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Left Radial Approach for Coronary Angiography: Results of a Prospective Study

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Although radial approach has been shown to be feasible for coronary angiography, angioplasty, and even stent placement, there have been no prospective evaluations of ease and safety of left radial approach for coronary angiogram. We examined procedural duration and success as well as complications in 415 consecutive patients. Radial artery occlusion was assessed immediately post-procedure and at 2 month follow-up using echo-Doppler measurements. Procedure failure rate was 9%, mean time for sheath insertion was 4.7 ± 4.7 min, and mean procedure duration was 19.1 ± 8.2 min. No major complications occurred. Asymptomatic radial artery occlusion was noted in 71% of the first 49 patients, decreased to 24% in the next 119 receiving 2,000–3,000 units of heparin, and to 4.3% in the last 210 receiving 5000 ($p < 0.05$). Comparison with the femoral approach in the same laboratory suggested that the radial approach took longer, but provided similarly high-quality results without great difficulty in coronary cannulation. Hence, the left radial approach for coronary angiography (with heparin administration) allows immediate ambulation and may be especially useful for outpatients and when the femoral approach is not possible. © 1996 Wiley-Liss, Inc.

Key words: cardiac catheterization, coronary angiogram, echo-Doppler measurement

INTRODUCTION

In 1989 Campeau first reported his experience of percutaneous radial artery approach for coronary angiography in 100 patients [1]; in 1992 Otaki presented a series of 40 coronary angiograms using the left radial artery [2]. However, this novel technique did not gain immediate wide acceptance. The radial approach was then used successfully by Kiemeneij [3,4] and Lotan [5] in coronary angioplasty. No prospective series of consecutive patients has been examined to determine procedural success, ease of performance, and safety of the left radial approach for diagnostic procedures. This report describes the technique and procedural results of 415 consecutive patients with radial artery patency assessed by clinical and echographic-Doppler examinations immediately and 2 months after the procedure.

METHODS

From March 1994 to June 1995, a total of 1,008 patients admitted for elective coronary angiography were screened according to the following inclusion criteria: absence of significant arteriopathy of the upper extremities or Raynaud's disease and a normal Allen test. A test was considered normal if the following two conditions were present: following compression of the radial and ulnar arteries, a return of normal color of the hand is observed within 10 s after release of the pressure over the ulnar artery, with no significant reactive hyperemia upon the release of the pressure over the radial artery [6]. Patients were excluded if they presented with a Q-wave myocardial infarction within the past week, known allergy to contrast medium, were left-handed, or required studies other than coronary angiography and left ventriculography such as right-heart catheterization, coronary angioplasty, or opacification of a right internal mammary arterial graft. The study protocol was approved by both institutional ethics committees on human research, and written informed consent was obtained from all patients.

Local anesthesia was obtained by applying a lidocaine cream on the wrist 2 h before the procedure. The left arm was abducted at a 70° angle, and the wrist hyperextended

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over a gauze roll. Radial puncture was performed using a 1 mm pediatric needle, a 0.21 in. straight-end guidewire and a 5 French standard sheath. All patients received 1 mg of isosorbide dinitrate through the sheath. A coronary angiogram was performed using standard 5 French Judkins catheters. The sheath was immediately pulled out after the procedure and hemostasis obtained by applying a pressure dressing for 30–40 min. Patients were not restricted to bed rest, were advised to limit movement of the wrist joint, and were instructed on the achievement of hemostasis by local pressure in case of a puncture site bleeding.

Coronary angiograms were performed by four experienced cardiologists. The following data were gathered during the procedure: sheath insertion delay, fluoroscopy, and procedure time; presence of radial spasm; difficulties in coronary intubation graded from 1 to 3 (0 = easy, 1 = slight difficulty, 2 = average difficulty, 3 = very difficult), and quality of coronary opacification also graded from 1 to 3 (1 = poor, 2 = average, 3 = good).

Clinical examination of the wrist was performed by a cardiologist 1 h after the procedure, before discharge, and at 2 months. The presence or absence of pain, radial pulse or hematoma were noted and the Allen test was repeated. Claudication of the hand was tested by having the patients open and close their hand 50 times.

Echographic-Doppler studies of the radial artery were performed 4–5 h after the procedure and at 2 two months. The following data was collected: diameter of the radial and ulnar arteries at the wrist; intensity and direction of blood flow in both arteries and in the palmar arch, spontaneously, and after compression of the radial or ulnar arteries; and presence of hematoma, false aneurysm, or arteriovenous fistula.

