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Original Article

Comparison of transradial and transfemoral artery approach for percutaneous coronary angiography and angioplasty: A retrospective seven-year experience from a north Indian center

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ABSTRACT

Background: With the increasing prevalence of coronary artery disease, percutaneous coronary artery procedures have become even more important. Our study has compared transradial to transfemoral artery approach for coronary procedures in Indian population.
Aims and objective: Comparison of transradial and transfemoral artery approach for percutaneous coronary procedures.
Material & methods: 26,238 patients, who underwent percutaneous coronary artery procedures, were divided into two groups depending upon transradial and transfemoral artery approach and compared for the various demographic and clinical characteristics, risk factors profile, vascular access and procedural details.
Results: 26,238 patients underwent percutaneous coronary procedures at our center. 81% were male and 19% were female. 55.65% and 44.35% procedures were done through transfemoral and transradial approach, respectively. 17,417 (66.38%) coronary angiographies were done, out of which 53.92% were transradial and 46.08% were transfemoral procedures. 8821 (33.62%) Percutaneous Transluminal Coronary Angioplasty (PTCA) were done, out of which 25.46% and 74.54% were done through transradial and transfemoral approach, respectively. Mean fluoroscopy time was 4.40 ± 3.55 min for transradial and 3.30 ± 3.66 min for transfemoral CAG ($p < 0.001$). For PTCA mean fluoroscopy time was 13.53 ± 2.53 min for transradial and 12.61 ± 9.524 min for transfemoral PTCA ($p < 0.001$). Minor and major procedure related complications and total duration of hospital stay were lower in transradial as compared to transfemoral group.

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Conclusion: The number of percutaneous transradial procedures have increased significantly with reduced complication rates and comparable success rate to transfemoral approach, along with the additional benefits to patient in terms of patient comfort, preference and reduced cost of health delivery.

1. Introduction

Coronary catheterization is usually performed via the transfemoral approach. Transradial access offers advantages in comparison with transfemoral access, especially under conditions of aggressive anticoagulation and antiplatelet treatment in which bleeding complications at the femoral puncture site can result in increased morbidity and duration of hospitalization.[1] Therefore, the rationale for the transradial approach is the intention to reduce access site bleeding complications, earlier ambulation, and improved patient comfort.[2–4] Transradial procedures have been demonstrated to be an effective and safe alternative to transfemoral procedures. Safety of transradial coronary catheterization is mainly determined by the favorable anatomic relations of the radial artery to its surrounding structures, like no major veins or nerves located near the artery, hence minimizing the chance of injury of these structures. Superficial course of the radial artery gives the advantage of easy hemostasis by local compression. Thrombotic or traumatic arterial occlusion does not endanger the viability of the hand if adequate collateral blood supply from the ulnar artery is present. Multiple studies have demonstrated that bleeding complications after PTCA can be substantially reduced with transradial access. Furthermore, transradial primary success rates, even in high-risk groups, are similar to those from the femoral approach.[5,6]

2. Methods

Data of 26,238 patients were collected who underwent coronary angiography and angioplasty during the study period from April 2004 to December 2011 at our center. The center has multiple operators and most of the coronary procedures are done through radial approach. Data was thoroughly analyzed comparing various study variables between transradial and transfemoral groups. Successful vascular access, coronary cannulation, entry site complications, asymptomatic loss of radial pulsations, procedural and fluoroscopy times, PTCA success, and length of hospital stay were compared.

An access site related endpoint was defined as either the necessity to puncture a second access site due to any procedural failure or a major access site complication. American College of Cardiology database definitions for vascular complications were used to define the complications as minor or major.[7] Minor vascular complications were defined as any of the following: hematoma <10 cm, arteriovenous fistulae, or pseudoaneurysm. Major vascular complications were defined as death caused by vascular complications, vascular repair, major vascular bleeding (>3 g hemoglobin decrease because of access site or retroperitoneal bleeding or requiring administration of blood transfusions or vascular repair, alone or in combination), vessel occlusion, or loss of pulse.[7,8] After a failed attempt to cannulate the coronary artery, the operator was free to select any other entry site. This site could be the same artery at the contralateral side or any other artery.

Procedure-related endpoints were defined as successful completion of the procedure from the first accessed puncture site, occurrence of any major cardiac event like death, myocardial infarction, coronary artery bypass graft surgery or repeat PTCA.

2.1. *Patient selection*

In order to assess the safety, feasibility, and efficacy of transradial catheterization, we retrospectively analyzed the patient database of our cardiac catheterization laboratory of seven years from a period of April 2004 to December 2011, in a tertiary care hospital. All patients who had underwent coronary catheterization procedures both diagnostic and therapeutic were included in the study.

2.2. *Vascular access*

Selection of the access site was individualized according to the preference of the operator and appropriateness of radial or femoral artery pulsations. Crossover from one arterial site to another was permitted at any time at the physician's discretion. Radial and femoral artery access were secured using the standard protocol and acceptable practice. Radial sheaths for diagnostic and interventional procedures had a diameter of 5- and 6-F, respectively, whereas 7-F radial sheaths were used in few patients with bifurcation lesions. Similarly for transfemoral access, 6-F sheaths were used for diagnostic procedures and 7-F sheaths were used for interventional procedures. Anticoagulation after sheath insertion was obtained using the standard practice guidelines. Unfractionated heparin with a target activated clotting time of 200–250 s if used in conjunction with glycoprotein (GP) IIb/IIIa inhibitors, or 250 to 300 s otherwise. Patients in the study received GP IIb/IIIa receptor inhibition also according to usual protocol with abciximab or tirofiban. Post-PTCA, patients were treated with aspirin and clopidogrel in a routine manner. Access site evaluation was routinely done after the procedure and before discharge.

