.4] min vs 24.5 [19.5] min), immediate success of the procedure (96.1% vs 94.9%), and the incidence of major adverse cardiac events (6.8% vs 8.5%) did not differ between the two groups. Bleeding complications due to local puncture were present only in the femoral artery access group (0 vs 5 patients; $P=0.007$)

Conclusions. In selected patients with acute myocardial infarction treated with primary stent implantation, the success rate and clinical safety of the radial artery approach are similar to those of the femoral artery approach, but the incidence of local complications, especially bleeding, is significantly lower in the former. Thus the radial artery approach should become the approach of choice in patients at high risk for bleeding complications.

Key words: Acute myocardial infarction. Coronary angioplasty. Radial artery approach.

Full English text available at: www.revespcardiol.org

SEE EDITORIAL ON PAGES 720-1

Correspondence: Dr. L.S. Díaz de la Llera. Pinsapo, 10. Urbanización Pinares de Oromana. 41500 Alcalá de Guadaíra. Sevilla. España. E-mail: luisalvadoridiaz@hotmail.com

Received January 22, 2004.
Accepted for publication May 5, 2004.

Vía transradial en el tratamiento percutáneo del infarto agudo de miocardio con *stents* coronarios

Introducción y objetivo. El tratamiento del infarto agudo de miocardio (IAM) mediante intervención coronaria percutánea (ICP) con *stent* determina un excelente resultado clínico inmediato y un buen pronóstico. El objetivo de este estudio es comparar la seguridad y eficacia de la vía arterial radial (VAR) con la vía arterial femoral (VAF).

Pacientes y método. Entre mayo de 2001 y junio de 2003, se incluyó en el estudio observacional a 162 pacientes consecutivos con IAM < 12 h tratados mediante implante percutáneo de *stents*. Por VAR se abordó a 103 pacientes y por VAF, a los 59 restantes. Se compararon el éxito del procedimiento, los acontecimientos cardíacos adversos mayores y la incidencia de complicaciones locales entre ambas vías.

Resultados. En ambos grupos la duración de la fluoroscopia (22,4 ± 15,4 min frente a 24,5 ± 19,5 min), la frecuencia de éxitos inmediatos (el 96,1 frente al 94,9%) y el número de acontecimientos cardíacos adversos mayores (el 6,8 frente al 8,5%) fueron similares. En ningún caso se produjeron complicaciones locales por la VAR (0 frente a 5 pacientes por VAF; $p = 0,007$).

Conclusiones. El éxito y la seguridad de la VAR en el tratamiento percutáneo con *stents* de pacientes con IAM son similares a los que se obtienen por VAF, pero la incidencia de complicaciones locales, especialmente hemorragia, es significativamente menor. Por tanto, la VAR podría ser la de elección en pacientes con riesgo elevado de hemorragia.

Palabras clave: Infarto agudo de miocardio. Angioplastia coronaria. Vía arterial radial.

INTRODUCTION

The radial artery access (RAA) has been suggested to be a good route for diagnostic coronary angiography and percutaneous coronary intervention (PCI) and has become a progressively widespread practice.¹⁻⁴ Percutaneous coronary intervention via RAA has been

ABBREVIATIONS

AMI: acute myocardial infarction.
 PCI: percutaneous coronary intervention.
 TIMI: Thrombolysis in Myocardial Infarction.
 FAA: femoral artery access.
 RAA: radial artery access.

criticized because the procedure takes longer and has a lower success rate compared to the femoral artery approach (FAA).³ However, once the technique has been correctly learnt, the duration of both the procedure and fluoroscopy decreases and it can be utilized as the first choice for most patients. The main advantage of RAA is the effective absence of local complications in high-risk patients: hypertension, women, and patients treated with thrombolytics and IIb/IIIa receptor inhibitors. Safety, efficacy, and clinical data on the use of RAA for PCI in the setting of acute myocardial infarction (AMI) are limited,⁶⁻⁸ and in some studies AMI has even been considered an exclusion criterion for RAA.⁹ In our hospital, in view of the fact that RAA considerably reduces local complications and is less uncomfortable for the patient, this technique has become the method of choice for any type of PCI. In this study we present the results obtained when performing PCI with stents via RAA for the treatment of AMI.

