Transradial Approach to Coronary Angiography and Angioplasty: Initial Experience and Learning Curve

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Introduction. The transradial approach has emerged as an attractive alternative to the femoral approach for coronary angiography and interventions. We describe our experience with the transradial approach and analyze the influence of the learning curve.

Patients and methods. The transradial approach was attempted in patients with a good radial pulse and normal Allen test. When feasible and clinically indicated, we attempted *ad hoc* intervention. We divided the study population into two groups: Group A (the first 200 cases) and B (all other patients). We compared the radial group with a matched femoral control group.

Results. We attempted the transradial approach in 526 patients (77.6% male; age 63.5 ± 11.51), and obtained a success rate of 93.7%. We found differences between group A and B in the success rate (91.0 vs 95.4%, p = 0,04), duration of procedure [23 (16-29) vs. 19 (15-24) minutes; p < 0.001], and fluoroscopy time [6.4 (4.2-10) vs. 5.0 (3.0-7.7) minutes; p < 0,001]. At 24 h of follow-up, we found small hematomas in 9.4%, bleeding in 4.9%, and radial artery obstruction in 2.8%, with no cases of arteriovenous fistula, pseudoaneurysm, or need for vascular surgery. We attempted intervention in 169 patients with 258 lesions, achieving angiographic success in 96.1%. We found no differences in the characteristics of the lesions and patients, or in the angiographic success rate of the radial and femoral PTCA groups.

Conclusions. The transradial approach is a safe and effective alternative to femoral catherization. There is a significant learning curve associated with the successful performance of transradial procedures.

Key words: *Angiography. Coronary disease. Coronary angioplasty. Stent. Radial artery.*

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Coronariografía y angioplastia coronaria por vía radial: experiencia inicial y curva de aprendizaje

Introducción. La vía transradial ha surgido como una alternativa atractiva a la vía femoral para realizar coronariografías e intervenciones coronarias. Describimos nuestra experiencia y analizamos la influencia de la curva de aprendizaje.

Pacientes y métodos. El abordaje transradial se intentó en pacientes con pulso radial y test de Allen normales. Cuando se consideró posible e indicado, se realizó una intervención coronaria en el mismo procedimiento. Dividimos a la población de estudio en 2 grupos: A (primeros 200 casos) y B (el resto de los pacientes). Comparamos el grupo radial con un grupo control femoral.

Resultados. Intentamos el acceso radial en 526 pacientes (77,6% varones; edad, 63,5 ± 11,51 años), con éxito en el 93,7%. Encontramos diferencias entre los grupos A y B en la proporción de procedimientos con éxito (91,0 frente a 95,4%; p = 0,04), los tiempos de procedimiento (23 [16-29] frente a 19 [15-24] min; p < 0,001) y de fluoroscopia (6,4 [4,2-10] frente a 5,0 [3,0-7,7] min; p < 0,001). A las 24 h, encontramos pequeños hematomas en el 9,4%, hemorragia en el 4,9%, obstrucción radial en el 2,8%, y ningún caso de fístula arteriovenosa, seudoaneurisma o necesidad de intervención quirúrgica. Se intentó realizar una angioplastia en 169 pacientes (258 lesiones), con éxito angiográfico en el 96,1%. No encontramos diferencias en las características de los pacientes, las lesiones y el resultado angiográfico entre los grupos de intervención radial y femoral.

Conclusiones. La vía radial es una alternativa segura y eficaz a la femoral. Existe una curva de aprendizaje significativa asociada a los procedimientos por vía radial.

Palabras clave: *Angiografía. Enfermedad coronaria. Angioplastia coronaria.* Stent. *Arteria radial.*

INTRODUCTION

The transradial approach for performing coronary angiography was initially proposed by Campeau[1] in 1989, and a few years later its use was initiated for coronary angioplasty procedures and stent implantation.[2,3] Several studies have shown that the radial approach allows treatment of the same type of patients and lesions as the «classic» femoral approach, with some advantages over the femoral approach because it involves a minimal vascular complication rate, eliminates the necessity for prolonged compression or closure devices, and allows for earlier ambulation for the patient, rendering the radial approach more comfortable for the patient and one that decreases hospital costs and length of stay. Nevertheless, the greater technical complexity of the procedure and the associated significant learning curve has resulted in limited use of this procedure in our country.

The aim of our study is to document our experience with the routine use of the transradial approach for coronary angiography and coronary intervention procedures, and to describe the difficulties and complications associated with the technique as compared with the transfemoral approach, in addition to analyzing the impact of the learning curve.

