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Transradial Access for Coronary Angiography and Angioplasty: A Novel Approach

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ABSTRACT

Coronary angiography and angioplasty are usually performed via transfemoral access. Though this route provides an easier vascular access, it is associated with a small but potentially serious incidence of vascular complications at the puncture site that may result in significant groin haematoma, blood transfusion or require surgical repair. A useful alternative approach is through the transradial access. This route has a very low rate of vascular complications and also allows early mobilisation of patients. We performed an analysis of our experience with transradial angiography and angioplasty, demonstrating this to be a safe and effective technique suitable for most patients.

Keywords: Allen's test, coronary angiography, coronary angioplasty, transradial angiography, transradial intervention

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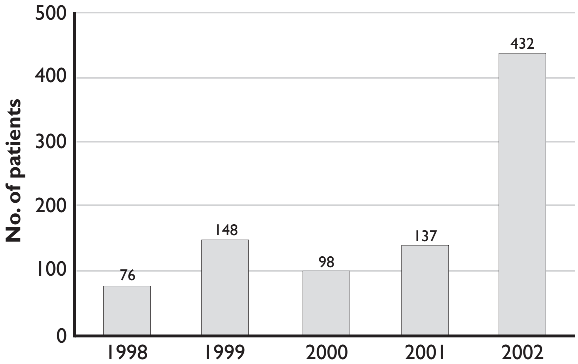
INTRODUCTION

The usual site of vascular access for coronary angiography or angioplasty is through the femoral artery, and the vast majority of coronary procedures are performed this way. The transfemoral route is popular, as puncturing the accessible and large calibre femoral arteries is relatively easy, and most coronary catheters are in fact pre-shaped to facilitate procedures performed from this route. In 1989, Campeau introduced transradial access for performing coronary angiography[1], and in 1993, Kiemeneij reported his experience with coronary angioplasty through the radial route[2,3]. The transradial route is now becoming increasingly popular, with the primary advantages of allowing earlier mobilisation of patients post procedure, and significantly less vascular complications when compared to transfemoral access. At the National Heart Centre, we have been performing transradial angiography and angioplasty since 1998 in increasing numbers (Fig. 1). In the year 2002, a total of 263 cases of transradial angioplasties were performed; these represented 13.3% of the total number of coronary angioplasties that year.

Fig. 1 Number of transradial procedures performed in National Heart Centre Singapore from 1998 until 2002.



METHODS

Patients

We collected data on all coronary angiographies or angioplasties performed in the National Heart Centre Cardiovascular Laboratory through the transradial route over a six-month period from May through October 2002. A total number of 255 patients underwent transradial approach during this time period. Transradial access was performed only if the modified Allen's test is normal (positive), suggesting the presence of an adequate collateral circulation from the ulnar artery. We avoided transradial procedures in patients with chronic renal impairment, as the use of single-plane fluoroscopy while performing transradial cases would necessitate higher radiocontrast usage with its concomitant increased risk of contrast-induced nephropathy. In addition, we may also help preserve a vascular access site should it be required for any future haemodialysis.

Procedure

Our preference was to use the right radial artery whenever possible as it was nearest to where the operator stood while facing the cardiac monitors. The wrist was sterilised and draped in the usual fashion, hyperextended over an arm board, and the skin over

