Original Article

Predictors of Conversion from Radial Into Femoral Access in Cardiac Catheterization

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Abstract

Background: Fewer bleeding complications and early ambulation make radial access a privileged route for cardiac catheterization. However, transradial (TR) approach is not always successful, requiring its conversion into femoral access.

Objectives: To evaluate the rate of conversion from radial into femoral access in cardiac catheterization and to identify its predictors.

Methods: Prospective dual-center registry, including 7632 consecutive patients undergoing catheterization via the radial access between Jan/2009 and Oct/2012. We evaluated the incidence of conversion into femoral access and its predictors by logistic regression analysis.

Results: The patients' mean age was 66 ± 11 years, and 32% were women. A total of 2969 procedures (38.4%) were percutaneous coronary interventions (PCI), and the most used first intention arterial access was the right radial artery (97.6%). Radial access failure rate was 5.8%. Independent predictors of conversion from radial into femoral access were the use of short introducer sheaths (OR 3.047, CI: 2.380-3.902; p < 0.001), PCI (OR 1.729, CI: 1.375-2.173; p < 0.001), female sex (OR 1.569, CI: 1.234-1.996; p < 0.001), multivessel disease (OR 1.457, CI: 1.167-1.819; p = 0.001), body surface area (BSA) ≤ 1.938 (OR 1.448, CI: 1.120-1.871; p = 0.005) and age > 66 years (OR 1.354, CI: 1.088-1.684; p = 0.007).

Conclusion: Transradial approach for cardiac catheterization has a high success rate and the need for its conversion into femoral access in this cohort was low. Female sex, older age, smaller BSA, the use of short introducer sheaths, multivessel disease and PCI were independent predictors of conversion into femoral access. (Arq Bras Cardiol. 2015; 104(5):401-408)

Keywords: Radial Access; Femoral Access; Cardiac Catheterization.

Background

For the last decades, transfemoral approach in cardiac catheterization has been the preferred access for invasive cardiac procedures. However, recent evidence favors transradial approach in several observational and randomized trials. It has been shown that radial artery access decreases vascular complications with fewer access site bleeding complications, early patient ambulation, shorter length of hospital stay and lower hospital costs[1-8]. Recently, the large RIFLE study, on patients with ST elevation myocardial infarction (STEMI), has reported a statistically significant benefit from radial approach on cardiac mortality[9]. Despite its proven clinical benefit, many interventional cardiologists perceive that the decrease in vascular complications is balanced by technical difficulties and a longer learning curve, which might explain why the transradial approach is still underemployed[5,10]. On the other hand, when radial access fails, the most common alternative route is the femoral one[11,12].

In this study, we aimed to evaluate the rate of conversion from radial into femoral access in cardiac catheterization and to identify its clinical, demographic and procedural predictors.

Methods

Study design and patient population

In a prospective registry of 14750 consecutive patients from two centres, who underwent cardiac catheterization for diagnostic or interventional coronary procedures, between January 2009 and October 2012, we selected for the purpose of this analysis all consecutive patients in whom the first intention was to use the radial artery (n = 7664). Of these patients, we excluded those in whom the radial access failed, and the alternative choice was the contralateral radial (n = 26), the humeral (n = 4) and the cubital artery (n = 2) (Figure 1).