PATIENTS AND METHODS

Study population

We included all patients who underwent coronary angiography in our medical center in whom a transradial approach was used during the study period. The choice of approach was left to the physician. In order to determine eligibility for attempted radial access, we determined if contraindications for the procedure were slight or absent, the existence an abnormal Allen test, the existence of a known arterial circulatory disease in one of the upper limbs, a history of coronary revascularization surgery with the left internal mammary artery, the need for the simultaneous performance of right catheterization, the presence of acute myocardial infarct (when a primary angioplasty or rescue angioplasty following failure of fibrinolitic treatment was planned) acute pulmonary edema, and shock.

In order to determine the impact of the learning curve, we divided the study population into 2 groups: A, which included the first 200 patients on whom the procedure was performed, and B, which included the remaining patients.

In order to compare the transradial diagnostic procedure with the transfemoral procedure, we used a control group of patients who underwent coronary angiography via the femoral artery before the transradial method was initiated. To this end, we obtained data from all the patients who had undergone diagnostic coronary angiography during the year 2000 in our medical center, including those with a history of coronary revascularization surgery, those who previously had a catheter placed in the femoral artery for a previous procedure, and also those patients on whom a right catheterization had been simultaneously performed. In order to compare the angioplasties performed transradially, we used the data from all patients who underwent an angioplasty in the year 2000, excluding primary angioplasties, rescue angioplasties, angioplasties of the left common trunk, and venous grafts. To analyze the length of the procedure and the fluoroscopy studies, we compared separately the diagnostic studies and the intervention procedures for both groups. All the procedures, whether transradial or transfemoral, were performed by the same specialist.

Coronary angiography

All patients first underwent an Allen test, which was considered abnormal when normal color did not return to the hand less than 10 seconds after removing pressure on the cubital artery.[4] The patient was placed in a decubitus supine position with the arm along the side of the body. Under local anesthetic (mepivacaine), we performed the puncture with a 21-gauge needle and then introduced a straight 0.021-inch guide catheter, followed by the introduction of a 6 F 11-cm introductory catheter (Transradial Kit, Cordis Corp, Miami, Fl., USA). All patients received 5000 units of sodium heparin in conjunction with a spasmolytic cocktail (2.5 mg verapamil and 200 µg nitroglycerine) via the lateral catheter before the procedure was begun; this cocktail was re-administered if the patient complained of forearm pain or if there was resistance to manipulation of the catheters. The introductory catheter was exchanged for a 0.035-inch angiography guide (Medtronic, Danvers, Mass., USA) up to the ascending aorta, and then the radiography-controlled catheters were inserted. The choice of catheters was left to the specialist. In all patients, the introductory catheter was removed immediately after the procedure, and hemostasis was achieved by means of an elastic compressor bandage, without using compression devices.[5] The bandage was kept in place for at least 4 hours. The patient was allowed to be ambulatory immediately following the procedure.

For each patient we gathered the data from the procedure: total length of time for the procedure, fluoroscopy time, contrast material volume, incidence of puncture difficulties, the progression of catheters from the ascending aorta or in catheterization of the coronary arteries, the presence of color in the arm during the procedure, and the total number and type of catheters used. All patients were evaluated 24 hours after the procedure and we noted the presence of palpable hematomas at the puncture point, hemorrhage, pain on palpation of the puncture area, and the presence of a distal radial pulse. Similarly, we performed an inverse Allen test which was considered abnormal if normal color did not return to the hand with 10 seconds after removing pressure to the radial artery. Radial artery obstruction was considered present in the absence of a radial pulse distal to the puncture site or an abnormal inverse Allen test result.[6] A successful diagnostic test was considered to be one accomplished completely transradially and that was of sufficient quality to allow a diagnosis to be established. Length of procedure was the time from the beginning of the procedure (immediately before administration of anesthesia) to the removal of the last catheter.

Angioplasty

When it was decided that percutaneous interventional treatment was required, it was performed on the spot; the introductory catheter was left in the radial artery and additional heparin was administered (up to a total of 100 units/kg). The choice of guide catheter, intracoronary catheters, angioplasty balloons, stents, and the administration of GP IIb/IIIa inhibitors was left to the specialist´s judgment. The procedure was considered to be successful if the presence of TIMI-3 was verified and there was less than 20% residual stenosis in the vessel being treated by the end of the procedure.[7] All patients continued to be treated with aspirin 150 mg/day, and when stents were implanted, with ticlopidine (a load dose of 500 and 250 mg every 12 hours for 1 month).