Statistical Analysis

Continuous variables are expressed as mean value ± SD; group differences were tested by using a paired Student *t*-test. Dichotomous variables were compared using contingency table and chi-square test or the Fisher exact test when appropriate. A p value < 0.05 was considered significant.

RESULTS

Study Population

Of the 1,008 patients who were screened, 593 were excluded for the reasons shown in Table I, including the 91 (9%) who had a negative Allen test. The characteristics of the 415 patients included in the study are shown in Table II.

Procedural Results (Table III)

Left radial approach failed in 37 patients (9%) because of puncture failure in 29 and inadequate coronary intubation in 8; successful right femoral approaches were performed during the same procedure. Radial spasm occurred in 8 patients (2%) and disappeared after administration of an additional 1 mg of isosorbide dinitrate through the sheath. Left and right Judkins catheters were first choices; other catheters were used in only 21 cases (5.5%) for the left coronary artery, and in 11 (3%) for the right. Coronary intubation was quite consistently graded as easy. Quality of coronary opacification was excellent with an average grading of 2.96 ± 0.2.

Superficial hematomas were noted at discharge in 8 patients (2%). In one patient an antebrachial hematoma occurred 4 h after the procedure in association with median nerve compression, but this resolved spontaneously without sequel after 48 h and was presumably due to guidewire perforation of a collateral artery in the forearm. Immediate ambulation was possible in all patients with a successful procedure; 113 (30%) were discharged on the same day.

TABLE I. Reasons for Exclusion

	No of pts	%
Recent myocardial infarction (< 1 week)	170	16.8
Other studies required (PTCA, right heart catheterization, right internal mammary graft)	152	15
Patient or referring physician's refusal	105	10.4
Unsatisfactory Allen's test	91	9
Upper extremities vascular disease	33	3.27
Suspected allergy to contrast media	24	2.4
Raynaud's disease	3	0.29
Left-handed patient	15	1.48
No exclusion criteria	415	41.1

TABLE II. Clinical and Angiographic Characteristics of the 415 Study Patients

Male	353 (85%)
Age	58 ± 11 years
Stable angina	174 (42%)
Unstable angina	112 (27%)
Post myocardial infarction (> 1 week)	128 (31%)
Normal coronary angiogram	10%
One vessel disease	35%
Two vessel disease	29%
Three vessel disease	22%
Left main lesion	4%
L.V. ejection fraction	53 ± 8%

Radial Artery Clinical, Echographic, and Doppler Evaluation

Clinical and echographic-Doppler evaluation of the radial artery were performed 4–5 h after the procedure in all 378 patients with a successful procedure, and in 340 at 2 months (90%). Claudication of the hand was tested by having patients open and close their hand 50 times; no ischemia was noted. Post-procedure evaluations revealed

TABLE III. Procedural Results

Left radial approach failure (No. of pts, %)	37 (9%)
Puncture failure	29 (7%)
Inadequate coronary intubation	8 (2%)
Sheath insertion delay (min)	4.7 ± 4.7
Procedure duration (min)	19.1 ± 8.2
Radial spasm (No. of pts, %)	8 (2%)
Left coronary intubation difficulties (0–3)	0.09 ± 0.36
Right coronary intubation difficulties (0–3)	0.12 ± 0.46
Quality of left coronary opacification (1–3)	2.91 ± 0.27
Quality of right coronary opacification (1–3)	2.98 ± 0.18

radial artery occlusion in 73 (19%). In this highly selected group of patients with a normal Allen test before the procedure, Doppler examination showed reversed flow in the palmar arch and in the radial artery in all patients. All patients with a post-procedure radial artery occlusion were asymptomatic at two months with the same echo-Doppler findings. No late occlusions at two months were noted in the remaining patients.

Post-procedure and 2-month echographic examination showed no false aneurysm or arteriovenous fistula.

Influence of Heparin Administration on Radial Artery Patency (Fig. 1)

Post-procedure asymptomatic radial artery occlusion occurred in 35 of the first 49 patients (71%, group 1). Heparin, 2,000 or 3,000 units (if body weight > 80 kg), was then administered intravenously at the beginning of the procedure in the 119 following patients (group 2); radial occlusion was then noted in 29 (24%). Finally, the dosage of heparin was increased to 5,000 units in the last 210 patients (group 3); only 9 occlusions (4.3%) were noted ($P < 0.05$ between all groups). Predictive factors of radial occlusion in groups 1 and 2 were sex and diameter of the radial artery (Figs. 2, 3). A radial artery diameter of less than 2.7 mm was associated with a higher risk of occlusion (Fig. 4). No predictive factor of radial occlusion was found in patients receiving 5,000 units of heparin.