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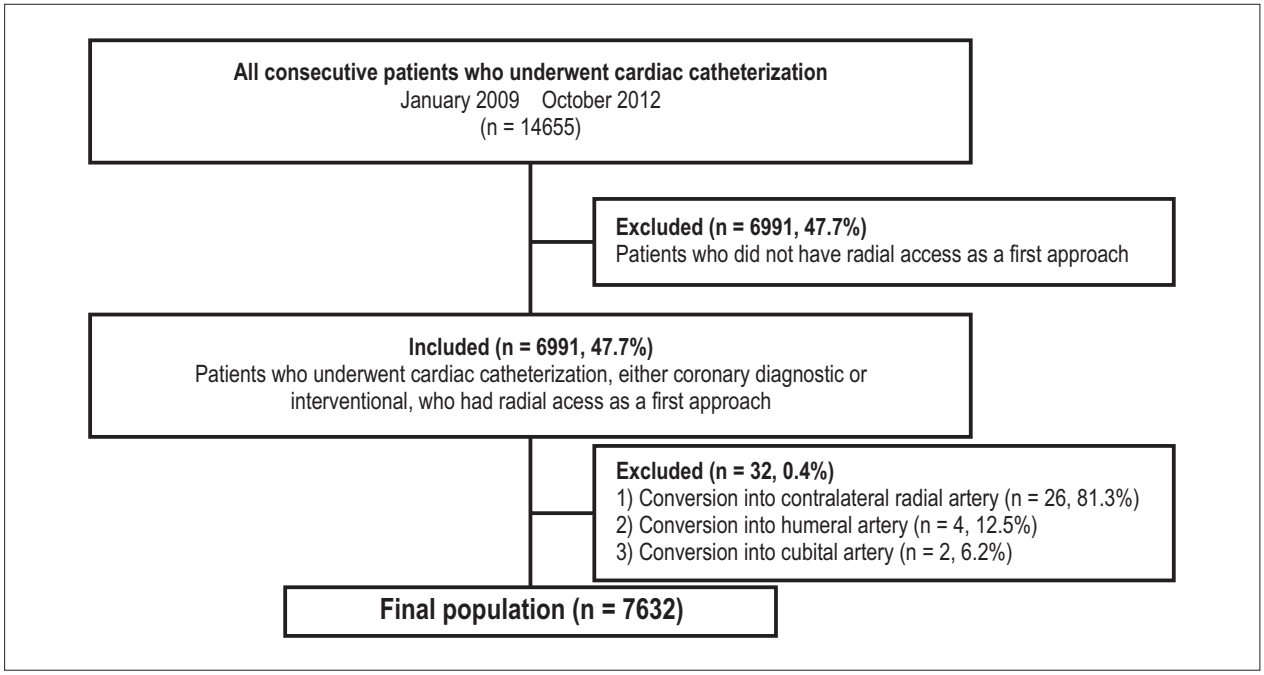

Figure 1 – *Patient selection and study design.*

Baseline characteristics, indication for and type of the procedure performed, procedural devices, details of coronary intervention, need for access site crossover and chosen alternative access were prospectively recorded.

Written informed consent was obtained from all patients as per protocol.

Transradial technique

During the study period, in the two institutions involved in this study, there were nine invasive cardiologists with high experience (> 100 procedures/year) in radial artery catheterization and three fellows in training. The choice of the arterial access was left at each operator's discretion. Either Allen's test or oximetry/plethysmography (Barbeau test) was used, as per protocol, in all patients to access the radial artery patency and adequacy of dual hand blood supply[13,14].

Using a dedicated arm board, with the patient's wrist slightly hyperextended, the right or left radial artery was cannulated with a short 20-gauge needle after administration of 2 to 3 mL of local anaesthetic. A straight 0.025-inch guide wire was then advanced into the radial arterial lumen through the needle, and a specific transradial 5F or 6F hydrophilic introducer sheath (Terumo Medical Corporation, Elkton, MD) was placed into the radial artery. Both long (25-cm) and short introducer (10-cm) sheaths were used at the operator's discretion.

Following sheath insertion, whenever radial spasm was suspected, verapamil (2 mg) and/or isosorbide dinitrate (2 mg) were administered.

An initial intra-arterial bolus of 5000 U of unfractionated heparin was administered to all patients. Monitoring of coagulation with activated clotting time (ACT) was used routinely during percutaneous coronary intervention (PCI) in the centers included in this registry. In case of ad hoc PCI, additional bolus of unfractionated heparin was given to achieve an ACT > 250 seconds. The use of additional glycoprotein IIb/IIIa inhibitors was left to the operator's discretion. The radial sheath was removed immediately in the catheter laboratory following completion of procedure, and hemostasis was achieved by application of an adjustable plastic clamp on the radial artery (TR Band™, Terumo Co., Tokyo, Japan). The clamp was gradually released over 2 to 3 hours, while monitoring for access site bleeding or hematoma, and removed after satisfactory access site hemostasis had been achieved.