PATIENTS AND METHOD

Patients

Between May 2001 and June 2003, all consecutive patients with a diagnosis of AMI < 12 h evolution (thoracic pain for more than 30 min not responding to nitroglycerine, with ST segment elevation > 1 mm in 2 or more contiguous leads) who were treated with PCI/stent were included. They were grouped according to whether the radial (RAA group) or femoral (FAA group) approach was used. The FAA group consisted of patients unsuitable for RAA, because of presenting a positive Allen test for ischemia, disease or sequelae due to injury to the right arm, or other factors that *a priori* hindered radial artery access. Among these difficulties we particularly include the inability to extend or place the hand upwards due to osteoarticular disease and blockage of radial access by vein catheterization. The patients included underwent primary PCI, "facilitated" PCI, and rescue PCI. Abciximab was mainly used in primary PCI (by definition, without previous use of fibrinolytics). "Facilitated" PCI was

done when the predicted opening of the coronary vessel was more than 90 min and less than 3 h, beginning with a half-dose of a fibrinolytic plus a glycoprotein IIb/IIIa inhibitor in the waiting period. Rescue PCI was preceded by fibrinolysis with in the absence of reperfusion criteria during immediate follow-up. Patients in cardiogenic shock were excluded. Three experienced operators carried out the interventions. All the patients or their family members were informed and gave written consent.

Procedure

Before the procedure, 500 mg acetylsalicylic acid and 300 mg clopidogrel were given to all patients providing these had not been given previously. Pulse oxymetry was used to assess the permeability of the arterial circulation of the hand, and the Allen test to evaluate the functional degree of the palmar arch between the radial and ulnar arteries. The radial pulse wave, its disappearance after simultaneous compression of the radial and ulnar arteries, and its reappearance after releasing the ulnar artery was quantified.¹⁰ In cases with good ulnar filling, after local infiltration with 0.5 mL of mepivacaine hydrochloride, radial artery puncture was done and an 11-cm 6 Fr introducer was placed using Seldinger's technique. A bolus of 5000 U heparin, 0.3 mg nitroglycerine and 4 mg verapamil diluted in 20 mL physiological saline solution was administered through the sheath. The use of glycoprotein IIb/IIIa inhibitors was left to the discretion of the operator, although this was used in most patients. After diagnosis, PCI was done with 6 Fr guide catheters. The technique of choice for the interventional treatment of AMI was elective stent implantation via RAA. Once PCI was finished, the sheath was immediately withdrawn, and manual compression applied for 60 s. This was followed by compression with a small cotton pad secured with strips of adhesive bandage for 4 h. The femoral introducer was withdrawn in the conventional way without the need for closure devices, manual compression was done until adequate hemostasis was obtained, and a compression bandage was kept in place for 8 h; the patient bed-rested for the following 16 h. After the procedure, clopidogrel treatment (75 mg/day) was maintained for 1 or 2 months and 150 mg acetylsalicylic acid, indefinitely. The use of abciximab prior to or during PCI was followed by intravenous perfusion with 10 µg/min for 12 h.

Angiographic Analysis

Before and after releasing the stent, quantitative coronary angiography was done with automated edge detection. The ventricular ejection fraction was measured using a program based on the area-length method. Pre- and post-stent coronary flow was classified in accor-

dance with the TIMI study (Thrombolysis in Myocardial Infarction). Coronary lesions were defined according to the American College of Cardiology/American Heart Association classification.