Statistical analysis

Continuous variables are expressed as mean±standard deviation (SD). Procedure times and fluoroscopy times are described as mean (interquartile range). Categorical variables are expressed as percentages. The comparison of means was performed by means of Student *t* test or the Mann-Whitney *U* test in each case, and the comparison of percentages was made with the Pearson χ^2 test. The associations between variables were considered statistically significant if the *P* value was <.05. All analyses were performed with the SPSS 11.0 statistical package for Windows.

RESULTS

Beginning on June 22, 2001, and continuing over 7 months, we performed 526 transradial coronary angiographies in our laboratory (44.4% of the total number of coronary angiographies performed during this period), 77.6% of which were on men, mean age of 63.5 years±11.5 years. We performed 520 (98.9%) procedures via the right radial artery and 6 (1.1%) via the left radial artery. The procedure was performed successfully in 93.7% of cases, and in 33 patients (6.3%) it was not possible to perform the procedure transradially; it was performed via the femoral artery. Reasons for procedural failure were: inability to cannulate the radial artery (n=19); inability to advance the guide or the radiography catheters up to the ascending aorta (n=11); and inability to selectively cannulate the coronary arteries (n=3). Inability to advance the guide or radiography catheters or to cannulate the coronary arteries was fundamentally due to the presence of a variety of anatomical features: tortuosity of the radial or subclavian artery (n=7); radial loop (n=1); accessory humeral artery (n=2); high origin of the radial artery (n=2); or abnormal origin of the right subclavian artery (n=2). In 1 patient, an obstruction was found in the brachial artery secondary to a previous catheterization. In 38 patients (7.3%) procedural radial spasm was observed, and in 3 cases extravasation of contrast material from the radial artery was present, which was resolved conservatively, permitting continuation of the procedure. Catheters of caliber 6 F were used in 98.8% of the cases, and of caliber 4 F in 1.2%; the curves used are summarized in Figure 1. Average diagnostic procedure time was 19 minutes (15 to 26 minutes) and the average fluoroscopy time was 5 minutes (3.3 to 8.1 minutes). Clinical followup at 24 hours revealed hematoma at the puncture site in 48 patients (9.4%), slight hemorrhage in 26 patients (4.9%), pain on palpation of the puncture site in 41 patients (7.9%), and the radial artery was considered to be obstructed in 14 patients (2.8%). We did not note a single case of pseudoaneurysm, arteriovenous fistula, extended length of hospital stay due to vascular problems, or the need for surgical intervention or a transfusion.

We included 1697 patients in the group who underwent the procedure via the femoral approach. The demographic, clinical, angiographic, and procedure characteristics, both for the transradial and the transfemoral procedures, are summarized in Table 1. We found significant differences in the percentage of successful procedures, as well as in the length of time needed for the procedures and length time needed for fluoroscopy (Table 1 and Figure 2) between the group of patients who underwent transradial procedures and the group of patients who underwent transfemoral procedures. During the study period (group A, first 200 patients; group, successive patients) we observed a significant decrease in the length of time for the procedures (group A, 23 minutes [16 to 29 minutes]; group B, 19 minutes [15 to 24 minutes]; *P*<.001); length of time for fluoroscopy (group A, 6.4 minutes [4.2 to 10.0 minutes]; group B, 5.0 minutes [3.0 to 7.7 minutes]; *P*<.001); and an increase in the number of successful procedures (91.0% for group A vs 95.4% for group B; *P*=.04). In the transfemoral group there were 10 major vascular complications (0.6% of patients; *P*=.085 with respect to the transradial group): 6 pseudoaneurysms and 4 arteriovenous fistulas (all cases were resolved by means of prolonged compression or local injection of thrombin, without surgical intervention being necessary).

Transradial angioplasty was attempted in 169 patients. In 3 patients transradial diagnostic catheteriza-