As per our routine, all patients undergoing elective or ad hoc PCI were preloaded with clopidogrel before the procedure (75 mg in the case of chronic treatment with clopidogrel > 10 days, or 600 mg, if not).

Definitions and statistical analysis

Procedural success was defined as successful completion of the coronary procedure (diagnostic or interventional) via the initial radial access.

Categorical variables are expressed as absolute values and percentages, and continuous variables, as mean ± SD or median (interquartile range). Continuous variables were tested for normal distribution using the Kolmogorov-Smirnov's test and for equality of variances using the Levene's test.

Baseline and procedural characteristics were compared using Fisher exact test or Chi-square test for categorical variables and Student *t* test for continuous variables. Multivariate analysis

regression was used to determine the independent predictors of conversion from radial into femoral access. The independent variables for entry into the multivariate model were selected according to their significance in univariate testing (included those with $p < 0.1$ in univariate analysis). The final model was built by forward stepwise variable selection with entry and exit criteria at the $p = 0.05$ and $p = 0.1$ levels, respectively. The goodness of fit of the model was evaluated by calculating the Hosmer-Lemeshow statistic.

A significance level of 0.05 with two-sided test was used, and all analyses were done with the *Statistical Pack for Social Sciences* (SPSS) software, version 19.

Results

A total of 7632 patients were included in the study. The baseline clinical and procedural characteristics are described in Table 1. The mean age of the study population was 66 ± 11 years, and 32% were women. About one third were diabetic, 73.3% had hypertension, 62.7% had hypercholesterolemia and 41.9% had smoking habits. The incidence of prior PCI was 22.2%, whereas 1.7% had had prior coronary artery bypass grafting. Of the total, 2969 procedures (38.4%) were PCIs and the right radial access was the first choice in most patients (97.6%).

Conversion from initial radial access into femoral access occurred in 5.8% of all patients. Univariate predictors of conversion from radial into femoral access are described in Table 1. Comparing with the successful transradial access group, the transradial access failure group patients were significantly older (mean age of 69 ± 12 years vs. 65 ± 11 years, $p < 0.001$), more likely to be women (46.7% vs. 30.7%, $p < 0.001$), to have chronic kidney disease (7.0% vs. 4.0%, $p = 0.002$) and a smaller body surface area (mean BSA of 1.82 ± 0.18 vs. 1.87 ± 0.19, $p < 0.001$). Conversion into femoral access was also more frequent when the procedure was a PCI (7.4% vs. 4.8% in diagnostic procedures, $p < 0.001$), in patients with multivessel disease (8.8% vs. 5.2%, $p = 0.001$) and when shorter introducers were used (8.0% vs. 3.6% with long introducers, $p < 0.001$). Smoking was associated with lower radial access failure (4.2% vs. 7.0% in non-smokers, $p < 0.001$), as well as the use of 6F introducers compared to 4F or 5F (5.5 % vs. 7.6%, $p = 0.009$). All patients who had an intra-aortic balloon pump needed the conversion into femoral access (2.7% vs. 0.0%, $p < 0.001$).

After multivariable adjustment (Figure 2), independent predictors of conversion from radial access into femoral access were female sex (OR 1.569, CI: 1.234-1.996, $p < 0.001$), age > 66 years (OR 1.354, CI: 1.088-1.684, $p = 0.007$), BSA ≤ 1.938 (OR 1.448, CI: 1.120-1.871, $p = 0.005$), multivessel disease (OR 1.457, CI: 1.167-1.819, $p = 0.001$), the use of short introducer sheaths (OR 3.047, CI: 2.380-3.902, $p < 0.001$) and PCI (OR 1.729, CI: 1.375-2.173).

Discussion

In this study, we sought to identify possible predictors of conversion from radial into femoral access in cardiac catheterization.