2.3. *Hemostatsis*

Arterial sheaths were removed immediately after diagnostic or interventional transradial procedures while still being anticoagulated. Hemostasis after diagnostic transradial coronary angiography was obtained using a pressure bandage with 2 elastic sticky straps immediately applied to the puncture site without a period of manual compression. In patients who underwent transradial angioplasty, hemostasis was achieved by immediate removal of vascular sheath and application of TR band, which was gradually loosened and removed after ACT < 180 s was achieved. The average time duration of TR band application varied widely but was less than 4-6 h in most patients.

In case of transfemoral diagnostic catheterization, the sheaths were removed in the catheterization laboratory, and hemostasis was obtained by manual compression. A bandage was applied, and the patients were restricted to bed rest for 6 h. After an interventional procedure via the transfemoral approach, hemostasis was achieved by sheath removal after activated clotting time (ACT) declined to <180 s followed by manual compression followed by a bandage for an additional period of 6 h.

3. Study variables

Data was analyzed for the demographic profile of the patient population including age, gender, height, weight, body mass index (BMI) and cardiovascular risks like hypertension, diabetes, dyslipidemia, smoking, family history of premature CAD. The access site complications which included access failure, minor hematomas, major hematoma, loss of distal or radial pulse, cross over to another access site and procedural details which included procedural success rate, fluoroscopy time and duration of hospital stay were studied. Additionally, vascular access site complications during hospitalization, like pseudoaneurysm, arteriovenous fistula, retroperitoneal hematoma, limb ischemia, surgical vascular repair were recorded. PTCA-related endpoints were defined as a residual stenosis > 50% or the occurrence of any *major cardiac event*: death, myocardial infarction, coronary artery bypass graft surgery or repeat PTCA during the same hospital admission.

4. Statistical analysis

Data were entered into a computerized database in Microsoft office excel sheets and was analyzed using SPSS 16.0 for Windows (SPSS Inc., Chicago, Illinois). Absolute numbers and percentages were computed to describe the patient population. Continuous variables are expressed as mean ± SD and are compared using the student's *t* test between the study groups. Categorical variables are expressed as absolute numbers or as percentages and were compared between the two groups using chi-square test. Value of $p < 0.05$ was considered to be statistically significant.

5. Results

5.1. Analysis of entire study population

From April 2004 to December 2011, a total of 26,238 patients underwent percutaneous coronary artery procedures including angiography and angioplasty through transradial and transfemoral approach. 14601 (55.65%) patients underwent procedures through transfemoral approach and 11637 (44.35%) patients had procedures done through transradial route. All of these patients had either palpable femoral and/or radial pulses. Baseline and demographic features of the patients are depicted in Table 1. There were no statistical differences between the transfemoral and transradial groups in terms of mean age, male:female ratio, body mass index, cardiovascular risk factors (smoking, hypertension, diabetes, hypercholesterolemia, family history of CAD), or in clinical presentation. However, we found that the post CABG (coronary artery bypass surgery) patients had significantly higher rate of transfemoral procedures as compared to transradial ($p < 0.001$). The mean fluoroscopy time for all the transradial procedures was significantly more than that for transfemoral procedures ($p < 0.001$). A total of 67 (0.25%) patients needed to

Table 1 – Baseline characteristics of patients.

	Total 26238 (100%)	Transfemoral 14601 (55.65%)	Transradial 11637 (44.35%)	*p* Value
Age	56.80 ± 9.86	56.99 ± 10.01	56.55 ± 9.66	NS
Male:Female	81%:19%	81%:19%	81%:19%	NS
BMI (kg/m^2)	24.10 ± 3.36	24.03 ± 3.35	24.11 ± 3.36	NS
CV risk factors:				
Smoking	5674 (21.63)	3149 (21.57%)	2525 (21.7%)	NS
Dyslipidemia	8191 (31.22)	4402 (30.15%)	3789 (32.56%)	NS
Diabetes	8664 (33.02)	4831 (33.09%)	3833 (33.94%)	NS
Hypertension	12144 (46.28)	6686 (45.79%)	5458 (46.90%)	NS
Family history	1183 (4.51)	662 (4.53%)	521 (4.47%)	NS
Diagnosis:				
Chronic stable angina	5911 (22.53%)	3349 (22.94%)	2562 (22.02%)	NS
Unstable angina	7470 (28.47%)	4105 (28.11%)	3365 (28.91%)	NS
Acute/recent MI	9535 (36.74%)	5571 (38.16%)	3964 (34.06%)	NS
Post CABG	824 (3.14%)	811 (5.55%)	13 (0.11%)	<0.001
Mean fluoroscopy time (min)	7.12 ± 7.40	6.24 ± 6.13	7.83 ± 8.21	<0.001
Crossover to contralateral access site	67 (0.25%)	19 (0.13%)	48 (0.41%)	<0.001
Crossover to another access site	125 (0.48%)	5 (0.03%)	122 (1.05%)	<0.001

be transferred to contralateral access site because of failure to secure the primary site of arterial access. Out of these 19 (0.13%) of all the patients in transfemoral group required to be shifted to left femoral from right femoral artery access site and 48 (0.41%) patients in transradial group were transferred to contralateral access site. The difference was statistically significant ($p < 0.001$). 125 (0.48%) of all the patients, were transferred to another access site which were 5 (0.03%) in from transfemoral to transradial site and 122 (1.05%) from transradial to transfemoral approach. The difference was statistically significant ($p < 0.001$).