Definition of the Main Aims

The main aim of this study was to determine the safety and efficacy of RAA. The clinical success of the selected approach was defined as the resolution of clinical symptoms and the absence of major adverse cardiac events (MACE) and local complications at 30 days. MACE were defined as all-cause death, new AMI with or without Q wave and the need for new revascularization via PCI or surgery. The procedure was defined as an immediate success when residual stenosis was <20% during online analysis and TIMI flow was grade 3. The diagnosis of AMI was based on the appearance of new pathological Q waves and creatine

kinase elevation, its MB fraction, or on troponin being at least 3 times higher than normal values.¹¹ Local complications were defined as the need for surgical repair of arteries, hemorrhage requiring blood transfusion and hematomas requiring prolonged hospitalization.

Statistical Analysis

The results are expressed as mean \pm standard deviation. Continuous variables were compared with Student's *t* test, and non-continuous variables by χ^2 or Fisher's exact test. To control confounding variables we used a logistic regression model in which the variables that reached a significance level less than 0.1 in the bivariate analysis were included. A *P*-value <.05 was considered significant.

RESULTS

Patients and Lesion Characteristics

Between May 2001 and June 2003, PCI via RAA was carried out in 963 consecutive patients (1733 lesions). During the same period, PCI was carried out in 162 patients who presented AMI <12 h. The RAA group included 103 patients and the FAA group the remaining 59. Baseline clinical data for both groups are shown in Table 1. Overall, the RAA group included younger patients (55 \pm 11 vs 61 \pm 12 years; *P*=.002), with a greater proportion of males (90.3% vs 77.6%; *P*=.027) and with a more frequent history of previous angina (13.6% vs 3.4%; *P*=.036). Other patient characteristics, as well as the lesions treated and the use of abciximab, were similar in both groups. When introducing the variables with *P*<.1 in a logistic regression model, we found age (odds ratio [OR]=1.039; confidence interval [CI] 95%, 1.002-1.077; *P*=.037) to be the only independent predictor of the use of RAA.

Results of the Procedure

Data on the interventional procedure are presented in Table 2. Multivessel PCI was carried out in one-third of the RAA and FAA groups. The estimated time of the procedures was quantified in relation to the fluoroscopy time in each group. This parameter, together with the others analyzed (post-PCI TIMI flow, material used and its characteristics), did not yield significant differences between the RAA and FAA groups. In 5 (4.6%) patients, PCI via the radial artery was impossible: in 1 case, this was due to puncture failure; in 2, due to arterial dissection, and in the remaining 2, due to the impossibility of adequate catheterization of the ostium of the AMI culprit artery with the guide catheter, leading to the procedu-

TABLE 1. Baseline Patient Characteristics

	RAA Group (n=103)	FAA Group (n=59)	<i>P</i>
Age, years (mean \pm SD)	55 \pm 11	61 \pm 12	.002
Male sex	93 (90.3%)	45 (77.6%)	.027
Diabetes	18 (17.5%)	10 (17%)	.795
Hypertension	35 (34%)	23 (39%)	.523
Hyperlipidemia	31 (30.1%)	14 (23.7%)	.384
Smoking	60 (58.8%)	26 (44.1%)	.071
Previous angina	14 (13.6%)	2 (3.4%)	.036
Previous myocardial infarction	8 (7.8%)	5 (8.5%)	.555
Previous PCI	9 (8.7%)	9 (15.3%)	.204
Acute anterior myocardial infarction	47 (45.6%)	28 (47.5%)	.810
Indications for PCI			
Primary	60 (58.2%)	39 (66.1%)	.373
Facilitated	28 (27.2%)	6 (10.2%)	.010
Rescue	15 (14.6%)	14 (23.7%)	.226
Number of diseased vessels			
1	57 (55.3%)	33 (55.9%)	
2	32 (31.1%)	17 (28.8%)	
3	14 (13.6%)	9 (15.2%)	.511
Culprit artery			
Descending anterior	49 (47.6%)	29 (49.2%)	
Circumflex	14 (13.5%)	7 (11.9%)	
Right coronary	39 (37.9%)	20 (35.6%)	
Left common trunk	1 (1%)	2 (3.4%)	.901
Pre-PCI TIMI flow			
0	64 (62.1%)	35 (59.3%)	.846
1	10 (9.7%)	9 (15.3%)	.708
2	13 (12.6%)	8 (13.6%)	.702
3	16 (15.5%)	7 (11.9%)	.696
LVEF, %	51.7 \pm 11.68	51.2 \pm 13.28	.793
LVEF<40%	24 (24.7%)	13 (23.6%)	.879
Abciximab	70 (68%)	39 (66.1%)	.808