Our main findings were: (1) a very low radial access failure (5.8%) in contemporary practice by intermediate (60-100 procedures/year) and high (> 100 procedures/year) volume transradial operators with standard radial sheaths and catheters; (2) the most common alternative access was the femoral artery; (3) independent predictors of radial access failure were the use of short introducers, PCI, female sex, multivessel disease, lower BSA and older age; and (4) both a smoking history and the use of larger sheaths (≥ 6F) were associated with radial access success.

Several aspects make radial access a privileged route. It is feasible, being superficial and easy to puncture and to compress, causing fewer complications at the vascular access site compared to femoral access. Likewise, it offers superior comfort for the patient in the post-procedural period, with earlier ambulation and higher cost-effectiveness[15]. Recent studies have shown a mortality benefit in STEMI patients[1,9]. Nevertheless, potential procedural difficulties still intimidate some operators and radial access success is highly dependent on the operator's experience and skills.

Failure can be due to inability to gain radial artery access or inability to successfully engage the coronary arteries, owing to radial spasm, anatomic variations or severe tortuosity in the radial, brachial, or subclavian arteries[11,16-18].

Over the years, as expected, the use of radial access had a gradual increase: 25% in 2009 to 76% in 2012 (Figure 3A). Focusing on radial access failure rates, one could anticipate a decrease with greater experience. Nonetheless, failure rate was higher in the last years and this could be explained by the fact that higher operator experience could have been offset by a widespread use of the technique, even in less favorable situations to the transradial approach (Figure 3B).

Procedural failure lessens with experience, and ultimately occurs with a frequency of less than 5%[19-21]. Our higher failure (5.8%) could be partly justified by the fact that we have fellows-in-training. Moreover, in the acute coronary syndrome setting, as in the RIVAL trial[1], a higher radial access failure rate has been reported (about 7%). After a systematic review of 23 randomized studies published up to 2007, comparing radial with femoral access in diagnostic and/or therapeutic coronary procedures, Jolly et al.[3] reported a transradial approach failure rate of 5.9%. Our radial access failure rate (5.8%) was similar, although we must consider that, in that meta-analysis, 85.3% of the procedures were PCIs, whereas in our population, the percentage is substantially lower (38.4%). In line with this remark, a non-randomized study performed in 2009[12], including 2100 patients undergoing PCI in the acute coronary syndrome setting, reported a radial access failure rate of 4.6%.

Comparing with the Brazilian experience, the study by Andrade et al.[21] showed a very low failure rate (2.5%), but with a substantially reduced use of the radial access (< 15%), which implies a highly selected population in which this approach was used and may justify the high success rate.

The choice of the catheterization approach (femoral, radial or brachial) is usually a function of the operator, institution, and patient preference. Despite some advantages related to radial access, femoral approach is still widely used since many