5.2. *Analysis of diagnostic procedures*

Total of 17,417 (66.4%) coronary angiographies (CAG) were done, out of which 9391 (53.92%) were done through transradial route and 8026 (46.08%) were done through transfemoral approach.

The demographic and baseline characteristics of the patients who underwent diagnostic coronary procedure are summarized in Table 2. There was no significant difference in terms of mean age, gender distribution, BMI, cardiovascular risk profile of the patients between the two diagnostic group. The mean total fluoroscopy time (FT) for all the CAG was 4.36 ± 3.96 min. Transradial CAG had longer FT (4.40 ± 3.55 min) than transfemoral CAG (3.89 ± 3.65 min) and the difference was statistically significant ($p < 0.001$). But once the access had been taken the procedural success for CAG was comparable between the two groups with CAG success rate of 99.9% in transfemoral group and 99.6% in transradial group ($p = 0.04$). The primary access site intended could not be secured in 0.12% and 1.16% of the patients in transfemoral and transradial procedures, respectively and the difference was statistically significant ($p < 0.001$). Transradial CAG group required more number of patients to be shifted to contralateral as compared to transfemoral group, [22 (0.23%) vs. 11 (0.13%), $p = 0.164$] and also to another access site [87 (0.93%) vs. 2 (0.02%), $p < 0.001$] because of inability to access the primary intended site because of different reasons. The difference between them found to be significant.

1.1% of the patients undergoing transfemoral CAG had minor hematoma at entry site, while 0.75% of the patients in diagnostic transradial group had entry site complications except for repeated attempts for the arterial access. These minor hematomas were managed conservatively. Radial artery spasm was found in 187 (2%) patients undergoing transradial CAG, which was managed conservatively in most of the patients with repeat dose of intraarterial and intravenous cocktail (mixture of lignocaine, diltiazem and nitroglycerine). The rate of spasm was more in patients who were of female gender, short stature, required prolonged procedural time due to technical difficulty and multiple catheter exchanges. In a few patients, access site was needed to be changed to either contralateral or another site. Four patients in transfemoral group developed pseudoaneurysm at puncture site, which were managed conservatively with ultrasound-guided compression without the need of surgery. Four patients, one in transfemoral group and three in transradial

Table 2 – Procedural data for diagnostic procedures.

	Transfemoral 8026 (46.08%)	Transradial 9391 (53.92%)	*p* Value
Demographic profile:			
Age	56.82 ± 7.1	56.94 ± 9.51	NS
Male:Female	80:20%	79.5: 20.5%	NS
BMI	24.11 ± 3.37	24.09 ± 3.35	NS
CV risk factors:			
Smoking	1679 (20.96%)	2051 (21.84%)	NS
Dyslipidemia	2363 (29.51%)	3022 (32.17%)	NS
Diabetes	2675 (33.40%)	3068 (32.66%)	NS
Hypertension	3702 (46.23%)	4383 (46.68%)	NS
Family history	381 (4.75%)	419 (4.46%)	NS
Mean fluoroscopy time for CAG (min)	3.89 ± 3.65	4.40 ± 3.55	<0.001
Crossover to contralateral access site	11 (0.1%)	22 (0.23%)	NS
Crossover to another access site	2 (0.02%)	87 (0.93%)	<0.001
Complications:			
Radial artery spasm	0	187 (2%)	<0.001
Minor hematomas	92 (1.1%)	71 (0.75%)	<0.001
Major hematoma	0	0	
Loss of distal/radial pulse	1 (0.01%)	93 (0.01%)	<0.001
Radial artery spasm	–	141 (1.5%)	<0.001
Pseudoaneurysm	4 (0.04%)	0	NS
Arteriovenous fistula	0	0	–
Retroperitoneal hematoma	0	0	–
Limb ischemia	0	0	–
Surgical vascular repair	0	0	–
Major bleeding	0	0	–
CVA/TIA	1	3	–
Hospital Stay (days)	1.9 ± 0.8	1.1 ± 0.6	NS
Mortality	0	0	–

group developed transient neurological deficit post procedure, which recovered over period of next 1–2 days without any residual deficit. The mean duration of hospital stay was shorter in transradial group (1.1 ± 0.6 days) as compared to transfemoral (1.9 ± 0.8 days).

5.3. *Analysis of interventional procedures*

Total of 8821 (33.62%) PTCA were done, out of which 2246 (25.46%) were done through transradial route and 6575 (74.54%) were done through transfemoral approach. The baseline characteristic, demographic profile and procedural details are depicted in Table 3. The baseline characteristics of the patient including age, gender distribution, BMI and cardiovascular risk profile were not significantly different amongst transfemoral and transradial groups. Transradial PTCA had longer fluoroscopy time (13.53 ± 2.53 min) as compared to transfemoral PTCA (12.61 ± 9.5 min) and the difference was statistically significant ($p < 0.001$). 8 (0.12%) patients in transfemoral group and 26 (1.17%) in transradial group required changing of the access site to contralateral site due inability to complete the procedure at various stages ($p < 0.001$). Whereas 3 (0.04%) and 35 (1.57%) patients required shifting to another access site in transfemoral and transradial group, respectively ($p < 0.001$). PTCA success rate was comparable between the two groups (99.6% vs. 98.1%). Rate of radial artery spasm was more in intervention group as compared to CAG group (2% vs. 7.5%). Out of these 167 patients, most of the spasms were non procedure limiting and managed conservatively, while few patients required shifting of access to another site. The rate of minor hematomas were 0.8% in transfemoral group as compared to 0.5% in transradial group. 0.2% of the patients in the transfemoral group had major entry site hematoma with significant drop in hemoglobin and were managed conservatively with extended compression and blood transfusions. 11 (0.16%) of the patients in transfemoral group had post procedure distal pulse loss. Two patients in transfemoral group had limb ischemia, one of which required surgical vascular repair including embolectomy and another needed limb amputation. The loss of radial artery pulse after the procedure was 5.34% after PTCA using 6-F sheaths. None of these patients had ischemic complication of upper extremity. One patient required vascular repair of the radial artery for avulsion. One patient had retroperitoneal hematoma after transfemoral PTCA, which was managed conservatively. Major bleeding including entry site and other sites (gastrointestinal, intracranial, urinary) was found in 16 (0.24%) of the patients undergoing PTCA through transfemoral approach. Three patients in transfemoral PTCA group and 2