Influence of the Learning Curve (Fig. 5)

Procedure failure rates, delay of sheath insertion, and procedure duration were strongly influenced by the learning curve, decreasing, respectively, from 14%, 10.2 ± 7.6 min, and 25.7 ± 12.9 min in the first 80 patients (20 patients per operator) to 2%, 2.85 ± 2.53 min, and 17.48 ± 4.71 min in the last 100.

Comparison with the femoral approach (Table IV)

One hundred patients with a coronary angiogram performed by femoral approach by the same operators between July 1994 and 1995 were matched with the last 100 patients of the study according to age and sex. Sheath insertion, procedure, and fluoroscopy times were compared and were longer for the radial approach.

DISCUSSION

Despite the use of 5 or 6 French catheters, femoral approach for coronary angiography still requires several hours of bed rest. Major complications such as thrombosis and pseudoaneurysm are rare but can require surgery [7,8]. Furthermore, the brachial approach is required in patients with severe aortoileofemoral obstruction, with a higher complication rate [8]. The radial approach for coronary angiogram was first proposed by Campeau in 1989 [1], and used for coronary angioplasty and even stent placement by Kiemeneij [3,4]. Lotan et al [5] reported radial coronary angiography in a series of 100 patients followed by immediate angioplasty in 63. In these series, puncture failure rates ranged from 4 to 12%, and difficulties in coronary intubation from 2 to 3%.

Our series is the first prospective study on the safety and feasibility of the left radial approach for coronary angiogram on a large series of patients with an immediate and 2-month echo-Doppler evaluation of radial artery patency. Temporal analysis (Fig. 5) shows that a procedural success of more than 95% can be obtained after an initial learning curve, with a marked reduction in radial cannulation and procedural time. However, puncture, procedural, and fluoroscopic times were longer when compared to a matched group of angiograms performed with the femoral approach (Table IV).

The left radial approach was preferred over the right because of initial concern over the consequences of radial occlusion on the functional status of the right hand. Furthermore, it allowed the use of Judkins catheters. Deep ostial intubation is generally avoided by the use of these catheters which may reduce the risk of ostial dissection during coronary angiogram. Using the right radial approach for PTCA, Kiemeneij used Judkins catheters for the left and right coronary artery, respectively, in only 49% and 40% of patients; multipurpose, Amplatz, and El Gamal catheters were used in the remaining [4].

No major complications such as death, myocardial infarction, or stroke were noted; however, our study population was highly selected and too small to yield definite conclusions, since major complications during diagnostic procedures are rare (0.25–0.65%) and occur more frequently in patients with left main coronary disease, and ejection fraction less than 30% [8].

Local complications included small hematomas in eight (2%) and an antebrachial hematoma in one patient. A high frequency of radial occlusion was seen without heparin, and reduced to 4.3% by use of 5000 units of heparin. This is comparable to the series of Campeau [1]