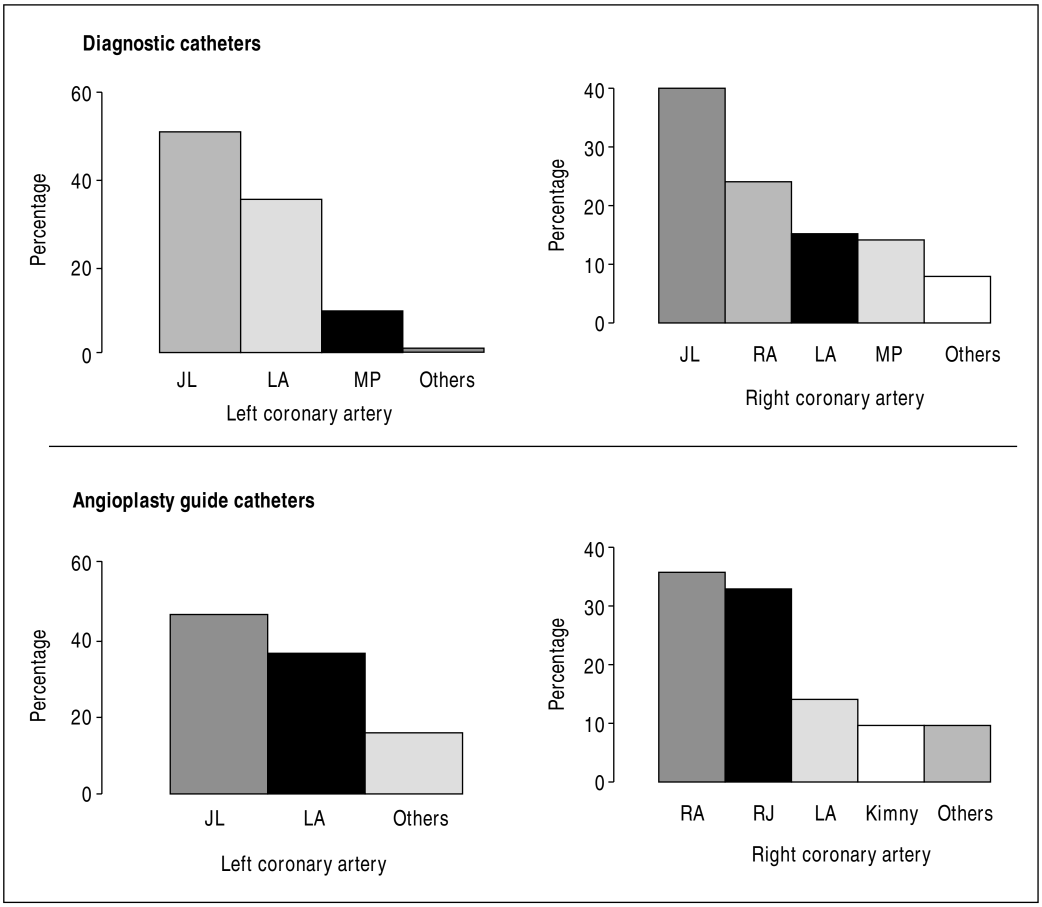

Fig. 1. Diagnostic catheters and angioplasty guide catheters used for the transradial approach. LA indicates left Amplatz; RA, right Amplatz; LJ, left Judkins; RJ, right Judkins; MP,

TABLE 1. **Clinical, angiographic, and procedural characteristics of patients who underwent transfemoral or transradial coronary angiography**

	Radial (n=526)	Femoral (n=1697)	*P*
Age, years	63.5±11.51	64.2±11.04	.188
Men, %	77.6	73.8	.081
Hypertension, %	46.3	49.5	.197
Hypercholesterolemia, %	47.8	52.3	.073
Smoking, %	48.6	45.3	.189
Diabetes,%	18.5	22.0	.092
Stable angina, %	17.3	16.4	.644
Unstable angina, %	45.6	46.0	.874
Valvulopathy, %	13.1	13.9	.646
Other indications, %	6.1	6.1	.970
Without significant lesions, %	35.4	37.8	.317
One-vessel disease, %	27.2	25.1	.339
Two-vessel disease,%	19.6	17.0	.169
Three-vessel disease, %	17.9	20.2	.249
Disease of the common trunk, %	4.4	5.3	.407
Ejection fraction, %	64±12.6	63±12.4	.055
Length of time for procedure, mina	19.0 (15.0-26.0)	16.0 (13.0-21.0)	<.001
Length of time for fluoroscopy, min[a]	5.0 (3.3-8.1)	3.0 (2.1-5.0)	<.001
Contrast volume, mL	143±47.3	143±58.4	.629
Procedure success rate, %	93.7	100	<.001
Major vascular complications[b]	0	10 (0.6%)	.081

[a]Expressed as an average (interquartile range).
[b]Defined as pseudoaneurysm, arteriovenous fistula, need for transfusion, or need for surgical intervention.