Table 1 – Baseline and procedural characteristics

Variables	Prevalence			
	Overall n = 7632	Conversion n = 445	RA success n = 7187	p
Clinical characteristics				
Age (years)	66 ± 11	69 ± 12	65 ± 11	< 0.001
Female, n (%)	2416 (31.7)	208 (46.7)	2208 (30.7)	< 0.001
Weight (Kg)	76 ± 13	74 ± 13	77 ± 13	< 0.001
Height (cm)	166 ± 9	163 ± 9	166 ± 9	< 0.001
BMI (Kg/m^2)	28 ± 4	28 ± 4	28 ± 4	0.479
BSA (m^2)	1.87 ± 0.19	1.82 ± 0.18	1.87 ± 0.19	< 0.001
CKD (GFR < 60 mL/min/1.73 m^2), n (%)	316 (4.1)	31 (7.0)	285 (4.0)	0.002
Heart failure, n (%)	343 (4.5)	17 (3.8)	328 (4.6)	0.464
COPD, n (%)	328 (4.3)	14 (3.1)	314 (4.4)	0.208
Peripheral arterial disease, n (%)	389 (5.1)	17 (3.8)	372 (5.2)	0.191
Previous valvular surgery, n (%)	1053 (13.8)	75 (16.9)	978 (13.6)	0.052
Previous myocardial infarction, n (%)	1312 (17.2)	88 (19.8)	1224 (17.0)	0.136
Previous cerebrovascular accident, n (%)	442 (5.8)	28 (6.3)	414 (5.7)	0.623
Previous revascularization				
Previous PCI, n (%)	1694 (22.2)	93 (20.9)	1601 (22.2)	0.510
Previous CABG, n (%)	130 (1.7)	10 (2.2)	120 (1.7)	0.374
Cardiac risk factors				
Hypertension, n (%)	5593 (73.3)	340 (76.4)	5253 (73.1)	0.131
Hypercholesterolemia, n (%)	4782 (62.7)	298 (67.0)	4484 (62.4)	0.053
Smoking, n (%)	3201 (41.9)	135 (30.3)	3066 (42.7)	< 0.001
Diabetes mellitus, n (%)	2317 (30.4)	139 (31.2)	2178 (30.3)	0.692
Clinical context / Procedural characteristics				
ACS, n (%)	2850 (37.3)	184 (41.3)	2666 (37.1)	0.077
PCI, n (%)	2970 (38.9)	221 (49.7)	2749 (38.2)	< 0.001
Multivessel disease, n (%)	412 (5.4)	39 (8.8)	373 (5.2)	0.001
Right RA, n (%)	7452 (97.6)	438 (98.4)	7014 (97.6)	0.261
Caliber ≥ 6F, n (%)	6666 (87.4)	374 (84.0)	6292 (88.2)	0.009
Longer sheats, n (%)	3718 (48.7)	132 (29.7)	3586 (49.9)	< 0.001
Intra-aortic balloon pump, n (%)	12 (0.2)	12 (2.7)	0 (0.0)	< 0.001

RA: radial access; BMI: body mass index; BSA: body surface area; CKD: chronic kidney disease; GFR: glomerular filtration rate; CODP: chronic obstructive pulmonary disease; PCI: percutaneous coronary intervention; CABG: coronary artery bypass grafting; ACS: acute coronary syndrome.

operators were initially trained in this access and it has also several advantages, such as allowing the use of larger sheaths (useful for procedures in need of higher catheter support and/or bulkier devices). In addition, the femoral access has been associated with less radiation time and contrast[22-26].

We found that the use of short introducers was linked to radial access failure. This could be explained by a potential selection bias (center preference concerning introducer choice) or by the fact that long sheaths, once inserted, provide protection to almost the entire length of the radial artery from further manipulation. Nevertheless, in a previous study, no association was found between sheath length and radial artery spasm[27]. We also found that the need for PCI and the presence of multivessel disease were associated with radial access failure, which are surrogates for a more challenging procedure, with more catheter manipulation and exchanges, which would probably be more difficult in transradial approach, and this was also found in other studies[28-30].

Figure 2 – *Predictors of conversion from radial access into femoral access.*
PCI: percutaneos coronart interventions; BSA: body surface area; CI: confidence interval.