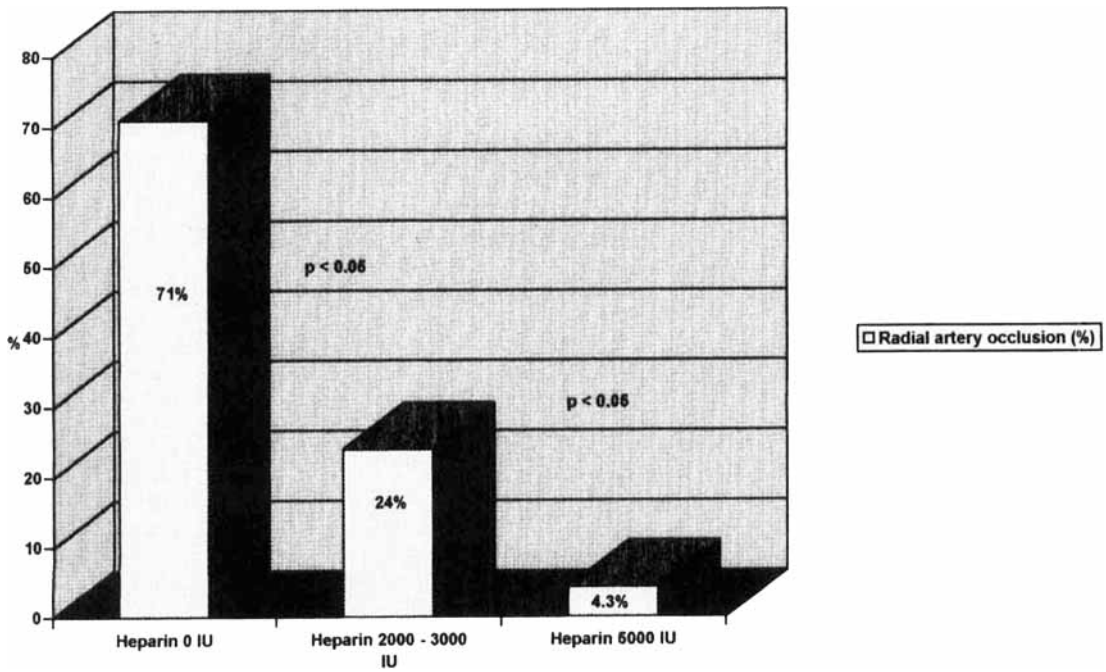

Fig. 1. Influence of heparin administration on radial artery patency.

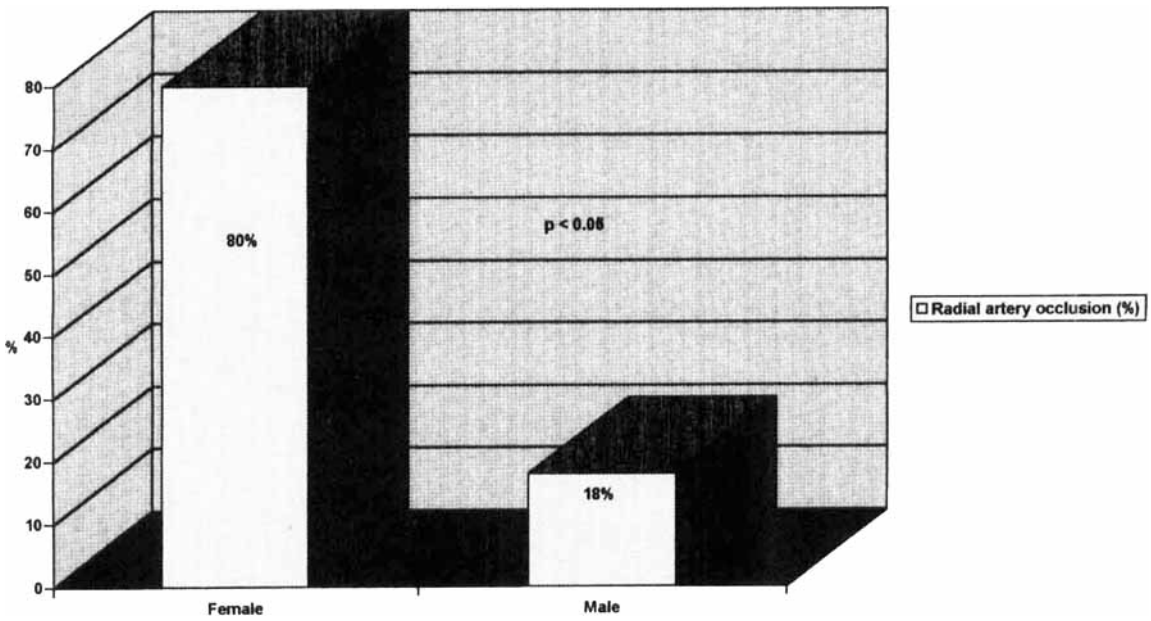

Fig. 2. Predictive factors of radial occlusion: female sex.

and Kiemeineij [4], where at least 5,000 units of heparin were administered and late pulse deficit was noted in, respectively, 6 and 3%.

No symptoms were noted in patients with an occluded artery immediately and at 2 months. All our patients were carefully selected on the basis of a normal Allen test. In all patients with an occluded radial artery, echo-Doppler evaluation revealed an increased flow in the ulnar artery. Radial occlusion in a highly selected population with a positive Allen test therefore seems to be well tolerated. However, long-term consequences have not been evaluated. Furthermore, occlusion of the radial artery after a diagnostic procedure prevents the use of this approach for angioplasty.