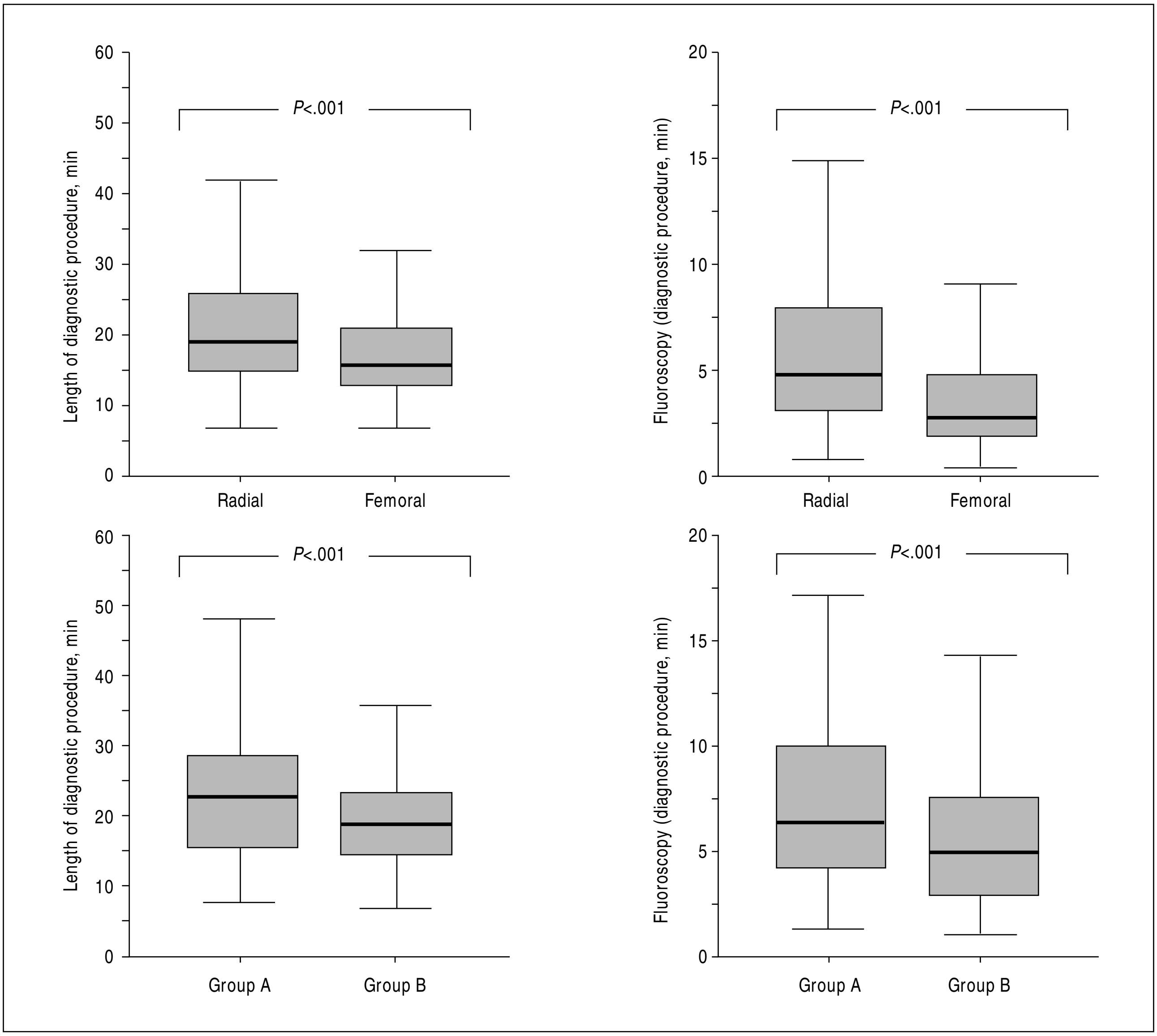

Fig. 2. Transradial and transfemoral procedure and fluoroscopy (diagnostic procedure) times (top) and transradial procedure and fluoroscopy times of groups A and B (bottom). Anomalous values are not shown.

tion was performed and transfemoral angioplasty was performed electively, in 2 cases due to difficulty in achieving proper alignment of the guide catheter with the coronary artery via radial access, and in 1 case because it was deemed better to use an 8 F guide catheter to treat a lesion of the left common trunk. A total of 258 lesions were treated transradially; 248 (96.1%) were treated successfully. The reason for procedural failure was the impossibility of crossing the lesion with the intracoronary guide catheter in 7 cases, inability to cross the lesion with a balloon angioplasty in 1 case, lack of support for the guide catheter in 1 case, and inability to dilate a lesion that was severely calcified in 1 case. Six F caliber guide catheters were used for all patients. The clinical, demographic, and procedural characteristics of the transradial and transfemoral groups are shown in Tables 2 and 3. The total procedure length of time (combining both the diagnostic and intervention times) was greater in the transradial group, although this was not significant (mean 1.5 minutes; *P*=.498), and the total fluoroscopy time was also greater in the transradial group than in the transfemoral group (mean, 2.8 minutes [95% CI, 0.6 to 4.9 minutes]). We found no significant differences between patient characteristics and the lesions treated either transradially or transfemorally, or in the percentage of angiographic successes between the 2 groups.