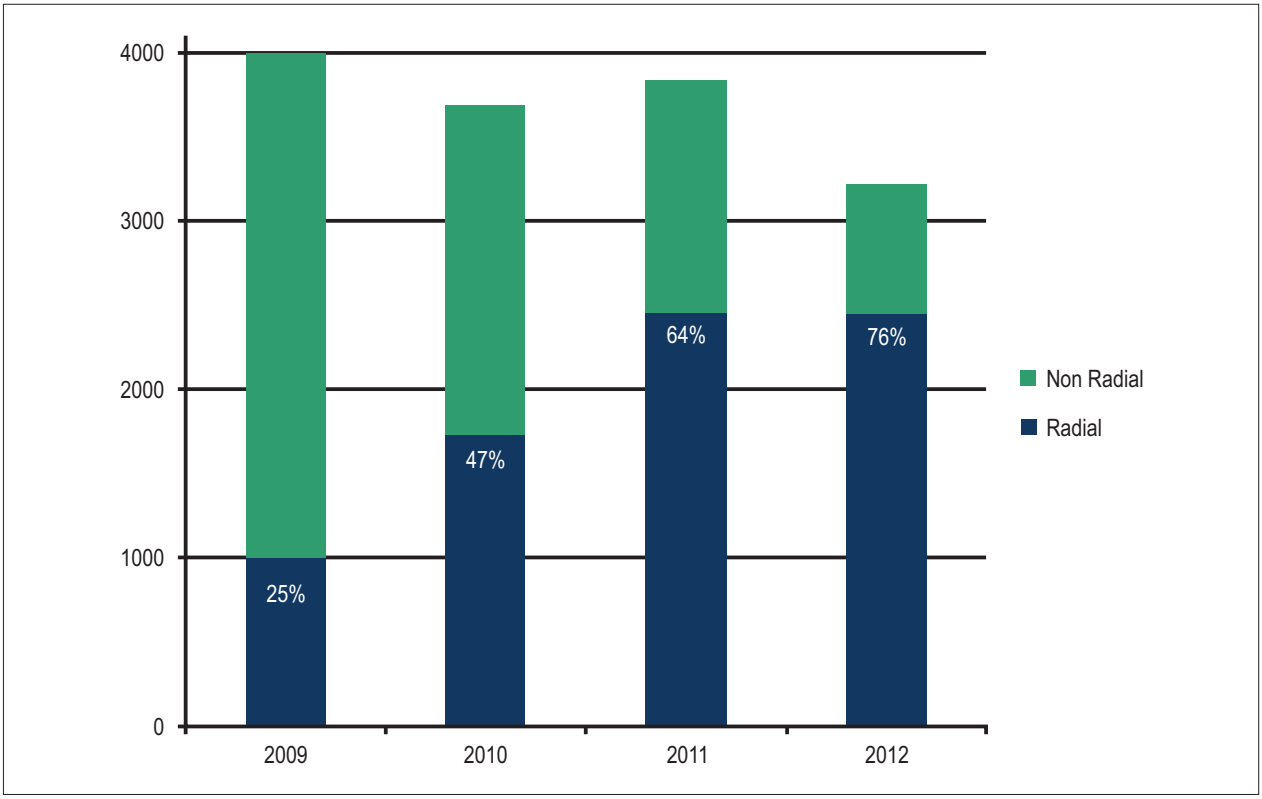

Figure 3A – *Radial access use over the years.*

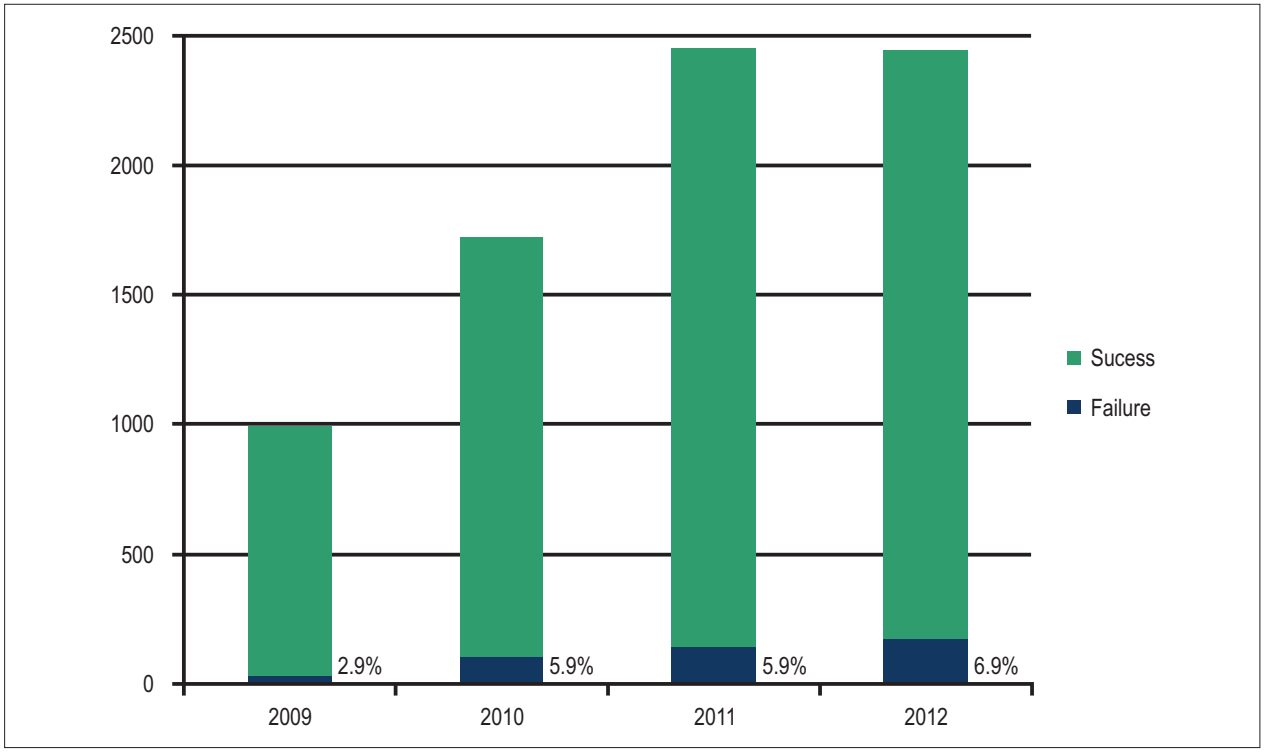

Figure 3B – *Radial access failure over the years.*

Female sex, as well as shorter BSA and older age, were found to be independent predictors of transradial cardiac catheterization failure. This is likely related to smaller size of radial artery, increased subclavian tortuosity, small aortic roots and short ascending aortas, preventing steady guide catheter coronary cannulation during the procedure, as previously described by other authors[1,11,19].

One interesting finding in our results was the association between smoking history and a lower radial access failure. In line with the smoking paradox for coronary artery disease this could also be explained by the younger age of smoking patients submitted to catheterization (in our study, the mean age of the smoking patients was 61 ± 11 vs. 69 ± 11 years, $p < 0.001$) and this has also been found in other studies[31]. Nevertheless, smoking remained an independent predictor of radial access success after multivariate analysis.

Finally, the association between larger sheaths (≥ 6F) and radial access success might be due to selection bias, because the operator would select smaller diameter sheaths for patients in which he would anticipate a more difficult radial access procedure, such as smaller and older patients, in line with International recommendations[27].

Study limitations