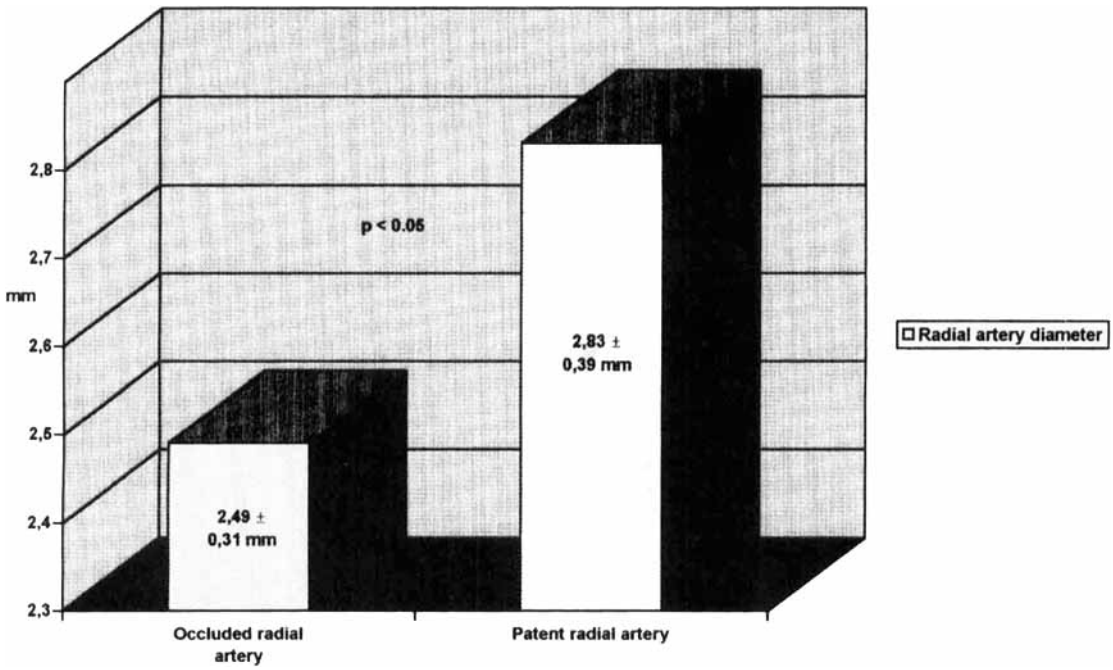

Fig. 3. Predictive factors of radial occlusion: radial artery diameter.

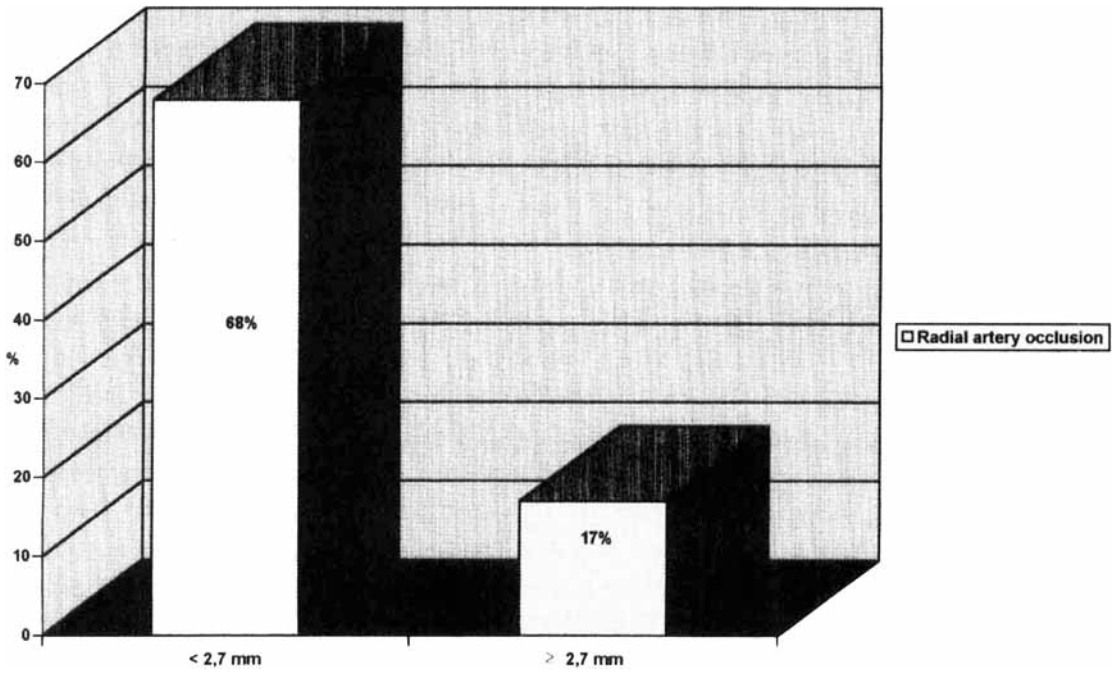

Fig. 4. Prediction of postprocedure occlusion by radial artery diameter.