Table 4 – Results of diagnostic procedures.

	Number	% of total PTCA ($n = 8821$)
Normal coronary arteries	1637	9.4%
Slow flow	540	3.1%
Obstructive CAD	15240	87.5%

Table 3 – Procedural data for Interventional procedures.

	Transfemoral 6575 (74.54%)	Transradial 2246 (25.46%)	*p* Value
Age	56.81 ± 9.71	56.97 ± 9.70	NS
Male:Female	84:16%	86:14%	NS
BMI	24.02 ± 3.35	24.06 ± 3.34	NS
Smoking	1464	480	NS
Dyslipidemia	2033	774	NS
Diabetes	2145	771	NS
Hypertension	2977	1084	NS
Family history	281	102	NS
Mean fluoroscopy time (minutes)	12.61 ± 9.52	13.53 ± 8.53	<0.001
Crossover to contralateral access site	8 (0.12%)	26 (1.16%)	<0.001
Crossover to another access site	3 (0.04%)	35 (1.56%)	<0.001
Complications:			
Access failure	7 (0.11%)	38 (1.7%)	<0.001
Access site success	99.9%	98.3%	NS
PTCA success	99.6%	98.1%	NS
Minor hematomas	52 (0.8%)	28 (1.2%)	0.150
Major hematoma	13 (0.2%)	4 (0.18%)	0.49
Loss of distal/radial pulse	11 (0.16%)	120 (5.34%)	<0.001
Radial artery spasm	0	167 (7.5%)	<0.001
Pseudoaneurysm	9 (0.14%)	0	NS
Arteriovenous fistula	0	0	–
Retroperitoneal hematoma	1 (0.015%)	0	NS
Limb ischemia	1 (0.015%)	0	NS
Surgical vascular repair	10 (0.15%)	2 (0.09%)	NS
Major bleedings	16 (0.24%)	2 (0.09%)	NS
CVA/TIA	3 (0.05%)	2 (0.09%)	NS
Hospital Stay (days)	2.2 ± 3.1	1.6 ± 2.4	NS
Mortality	3	5	NS

Table 5 – Vessel wise distribution of interventional procedures.

Vessel	Number	% of total PTCA ($n = 8821$)
Single vessel	6989	79.22%
Double vessel	1705	19.32%
Triple vessel	128	1.45%
Left main	31	0.35%
D1	147	1.66%
LAD	5108	57.90%
RAMUS	167	1.89%
LCX	1839	20.84%
OM	536	6.07%
RCA	2895	32.81%
PDA	34	0.38%
PLV	10	0.11%
SVG	6	0.06%
LAD graft	4	0.04%
OM graft	2	0.02%
RCA graft	11	0.12%

patients in transradial group had transient neurological deficit post procedure, which improved over the course of the hospital stay. The mean hospital stay of the patients undergoing PTCA through femoral approach was 2.2 ± 3.1 days as compared to 1.6 ± 2.4 days in patients of transradial group. Majority of the stenting done were conventional, preceded by balloon dilation of the lesion. Conventional stenting in transfemoral group and transradial group was done in 99.7% and 99.8% patients, respectively, whereas direct stenting was done in 0.3% and 0.2% patients, respectively.

The angiographic data of the result of CAG shown in Table 4 and vessel wise distribution of the interventional procedures is shown in Table 5. Of all the interventional procedures ($n = 8821$), 79% were single vessel PTCA of which LAD was the most common vessel (58%). Approach wise distribution of the vessels is depicted in Table 5, which shows that there were no significant difference between the interventional approach for single vessel, double vessel, triple vessel PTCA (79%,19%, 1.3% vs. 80%, 19%, 1.9%) between transfemoral and transradial group. However, we found that except one, all the PTCA of CABG grafts including LIMA (left internal mammary artery) and SVG's (saphenous venous grafts) were done through transfemoral approach (Table 6).

We also appreciated the significant increase in trend towards the transradial approach for both diagnostic and interventional procedures over the study period of seven years which has been depicted in Table 7, Figs. 1 and 2.

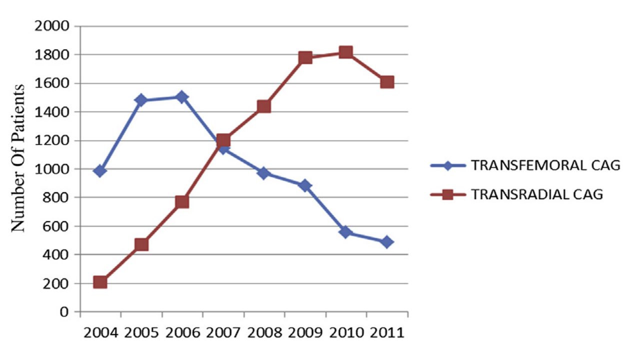

Fig. 1 – Year wise trend of total number of cases of diagnostic procedures through transfemoral and transradial route.