*SD indicates standard deviation; LVEF, left ventricular ejection fraction; AMI, acute myocardial infarction; PCI, percutaneous coronary intervention; TIMI, coronary flow according to the TIMI study; FAA, femoral artery approach; RAA, radial artery approach.

TABLE 2. Procedural Characteristics

	RAA Group (n=103)	FAA Group (n=59)	P
Multivessel PCI	35 (34%)	18 (30.5%)	.650
Fluoroscopy time, min	22.36±15.41	24.46±19.46	.467
Number of guide catheters used	1.30±0.4	1.26±0.29	.326
Stent diameter, mm	3.24±0.6	3.18±0.50	.620
Number of stents	1.41±0.62	1.46±0.92	.671
Total stent length, mm	26.87±13.25	28.61±17.50	.482
Post-PCI TIMI flow			.634
0	2 (1.9%)	1 (1.7%)	
1	2 (1.9%)	0	
2	0	2 (3.4%)	
3	99 (96.1%)	56 (94.9%)	

*PCI indicates percutaneous coronary intervention; FAA, femoral artery approach; RAA, radial artery approach.

TABLE 3. Results, Vascular Complications and In-hospital Major Cardiac Events

	RAA Group (n=103)	FAA Group (n=59)	P
Immediate success	99 (96.1%)	56 (94.9%)	.501
Clinical success	96 (93.3%)	49 (83.0%)	.043
MACE	7 (6.8%)	5 (8.5%)	.527
Death	4 (3.9%)	3 (5.1%)	.513
Reinfarction	0	0	
Subacute thrombosis of the stent and RARI	3 (2.9%)	2 (3.4%)	.620
Heart surgery	0	0	
Local complications	0	5 (8.5%)	.007
Vascular repair	0	1 (1.6%)	.364
Hospitalization prolonged by hematoma	0	2 (3.2%)	.131
Serious hemorrhage ^a	0	2 (3.2%)	.131

*MACE indicates major adverse cardiac events; RARI, revascularization of the artery responsible for the infarction; FAA, femoral artery approach; RAA, radial artery approach.

^aDecline of hemoglobin ≥ 4 g/dL, and need for transfusion.

re being done via FAA. The frequency of immediate success was high in both groups and did not present significant differences.

During the first 30 days, the incidence of MACE did not yield significant differences between RAA and FAA. Four patients died in the RAA group (3 from subacute stent thrombosis undergoing new revascularization) and 3 patients in the FAA group (2 with subacute stent thrombosis also undergoing new revascularization). On the other hand, vascular complications regarding the arterial puncture area were not observed (i.e. need for vascular repair, hematoma prolonging hospitalization or hemorrhage requiring blood transfusion) in the RAA group, whereas in the

FAA group these occurred in 5 patients ($P<.007$) (Table 3).

DISCUSSION

The treatment of AMI via a mechanical reperfusion strategy was advocated in 1983 by Hartzler et al² to restore antegrade blood flow in the artery responsible of the infarction. Currently, primary PCI is the treatment of choice for patients with AMI.¹³⁻¹⁵ The general application of primary PCI can be limited by logistic difficulties, but in health institutions that have an adequate provision of personnel and equipment it is, at the present time, the most effective intervention, especially since the introduction of coronary stents and glycoprotein IIb/IIIa inhibitors.¹⁹ Clinical success can be limited by hemorrhagic complications in the puncture area, especially when glycoprotein IIb/IIIa inhibitors are given, or facilitated or rescue PCI is done which involves the previous use of fibrinolytics. In these cases, the low rate of local complications with RAA,^{14,20} in contrast to FAA, has made RAA the first choice for primary PCI in our center.