CLINICAL IMPLICATIONS

Transfemoral approach is not possible in 2–6% of patients [9] because of severe aortoileofemoral obstructive disease or aneurysm of the abdominal aorta, and is unwarranted or hazardous in obese patients or through transarterial prostheses. Of the arm approaches, the radial approach may be the best alternative in order to prevent rare but troublesome complications related to humeral arterial occlusion [8,9]. In our experience, radial occlusion was always asymptomatic in patients with a normal Allen test.

Immediate ambulation was possible in all patients.

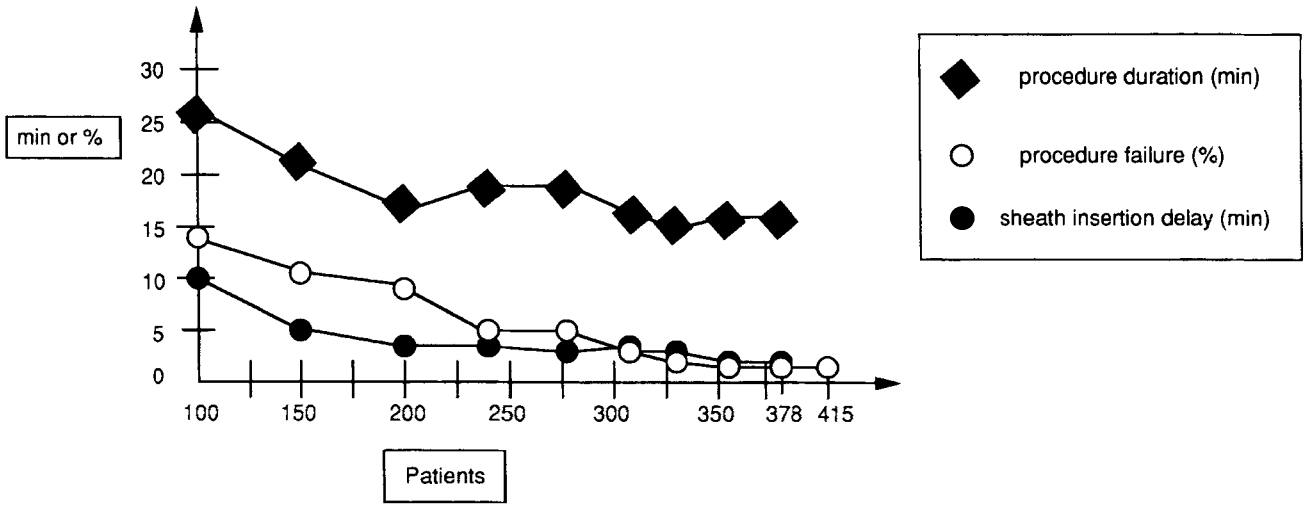

Fig. 5. Learning curve procedure failure rate, sheath insertion delay, and procedure duration.

TABLE IV. Non-Randomized Retrospective Comparison of Femoral Versus Radial Approach (100 last patients)

	Radial	Femoral	*P*
Patients	100	100	
Sheath insertion delay (min.)	2.85 ± 2.53	1.86 ± 1.92	< 0.05
Procedure time (min)	17.48 ± 4.71	14.72 ± 3.81	< 0.05
Fluoroscopy time (min)	8.49 ± 3.57	6.55 ± 4.58	< 0.05

Discharge on the same day after a successful procedure was based on clinical and angiographic factors only, and was possible in 113 patients (30%). No late complications were noted at the puncture site. Radial approach for coronary angiogram could therefore be applied as an outpatient procedure. We are currently starting a prospective randomized trial comparing femoral and radial approaches with 5 French catheters for outpatient coronary angiography. Finally, the radial approach could be used in a combined strategy of angiography and angioplasty with early discharge in selected patients presenting low risk lesions. However, these potential applications must be warranted by larger clinical trials.

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