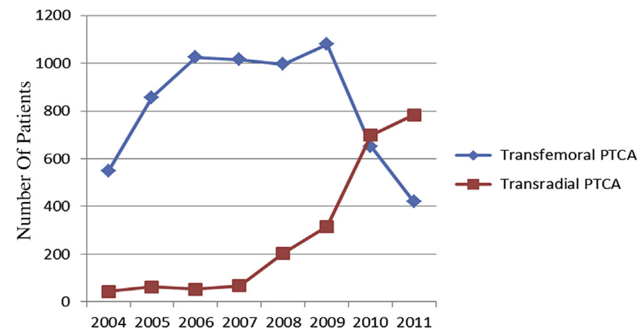

Fig. 2 – Year wise trend of total number of cases of interventional procedures through transfemoral and transradial route.

The FT, which is the key determinant of the radiation exposure and may be a marker of the operators expertise, decreased significantly in transradial diagnostic group over a period of seven years. But in transfemoral diagnostic, transfemoral interventional and transradial interventional groups, it did not show any significant difference. This may be explained by increasing complexity of the procedures, which are being done with increasing expertise. The trends of FT of over the seven years is depicted in Table 8, Figs. 3 and 4.

Successful PTCA was achieved in 99.6% and 98.1% of patients who underwent PTCA through transfemoral and transradial, respectively. The reasons for failed PTCA in radial group and femoral group were inability to cross stenosis, suboptimal results, side branch occlusion, partial success in multivessel disease and coronary spasm. No significant differences were noted between the reasons for PTCA failure among the two groups. The total study mortality were five in the radial group and three in the femoral group and were due to severe left ventricular dysfunction and hemodynamic instability.

Radial artery occlusion was not found in patients undergoing CAG with 5 F sheath but was found in 120 patients (5.4%)

Table 6 – Approach wise distribution of vessels.

	Transfemoral	Transradial
Single vessel	5218 (79.13%)	1769 (79.54%)
Double vessel	1291 (19.57%)	412 (18.52%)
Triple vessel	85 (1.28%)	43 (1.93%)
Left main	25 (0.38%)	7 (0.31%)
LAD	3794 (57.53%)	1295 (58.22%)
Diagonal	111 (1.68%)	36 (1.61%)
Ramus	124 (1.88%)	43 (1.93%)
LCx	1393 (21.12%)	449 (20.18%)
OM	377 (5.71%)	159 (7.14%)
RCA	2173 (32.95%)	718 (32.38%)
PDA	22 (0.33%)	12 (0.53%)
PLV	8 (0.12%)	2 (0.08%)
LAD graft	3	1
OM graft	6	–
RCA graft	14	–

Table 7 – Increasing use of transradial approach over years.

	Transfemoral CAG	Transradial CAG	Transfemoral PCI	Transradial PCI
2004	985	208	548	44
2005	1480	470	857	62
2006	1502	771	1025	53
2007	1142	1202	1016	67
2008	968	1439	996	203
2009	884	1777	1080	315
2010	556	1814	652	698
2011	490	1610	420	783

at hospital discharge in patients who underwent PTCA through 6-F sheath.

The hospital stay was significantly shorter with the transradial procedures as compared to transfemoral procedures. Patient who underwent CAG through transfemoral approach had mean hospital stay of 1.9 ± 0.8 days as compared to those who had transradial CAG and had hospital stay of 1.1 ± 0.6 days. In the PTCA arm, the mean hospital stay for transfemoral approach was 2.2 ± 3.1 while in transradial group it was 1.6 ± 2.4 days. In our study, it was observed that the patients who underwent transradial procedures had early mobilization and lesser total cost of the procedure due to shorter hospital stay.

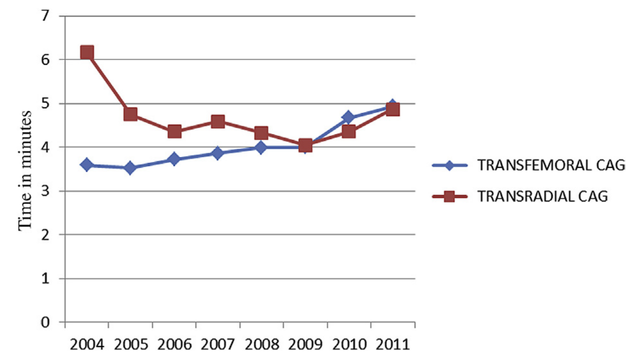

Fig. 3 – Trends of FT of transradial and transfemoral diagnostic procedures over seven years.