TABLE 2. **Clinical and procedure characteristics of patients who underwent transfemoral or transradial angioplasty**

	Radial (n=169)	Femoral (n=565)	*P*
Age, years	62.0±11.64	63.2±11.46	.227
Men, %	87.0	82.3	.151
Hypertension, %	43.8	48.0	.340
Hypercholesterolemia, %	54.4	55.6	.794
Smoking, %	62.7	55.9	.117
Diabetes, %	18.9	21.9	.401
Ejection fraction, %	64.4±12.87	62.0±12.76	.076
Stable angina, %	14.8	14.5	.928
Unstable angina, %	59.2	62.3	.463
Inducible ischemia, %	26.0	24.8	.741
Lesions treated per patient	1.5±0.87	1.5±0.80	.998
Use of abciximab, %	4.7	5.8	.582
Contrast volume, mL	342±125.1	337±118.4	.875
Procedure length of time, min*	53 (41-71)	50 (39-67)	.498
Fluoroscopy length of time, min*	16.1 (11.0-24.8)	13.7 (9.0-20.4)	.013
Final device diameter	3.0±0.49	3.0±0.91	.576
Angiography success rate, %	96.1	96.2	.935

*Expressed as an average (interquartile range). The length of time for the diagnostic procedure is included with the length of time for the angioplasty.

TABLE 3. **Characteristics of lesions treated by transradial or transfemoral angioplasty**

	Radial (n=258)	Femoral (n=943)	P
Location of the lesions			
AD, %	41.4	37.2	.227
CX, %	24.6	23.9	.26
RC, %	33.2	37.8	.180
verage branch, %	0.8	1.1	.694
Type of lesion*			
Type A, %	9.8	12.8	.226
Type B, %	63.4	65.6	.541
Type C, %	27.1	21.6	.082

RC indicates right coronary artery; CX, circumflex artery; AD, anterior descending. *AHA/ACC classification (from Ryan et al. J Am Coll Cardiol 1993;22:2033-54.)

DISCUSSION

Transradial access is an attractive alternative for the performance of coronary angiography and coronary intervention,[1-3,8-15] as it has, in theory, several advantages over transfemoral access: there are important veins or nerves close to the radial artery in the wrist, which decreases the possibility of arteriovenous fistulas or nerve lesions; the superficial trajectory of the artery and its proximity to the bone allow simple hemostasis by means of simple compression, eliminating the need for closure devices and decreasing the possibility of hematoma and pseudoaneurysm. In addition, iatrogenic obstruction of the artery does not seriously compromise the blood flow to the hand, which is maintained by the cubital artery in patients with a normal Allen test. Several studies have reported that the patients can ambulate almost immediately following the procedure, which increases the patient´s comfort and level of satisfaction, and at the same time decreases the length of hospital stay and the cost.[16-20] Nevertheless, the procedure could only be performed with safety in patients with a normal Allen test, and the procedure is technically more complex than the transfemoral procedure due to the greater difficulty in cannulating the artery, the possibility of spasm, anatomical variations in the arteries of the upper limb, and the change in manipulation of the catheters that is necessary to cannulate the coronary arteries. All these difficulties result in a slight increase in the length of time needed for the procedure and time needed for fluoroscopy, and the existence of a significant learning curve, including for specialists with a great deal of experience in transfemoral procedures.

In our study, we observed that the learning curve had a great impact; in the first 200 patients, the percentage of successes was only 91%, the same as in other initial study series that included only a few patients.[21,22] Nevertheless, in the later cases the percentage of successful procedures improved to up to 95.4%, similar to the rate noted in other studies that analyzed the impact of the learning curve.[10,12,22] We also observed a significant decrease in the length of time needed for the procedure and of the time needed for fluoroscopy, although these continued to be greater than in the transfemoral group, as was the case in other studies of randomly assigned[7,20] or nonrandomly assigned patients.[16] In the study by Ludman et al,[16] an improvement in the success rate was not observed, and there was no decrease in the procedural or fluoroscopy times for the duration of the study; nevertheless, in this series, only 116 patients were included in the transradial group, which is probably too small a number to determine the impact of the learning curve. This is also the case with the study by Goldberg et al,[21] which only included 27 patients.