The small caliber of the radial artery compared to the femoral artery, along with resistance to learning a new technique on the part of interventional cardiologists expert in the femoral approach, are generally the greatest limiting factors to RAA. However, the advantage of a lower rate of local complications compensates for the initial difficulty. In our patients, the rate of local femoral complications was 8.5%, an acceptable figure if it is taken into account that the majority received abciximab and fibrinolytic treatment in the case of "facilitated" or rescue PCI. Louvard et al, in a similar study, compared the radial and femoral routes in patients with AMI undergoing PCI in 2 different centers. The rate of femoral complications was very unequal (2% vs 10%), probably because the first center used percutaneous closure devices and fewer fibrinolytics (16% vs 22%) and abciximab (5.8% vs 48.3%). In the TEMPURA study, which randomly compared the radial and femoral approaches in AMI patients, the rate of local femoral complications was 3% lower than in our series, although abciximab and fibrinolytics were not used.⁸ In the present study, the duration of the procedure, the material used, the success rate and the number of MACE were similar in both approaches. However, local complications were significantly lower when RAA was used. Other the other hand, RAA makes it possible for patients undergoing coronary stent implantation, with combined antiplatelet therapy, to deambulate and be discharged from hospital earlier. For this reason, the radial approach should also always be the treatment of choice in elderly patients in whom prolonged immobilization and hemorrhagic compli-

cations after PCI for AMI can become particularly important.²³

Study Limitations

This study is an observational study based on daily clinical practice. Since this is not a randomized study, the results could be influenced by the choice of the arterial access route as a function of the operators subjective criteria. The absence of post-intervention permeability of the radial artery has not been systematically investigated, although various studies have demonstrated its low incidence and the low impact of asymptomatic occlusions.

CONCLUSIONS

The present study shows that RAA has a high success rate and a MACE rate similar to FAA. RAA is a safe and effective way to perform PCI with coronary stent implantation in AMI in patients with a high risk of hemorrhage, such as those receiving abciximab, thrombolytics or both.

ACKNOWLEDGMENT

To the nursing personnel of our Unit (Vincent Fernández Álvarez, Maribel García Fernández, and Ángel Santigosa Colomer), without whose collaboration and enthusiasm this study could not have been carried out.

REFERENCES

1. Campeau L. Percutaneous radial artery approach for coronary angiography. *Cathet Cardiovasc Diagn* 1989;16:3-7.
2. Kiemeneij F, Laarman GJ, de Melker E. Transradial artery coronary angioplasty. *Am Heart J* 1995;129:1-7.
3. Lotan C, Hasin Y, Mosseri M, Rozenman Y, Admon D, Nassar H, et al. Transradial approach for coronary angiography and angioplasty. *Am J Cardiol* 1995;76:164-7.
4. Louvard Y, Lefèvre T, Allain A, Morice MC. Coronary angiography through the radial or the femoral approach: the Carafe study. *Cathet Cardiovasc Intervent* 2001;52:181-7.
5. Salgado J, Calviño R, Vázquez Rodríguez JM, Vázquez González N, Vázquez Rey E, Pérez Fernández R, et al. Coronariografía y angioplastia coronaria por vía radial: experiencia inicial y curva de aprendizaje. *Rev Esp Cardiol* 2003;56:152-9.
6. Ochiai M, Isshiki T, Toyozumi H, Eto K, Yokoyama N, Koyama Y, et al. Efficacy of transradial primary stenting in patients with acute myocardial infarction. *Am J Cardiol* 1999;83:966-8.
7. Mulukutla S, Cohen H. Feasibility and efficacy of transradial access for coronary interventions in patients with acute myocardial infarction. *Cathet Cardiovasc Intervent* 2002;57:167-71.
8. Saito S, Tanaka S, Hiroe Y, Miyashita Y, Takahashi S, Tanaka K, et al. Comparative study on transradial approach vs transfemoral approach in primary stent implantation for patients with acute myocardial infarction: Results of the test for myocardial infarction by prospective unicenter randomization for access sites (TEMPURA) trial. *Cathet Cardiovasc Intervent* 2003;59:26-33.