6. Discussion

Coronary interventions have become an essential part in the management of patients with CAD. Percutaneous coronary procedures are usually performed via the transfemoral approach. Transradial access for coronary artery catheterization has several advantages in comparison with the transfemoral route. Bleeding complications at the femoral puncture site can result in increased morbidity and duration of hospitalization.[1] Transradial approach reduces access site bleeding complications, allows earlier ambulation, and improves patient comfort.[2–4] The near elimination of bleeding complications makes the radial artery a safe entry site for coronary procedures in patients with normal Allen test results. Outpatient treatment is a powerful tool for coping with an increasing patient load in an unchanging hospital environment and for reducing long waiting lists for coronary angioplasty. The feasibility of transradial coronary stenting on an outpatient basis has been demonstrated in 100 patients.[9] The safety and efficacy of transradial CAG and angioplasty in the same setting have been demonstrated by Barbeau et al in a group of 250 consecutive patients with normal Allen test results, of whom 129 (51.6%) had subsequent balloon angioplasty and 27 (10.8%) coronary stent implantation.[10] Barbeau et al concluded that this approach could be ideal in outpatient for adhoc invasive coronary interventions. This patient-friendly strategy additionally decreases the costs of health delivery. Thus, despite the higher incidence of transradial coronary cannulation failure than with the 6F transfemoral approach, the transradial approach is a good routine technique for coronary procedures because of high procedural success rates and PTCA outcomes similar to those for 6F transfemoral PTCA, together with nearly complete elimination of major bleeding complications. Major additional arguments are increased patient comfort and preference, reduced postprocedural workload associated with the achievement of hemostasis and the potential for outpatient treatment. Factors probably contributing to the low incidence of vascular complications are small-sized sheaths, use of 5000 IU of heparin during uncomplicated procedures and immediate sheath removal.

In our study, we observed that the successful access site was secured in 99.98% of the patients in transfemoral diagnostic group and 99.07% of the patients in transradial diagnostic group, whereas the similar rates in interventional group were 99.06% and 98.44%, respectively. In a study done by Martin Brueck et al including 1024 patients undergoing coronary catheterization, successful catheterization was

Table 8 – Trend of fluoroscopy time (min).

	Total CART	TF CART	TR CART	Total PTCA	TF PTCA	TR PTCA
2004	4.23 ± 3.48	3.59 ± 3.03	6.17 ± 3.98	12.22 ± 8.11	12.10 ± 7.68	15.08 ± 11.59
2005	3.82 ± 3.23	3.52 ± 2.93	4.75 ± 3.90	12.22 ± 8.63	12.24 ± 8.57	11.90 ± 9.53
2006	3.93 ± 3.05	3.72 ± 3.06	4.35 ± 2.99	11.56 ± 8.24	11.62 ± 8.35	10.25 ± 5.59
2007	4.23 ± 3.63	3.86 ± 3.66	4.59 ± 3.56	11.99 ± 7.90	12.05 ± 7.97	10.97 ± 6.68
2008	4.19 ± 2.70	3.99 ± 2.85	4.33 ± 3.36	12.02 ± 8.75	11.98 ± 9.17	12.20 ± 6.32
2009	4.03 ± 3.69	4.00 ± 3.90	4.05 ± 3.48	13.33 ± 10.42	13.31 ± 10.46	13.37 ± 8.34
2010	4.43 ± 3.85	4.67 ± 4.83	4.35 ± 3.57	14.01 ± 12.45	14.67 ± 11.77	13.40 ± 9.60
2011	4.89 ± 4.76	4.93 ± 5.95	4.87 ± 4.34	14.64 ± 9.24	14.56 ± 10.36	14.69 ± 8.57

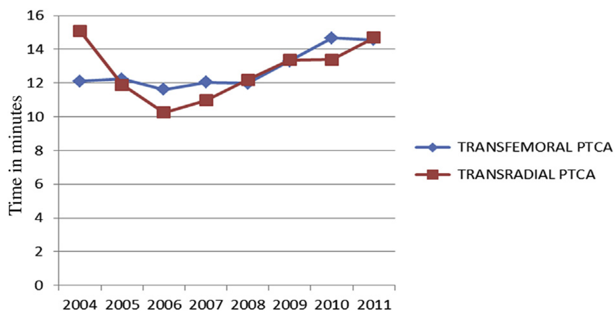

Fig. 4 – Trends of fluoroscopy time of transradial and transfemoral interventional procedures over seven years.

achieved in 96.5% of 512 patients in the transradial group and in 99.8% of 512 patient in the transfemoral group.[11] Transfemoral approach had higher access site success rate as compared to transradial approach, the difference being statistically insignificant ($p = 1.000$, ns).

We found that in the diagnostic group, the primary access site intended could not be secured in 0.12% and 1.16% of the patients in transfemoral and transradial procedures, respectively and transradial CAG group required more number of patients to be shifted to contralateral as compared to transfemoral group, [(0.23% vs. 0.13%), $p = 0.164$] and also to another access site [(0.93%) vs. (0.02%), $p < 0.001$] because of inability to access the primary intended site because of different reasons. The difference between them was found to be significant. In the intervention group, 0.12% patients in transfemoral group and 1.17% in transradial group required changing of the access site to contralateral site due inability to complete the procedure at various stages ($p < 0.001$). Whereas 3 (0.04%) and 35 (1.57%) patients required shifting to another access site in transfemoral and transradial group, respectively which was significant ($p < 0.001$). The failed attempts in transradial group were due to radial artery puncture failure, radial artery spasm, tortuosity of the innominate trunk, dilatation of the ascending aorta, lusoria artery and inability to track the catheter in the left main. Martin Brueck et al observed that 0.2% required crossover to the transradial access because of an angiographically proven occlusion of the abdominal aorta and 3.5% in the transradial group needed crossover to femoral access site.[11] In all cases, the procedure was successfully performed by the transfemoral approach.