The present study is a registry from two high-volume centers, with bias in the selection of patients for radial access. The procedures were performed by different operators, with variable degrees of experience, and it was not possible to evaluate the impact of the operator's experience on failure rate.

Our results reflect radial access learning curve, since, in the first 2 years, less than 50% of the procedures were performed via radial access, and thus, predictors of radial access failure in more experienced centers/operators might be different.

Conclusions

Transradial approach for cardiac catheterization was associated with a high success rate. The predictors of conversion into femoral access were female sex, older age, smaller BSA, multivessel disease, PCI and the use of short introducers.

These findings could contribute to improve patient selection and increase radial access success.

Author contributions

Conception and design of the research: Carvalho MS, Calé R. Acquisition of data: Carvalho MS, Calé R, Gonçalves PA, Vinhas H, Raposo L, Teles R, Martins C, Gabriel HM, Pereira H, Almeida M. Analysis and interpretation of the data: Carvalho MS, Calé R, Almeida M. Statistical analysis: Carvalho MS, Calé R. Writing of the manuscript: Carvalho MS, Calé R. Critical revision of the manuscript for intellectual content: Gonçalves PA, Almeida M.

Potential Conflict of Interest

No potential conflict of interest relevant to this article was reported.

Study Association

This study is not associated with any thesis or dissertation work.

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