9. Kiemeneij F, Laarman GJ, Odekerken D, Slagboom T, van de 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.
10. Barbeau G, Arsenault F, Dugas L, Larivière M. A new and objective method for transradial approach screening: comparison with Allen's test in 1010 patients. *J Am Coll Cardiol* 2001;37:34A-6A.
11. Brener SJ, Ellis SG, Schneider J, Topol EJ. Frequency and long-term impact of myonecrosis after coronary stenting. *Eur Heart J* 2002;23:869-76.
12. Hartzler G, Rutherford B, McConahay D, Johnson W, McCallister B, Gura G, et al. Percutaneous transluminal coronary angioplasty with and without thrombolytic therapy for treatment of acute myocardial infarction. *Am Heart J* 1983;106:965-73.
13. Vogt A, Neuhaus KL. Thrombolysis and mechanical intervention following myocardial infarction. *Eur Heart J* 1996;17(Suppl E):49-54.
14. Grines CL, Browne KF, Marco J, Rothbaum D, Stone GW, O'Keefe 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.
15. Zahn R, Schiele R, Scheneider S, Gitt AK, Wienberger H, Seidl K, et al. Primary angioplasty versus intravenous thrombolysis in acute myocardial infarction: can we define subgroups of patients benefiting most from primary angioplasty? Results from the pooled data of the Maximal Individual Therapy in acute Myocardial Infarction Registry and the Myocardial Infarction Registry. *J Am Coll Cardiol* 2001;37:1827-35.
16. Grines CL, Cox DA, Stone GW, Garcia E, Mattos LA, Giambartolomei A, 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.
17. Montalescot G, Barragan P, Wittenberg O, Ecollan P, Elhadad S, Villain P, et al, for the ADMIRAL Investigators. Platelet glycoprotein IIb/IIIa inhibition with coronary stenting for acute myocardial infarction. *N Engl J Med* 2001;344:1895-903.
18. Choussat R, Black A, Bosi I, Fajadet J, Marco J. Vascular complications and clinical outcome after coronary angioplasty with platelet IIb/IIIa receptor blockade: comparison of transradial vs transfemoral arterial access. *Eur Heart J* 2000;21:662-7.
19. The EPILOG Investigators. Platelet glycoprotein IIb/IIIa receptor blockade and low-dose heparin during percutaneous coronary revascularization. *N Engl J Med* 1997;336:1689-96.
20. Mann T, Cowper PA, Peterson ED, Cubeddu G, Bowen J, Giron L, et al. Transradial coronary stenting: comparison with femoral access closed with an arterial suture device. *Cathet Cardiovasc Intervent* 2000;49:150-6.
21. Benit E, Missault L, Eeman T, Carlier M, Muyldermans L, Materne P, et al. Brachial, radial, or femoral approach for elective Palmaz-Schatz stent implantation: a randomized comparison. *Cathet Cardiovasc Diagn* 1997;41:124-30.
22. Louvard Y, Ludwig J, Lefèvre T, Schmeisser A, Brück M, Scheinert D, et al. Transradial approach for coronary angioplasty in the setting of acute myocardial infarction: a dual-center registry. *Cathet Cardiovasc Intervent* 2002;55:206-11.
23. Berger AK, Schulman KA, Gersh BJ, Piroz S, Breall JA, Johnson AE, et al. Primary coronary angioplasty vs thrombolysis for the management of acute myocardial infarction in elderly patients. *JAMA* 1999;282:341-8.