In Martin Brueck et al study, the large majority of PCIs were adhoc angioplasty (91.0% in the transradial group and 93.2% in the transfemoral group; $p = 0.55$).[11] Overall success rate in PCI was 99.5% in the femoral group and 96.6% in the transradial group ($p = 0.06$). There was 1 stent delivery failure due to a tortuous coronary artery in the transfemoral group. Causes of interventional failure in the transradial group were severe radial artery spasm ($n = 3$), tortuosity of the innominate trunk ($n = 2$), and impossible engagement of the left main ($n = 1$) requiring switch to the transfemoral, which was performed successfully in all cases. The percentage of patients treated by drug-eluting stent implantation was similar in both groups (23.4% in the transradial group and 25.7% in the transfemoral group; $p = 0.76$).

In our study the mean total fluoroscopy time (FT) for all the CAG was 4.36 ± 3.96 min. Transradial CAG had significantly longer FT than transfemoral CAG (4.40 ± 3.55 min vs. 3.89 ± 3.65 min, $p < 0.001$). Transradial PTCA had longer FT (13.53 ± 2.53 min) as compared to transfemoral PTCA (12.61 ± 9.5 min) and the difference was statistically significant ($p < 0.001$). Martin Brueck et al also had similar findings and had observed that the median fluoroscopic time was significant longer ($p = 0.001$) in the transradial group (9.0 min, interquartile range i.e. IQR range 3.9–10.7 min) compared with the transfemoral group (5.8 min, IQR 1.7–7.5 min).

We, in our study, found that the access site related complications were less in diagnostic group as compared to the intervention group and also that the complications were less in transradial group as compared to the transfemoral group. Martin Brueck et al found that despite the usage of vascular closure devices in 93.2% after transfemoral intervention, vascular access site complications were higher in the transfemoral group (3.71%) compared with the transradial group (0.58%; $p = 0.0008$).[11] Whereas in our study, we observed that without using vascular closure device the total complication rates in the diagnostic group were 1.15% and 4.26% in transradial and transfemoral group, respectively. In the interventional group the total complication rates were 1.8% and 14.5% in the transfemoral and transradial group, respectively. The higher complication rate in transradial cohort were mainly due to radial artery spasm. In our study, pseudoaneurysms were seen in none of the patients in transradial procedures, which were similar to the results from Martin Brueck et al, while 4 patients of transfemoral diagnostic and 9 patients of transfemoral interventional group developed pseudoaneurysm as compared to 3 patients after transfemoral procedure in the study by Martin Brueck et al. All of them in our study were successfully treated by ultrasound-guided compression.

In our cohort, two patients in transfemoral group had limb ischemia, one of which required surgical vascular repair including embolectomy and another needed limb amputation, whereas in study by Martin Brueck et al none of the patients was sent to surgery due to procedural complications. In the transfemoral group, 63 (1.0%) patients developed groin hematoma out of which 13 were major hematomas and required blood transfusion, none of the patients in our study could be detected to have developed arteriovenous fistula in either groups as compared to 2 patients who suffered from an arteriovenous fistula after diagnostic angiography that was treated conservatively in the study by Martin Brueck et al. 93 (0.01%) and 120 (5.34%) of the patients in the diagnostic and interventional group, respectively, had loss of radial pulse at discharge as compared to only 3 patients (0.59%) in the transradial group who had no beating radial artery pulse at discharge without any evidence of forearm ischemia in the study by Martin Brueck et al. No cases of major vascular or bleeding complications occurred in the transradial group. Three patients in transradial group and two patients in the transfemoral group experienced periprocedural neurological deficit, while 4 patients suffered from a transient ischemic attack that promptly resolved after diagnostic coronary angiography, whereas one, during a PCI procedure, had a stroke with left hemiplegia that was managed conservatively.

One of the largest meta-analysis comparing radial vs. femoral approach for diagnostic catheterization and interventional procedures by Agostoni et al included 12 randomized trials (3224 patients).[12] Major adverse cardiovascular events were similar between transradial and transfemoral groups (2.1 vs. 2.4%, 95% CI: 0.57–1.68; $p = 0.7$). The transradial approach was superior to transfemoral approach in entry site complications (0.3 vs. 2.8%; 95% CI −0.82 to −0.29; $p < 0.001$) and lower total hospital charge. Conversely, transradial success was associated with a significantly higher number of procedural failures in comparison to femoral success (7.2 vs. 2.4%; $p = 0.001$) and longer FT (8.9 vs. 7.8 min, $p < 0.001$).

In a study published by Patel et al, transradial route was used successfully in 98.1% of the patients, while through transfemoral route in 1.9% of the patients.[13] 73.6% patients underwent CAG, while PCI was performed in 26.4% of the patients. The mean age was 64.6 ± 11.8 years and 76% were men. In 3.9% patients, left radial approach was required. In CAG, 9.9% had normal coronary arteries, 3.5% had slow flow and 86.6% had obstructive coronary artery disease. Percutaneous intervention was attempted in 7083 lesions with angiographic success rate being 97%. Direct stenting was attempted in 58% of the patients and successfully performed in 91%. The remaining lesions were predilated to complete the procedure (overall success rate being 100%). Conventional stenting (with pre dilation) and plain balloon/cutting balloon angioplasty were attempted in 34% and 8% lesions, respectively. The success rate of combined group was 96.2%. No patient suffered from ischemia of the hand or impairment of hand function. No patient had bleeding from the access site and hence no blood transfusion was required. Minor hematomas were observed in 0.8% of the patients. Hematoma extending upto the mid forearm occurred in 0.1% of the patients. Major complications (CVA) observed in 0.03% of the patients. Radial artery spasm and pain were noted in 8.55 and 4.8% patients, respectively. 0.7% had small pseudoaneurysm.