Judkins catheters are the first choice in most laboratories for femoral access procedure. Some authors report difficulty with the use of these catheters in transradial procedures,[17] indicating that they prefer Amplatz or multipurpose catheters. We, as reported by other authors,[3,15,21] prefer Judkins catheters as the first choice for transradial procedures. To cannulate the left coronary artery, we generally used a Judkins left curve 3.5, saving the 4.0 and 5.0 curves for patients with dilatation of the ascending aorta. The left Judkins catheter is inserted into the guiding catheter and is rotated toward the left coronary ostium; removal of the guiding catheter produces the angulation of the secondary curve that raises the catheter end and, in most of cases, orients it toward the ostium.[3] When canalization of the left coronary artery was not achieved with this catheter, we used the left Amplatz (more frequently curve 2), or the multipurpose, or other types of catheters. For the right coronary artery, we most often used the Judkins right curve 4 or 5, manipulating it in a similar manner as when it is used for transfemoral procedures, until we canalized the right ostium. Less frequently, we used Amplatz catheters (particularly the right curve 2), multipurpose catheters, or other types of catheters. Several types of diagnostic and guiding catheters are commercially available that are specifically designed for use in transradial procedures, with different curves for the right and left coronary arteries, such as the MUTA (Boston Scientific-Scimed, Plymouth, Minn.), or ones that are designed to cannulate both coronary arteries with a single catheter, such as the Kimny (Boston Scientific Scimed). At present, we have limited experience with these curved catheters which are widely used in other laboratories where a large number of transradial procedures are performed.

As has been shown in several studies, radial access permits treatment by means of angioplasty and stent implantation in the same type of patients and lesions as femoral access provides.[3,9,10,14,15,20] In our study we did not find significant differences between the characteristics of the patients or the lesions treated transfemorally or transradially (Tables 2 and 3), or in the percentage of lesions treated successfully (Table 2). The only limitation of transradial angioplasty is the need to use guiding catheters that are larger in caliber than usual to treat some lesions; nevertheless, with the guiding catheters available today, most lesions can be treated by using 6 F guiding catheters; also, in some patients it is possible to used 7 F or 8 F caliber guiding catheters to treat lesions transradially with good results.[14,23] A theoretical advantage of transradial angioplasty is the possibility of performing the procedure in an outpatient setting for some patients, as has been shown in several studies,[24,25] although in our medical center it is usual to delay the discharge at least 24 hours after performing the angioplasty and trying to decrease the length of hospital stay is not one of our objectives. Some studies have also evaluated the possibility of performing primary angioplasty via radial access;[23,26,27] however, given the longer duration of access with this method, in our laboratory we continue to routinely use femoral access for this procedure, reserving radial or brachial access only for those patients in whom femoral access is not possible.

During our study there were no vascular complications that required a transfusion or surgical intervention, and in only a small percentage of patients did we observe palpable hematoma at the puncture site or hemorrhage that required a change of bandage. The percentage of radial asymptomatic obstruction was very small, only 2.8%, significantly lower that in other, older series,[1,11,15,20] although similar to that found by Stella et al[6] and Saito et al.[14] Most likely, the lower rate of occlusions in these series of studies is due to the use of aggressive anticoagulation in all cases, short cannulation times, and the immediate removal of the introductory catheter after the procedure.[6] In this study, we did not perform systematic followup by Doppler of the radial artery, and it is possible that the number of patients who had radial obstruction could be somewhat higher; for instance, in the study by Louvard et al,[12] the percentage of patients with an the absence of a pulse distal to the puncture site was 3.6%, but on Doppler study an occlusion rate of 8.6% was recorded. Nevertheless, we believe that the palpation of the radial pulse distal to the puncture site and a favorable inverse Allen test is a good way to evaluate the permeability of the distal radial artery without the need for a control Doppler study of all patients.

One limitation of this study is that the data from the transfemoral group were collected retrospectively. Nevertheless, all the data that was analyzed was collected routinely in our laboratory for all patients at the time we performed the procedure, which diminishes the bias. On the other hand, the demographic and clinical characteristics of the 2 groups are overlapping, and the results from comparing procedure and fluoroscopy times coincides with the results from other studies, whether they were randomized or not, that compare the 2 techniques. The choice of access was made according to the judgment of the specialist, which introduces difficult subjective variables to be quantified when assessing the selection of patients. Although initially only patients with a high probability of success were elected for the procedure (men, young people, good radial artery size for palpation, greater body surface), we later also included cases considered to be «suboptimal», but the criteria that influenced patient selection was not systematically studied.