A meta-analysis of 18 randomized trials comparing transradial approach vs. transfemoral approach that mainly focused on elective patients undergoing coronary angiography and/or adhoc intervention showed a 73% reduction of access site bleeding complications and a trend toward a 29% reduction of the ischemic composite endpoint of death, myocardial infarction, or stroke in the transradial group.[14]

A systematic review of the literature involving 2808 STEMI patients who were largely recruited via non-randomized comparisons, showed that transradial intervention was associated with a significant, almost 50% decrease of overall mortality. Mortality in the 516 patients in whom access sites were randomly allocated was also numerically almost 40% lower in the transradial group, but this difference failed to reach statistical significance.[15]

In the RIVAL (RadIal Vs femorAL access for coronary intervention) study, patients randomized to the transradial arm in the highest tertile for radial percutaneous coronary intervention (PCI) center volume showed a 50% reduction of death, myocardial infarction, or stroke compared with the transfemoral group, which came along with a 55% reduction of major bleeding complications.[16] Interestingly, in the 1958 STEMI study patients, a 41% significant reduction of the composite ischemic endpoint and a 61% reduction of mortality alone were noted in the transradial group, suggesting that this patient population may benefit relatively more from a dedicated bleeding minimization strategy (16). An alternative hypothesis that merits further investigation is that only centers with high radial PCI volumes were confident in randomizing STEMI patients in the study; therefore, STEMI patients in the study may simply serve to identify operators particularly experienced for transradial PCI.

A study by Marco Valgimigli et al suggests that the risks of transitioning toward the transradial route over the conventional transfemoral approach in STEMI patients, provided the process is undertaken in a step-wise approach as part of a global transradial intervention program, may be largely outweighed by a lower mortality rate.[17] Although a causal relationship between the observed improved short-term safety profile and the lower 2-year fatality rate was not proven by this study (19), this hypothesis is of major potential relevance for the whole medical community, and it is currently being tested in the MATRIX (Minimizing Adverse haemorrhagic events by Transradial access site and systemic Implementation of angioX) study. Finally, based on a substantial reduction in the length of hospitalization as well as in access site bleeding and vascular complications the widespread adoption of transradial intervention may dramatically impact the economic burden of the developed as well as developing countries.[14,15] The RIFLE-STEACS (Radial Versus Femoral Randomized Investigation in ST-Elevation Acute Coronary Syndrome) was a multicenter, randomized, parallel-group study.[18] Between January 2009 and July 2011, 1001 acute ST-segment elevation acute coronary syndrome patients undergoing primary/rescue PCI were randomized to the radial (500) or femoral (501) approach at 4 high-volume centers. The primary endpoint was the 30-day rate of net adverse clinical events (NACEs), defined as a composite of cardiac death, stroke, myocardial infarction, target lesion revascularization, and bleeding. Individual components of NACEs and length of hospital stay were secondary end points. The primary endpoint of 30-day NACEs occurred in 68 patients (13.6%) in the radial arm and 105 patients (21.0%) in the femoral arm ($p = 0.003$). In particular, compared with femoral, radial access was associated with significantly lower rates of cardiac mortality (5.2% vs. 9.2%, $p = 0.020$), bleeding (7.8% vs. 12.2%, $p = 0.026$), and shorter hospital stay (5 days first to third quartile range, 4–7 days] vs. 6 [range, 5–8 days]; $p = 0.03$). This study concluded that radial access in patients with ST-segment elevation acute coronary syndrome is associated with significant clinical benefits, in terms of both lower morbidity and cardiac mortality. Thus, it should become the recommended approach in these patients, provided adequate operator and center expertise is present.

7. Study limitations

Our findings should be interpreted in the context of our study design and its limitations. First, our study is retrospective and data are observational. Second, there was a substantial use of glycoprotein IIb/IIIa inhibitors in our study population. Whether our observations are similarly valid also for patients receiving a less aggressive pharmacological treatment remains to be determined. Bleeding events were not prospectively collected in our study; therefore, red blood cell transfusion and access site surgical repair was used as a surrogate for major bleeding or vascular events. It remains to be determined whether the reduction of myocardial infarction and stroke at 2-year follow-up favoring the transradial approach is a spurious finding or may reflect a true long-term advantage of a strategy that minimizes bleeding and vascular events. Finally, the use of secondary prevention medications was not prospectively collected in our study. Therefore, we cannot rule out the possibility that a less aggressive implementation of secondary prevention pharmacological measures in patients who experienced major in-hospital bleeding and vascular events may at least partially explain the observed association between transradial intervention and improved cardiovascular outcomes. Our study design is a retrospective and non-randomized study, a selection bias cannot be ruled out. This present study reflects a real world clinical setting of unselected consecutive patients. Finally, our study represents a single-center experience.

8. Conclusion

Transradial coronary catheterization is safe, feasible, effective and nearly abolishes entry site complications, in comparison with significantly higher rates in patients undergoing transfemoral catheterization. However, transradial access used to be limited by a significantly higher rate of procedural failure but with increasing expertise it has become as successful as transfemoral approach. It does not allow the possibility of using other devices such as intra-aortic balloon pump or to perform PCI requiring 8-F catheters. However, radial artery access almost abolishes complications at entry site in comparison with significantly higher rates in transfemoral approach. The procedural duration (excluding hemostasis period), fluoroscopy time, and radiation exposure are higher compared with transfemoral access. Major additional benefits with transradial approach like increased patient comfort and preference and additional decrease in the cost of health delivery guide us for a wider spectrum of therapeutic options in the current era of increasing percutaneous coronary procedures.

Conflicts of interest

All authors have none to declare.

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