CONCLUSIONS

Radial access permits safe performance of coronary angiography and coronary interventions in the same type of patients and lesions as radial access does, with few limitations and few vascular complications, and allows for the patients to ambulate immediately after the procedure, thus increasing patient comfort and possibly decreasing hospital costs and hospital stays. Even for experienced specialists, there is a significant learning curve, and the length of time needed for the procedure and for the fluoroscopy is slightly greater than that needed for the transfemoral procedure, although this diminishes when the specialist´s level of expertise is higher. Radial access can be used as the first choice in most patients.

REFERENCES

1. Campeau L. Percutaneous radial artery approach for coronary angiography. Cathet Cardiovasc Diagn 1989;16:3-7.
2. Kiemeneij F, Laarman GJ. Percutaneous transradial artery approach for coronary stent implantation. Cathet Cardiovasc Diagn 1993;30:173-8.
3. Kiameneij F, Laarman GJ, De Melker E. Transradial artery coronary angioplasty. Am Heart J 1995;129:1-7.
4. McConnell EA. Performing Allen's test. Nursing 1997;27:26.
5. Kiemeneij F. Radial Hemostasis devices: alternatives for a simple pile of gauze and elastic plasters? J Invas Cardiol 2000;12:623-4.
6. Stella PR, Kiameneij F, Laarman GJ, Odekerken D, Slangboom T, Van der Wieken R. Incidence and outcome of radial artery occlusion following transradial artery coronary angioplasty. Cathet Cardiovasc Diagn 1997;40:156-8.
7. Smith SC Jr, Dove JT, Jacobs AK, Kennedy JW, Kereiakes D, Kern MJ, et al. ACC/AHA Guidelines for percutaneous coronary intervention: 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). J Am Coll Cardiol 2001; 37:2239 i-lxvi.
8. Mick MJ. Transradial approach for coronary angiography. J Invas Cardiol 1996;8(Suppl D):9-12.
9. Fajadet J. Percutaneous transradial approach for coronary revascularization: what have we learned? J Invasive Cardiol 1996; 8(Suppl D):8-13.
10. Schneider JE, Mann T, Cubeddu MG, Arrowood ME. Transradial coronary stenting: a United States experience. J Invasive Cardiol 1997;9:569-74.
11. 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.
12. Louvard Y, Krol M, Pezzano M, Sheers L, Piéchaud JF, Marien C, et al. Feasibility of routine transradial coronary angiography: a single operator's experience. J Invas Cardiol 1999;11:543-8.
13. Caputo RP, Simons A, Giambartolomei A, Grant W, Fedele K, Abraham S, et al. Transradial cardiac catheterization in elderly patients. Cathet Cardiovasc Intervent 2000;51:287-90.
14. Saito S, Miyake S, Hosokawa G, Tanaka S, Kawamitsu K, Kaneda H, et al. Transradial coronary intervention in Japanese patients. Cathet Cardiovasc Intervent 1999;46:37-41.
15. 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.
16. Ludman PF, Stephens NG, Harcombe A, Lowe MD, Shapiro LM, Schofield PM, et al. Radial *versus* femoral approach for diagnostic coronary angiography in stable angina pectoris. Am J Cardiol 1997;79:1239-41.
17. 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.
18. 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.
19. Mann JT, Cubeddu G, Schneider JE, Arrowood M. Right radial access for PTCA: a prospective study demonstrates reduced complications and hospital charges. J Invas Cardiol 1996;8(Suppl D): 4-40.
20. Kiemeneij F, Laarman GJ, 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.
21. Goldberg SL, Rensio R, Sinow R, Franch WJ. Learning curve in the use of the radial artery as vascular access in the performance of percutaneous transluminal coronary angioplasty. Cathet Cardiovasc Diagn 1998;44:147-52.
22. Lovard Y. Radial approach: what about the learning curve? Cathet Cardiovasc Diagn 1997;42:467-8.
23. Ochiai M, Takaaki I, Toyoizumi H, Toyoizumi H, Eto K, Yokoyama N, et al. Efficacy of transradial primary stenting in patients with acute myocardial infarction. Am J Cardiol 1999;83:966-8.
24. Kiemeneij F, Laarman GJ, Slagboom T, Van der Wieken. Outpatient coronary stent implantation. J Am Coll Cardiol 1997;29: 323-7.
25. Slagboom T, Kiemeneij F, Laarman GJ, Van der Wieken R, Odekerken D. Actual outpatient PTCA: results of the OUTCLAS Pilot Study. Cathet Cardiovasc Interv 2001;53:204-8.
26. Steg G, Aubry P. Radial access for primary PTCA in patients with acute myocardial infarction and contraindication or impossible femoral access. Cathet Cardiovasc Diagn 1996;39:424-6.
27. 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.