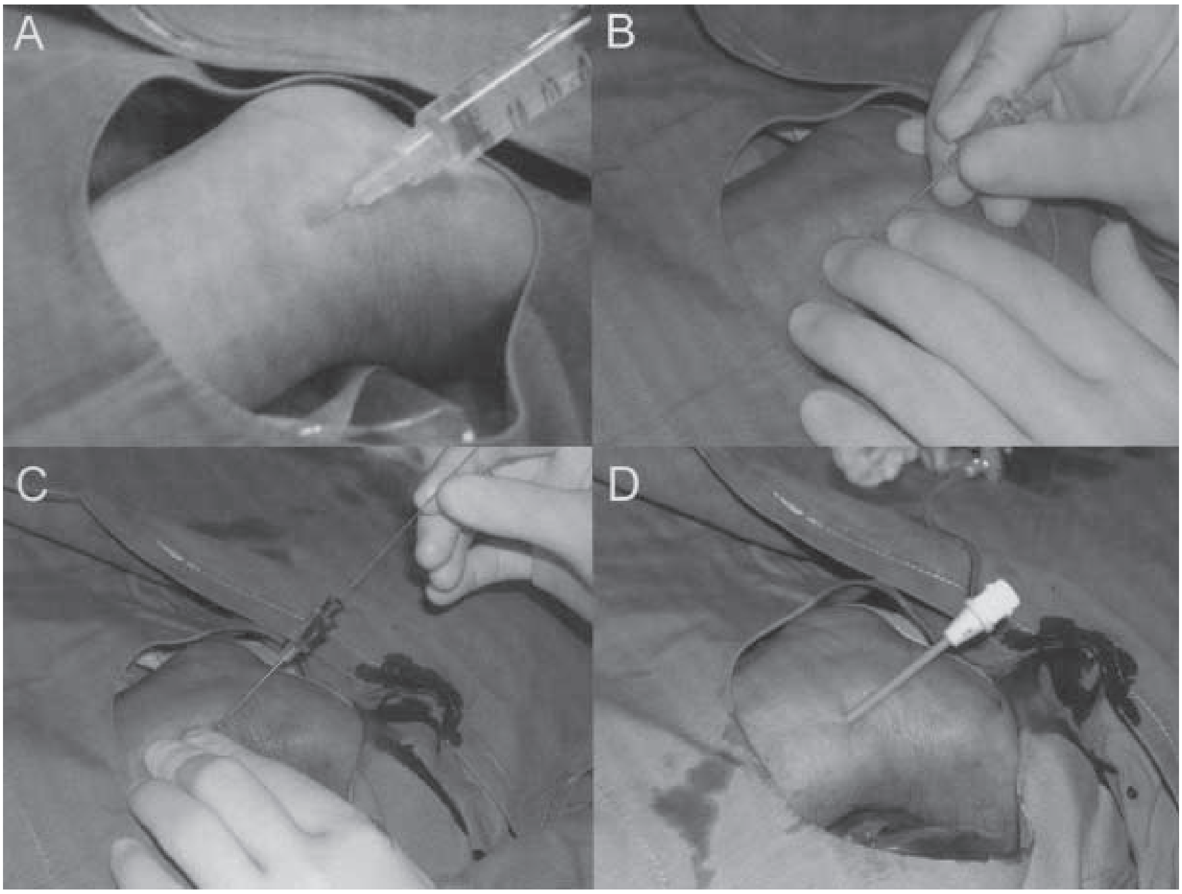


Fig. 2 Transradial access. A) Local anaesthetic is instilled over the radial artery. B) Radial puncture is performed at a site 1 cm proximal to the styloid process with a 21G needle. C) After successful puncture, a 0.021" straight wire is carefully passed into the radial artery. D) The needle is removed and a radial sheath is then passed over the wire into the radial artery.

the puncture site was anaesthetised with about 2-3 ml of 1% lignocaine. A small scalpel skin incision was performed 1 cm proximal to the styloid process of the radius where the arterial pulsation was easily felt. The radial artery was punctured with a 21G needle and an 11-cm sheath was then inserted into the artery using the Seldinger technique (Fig. 2). All patients received, through the radial sheath side arm, a cocktail consisting of verapamil (5 mg) to reduce radial vasospasm, and heparin (2000 U) to prevent artery occlusion; if angioplasty was to be performed, a total dosage of heparin 100 IU/kg was given. The coronary catheters were advanced into the aortic root over a 150 cm-long 0.038" Terumo guidewire under fluoroscopic guidance. The usual coronary catheters used from transfemoral approach were suitable, but we also used catheters specially shaped for transradial approach, such as the Tiger catheter (Terumo Corporation, Tokyo, Japan) which can be used to engage both left and right coronary arteries. Procedural time (defined as the interval between arterial access and sheath removal) and fluoroscopy time were recorded.

Once the procedure was completed, the radial sheath was immediately removed in the cardiovascular lab, and pressure over the puncture site applied using a "Stepty-P" device (Nichiban, Tokyo, Japan) to secure haemostasis. Patients were then transferred back to the ward, where the radial site was closely monitored for bleeding. Generally, the "Stepty-P" device can be removed after two hours for coronary angiographies, and after four hours for angioplasties.

Procedural (i.e. during and just after the procedure) and in-hospital complications were defined as those that may be related to the transradial approach. Any significant in-hospital major adverse cardiac events (MACE) were also noted. Data regarding follow-up complications were collected by reviewing the patients' files.

Data analysis

Data collected were analysed where necessary with a SPSS 10.0 statistical analysis programme.

RESULTS

The baseline characteristics of the patients are detailed in Table I. Out of the 255 transradial cases, 211 transradial angiographies were performed (117 cases of transradial angiography followed by adjunctive angioplasty, 94 cases of angiography alone). There

Table I. Baseline clinical characteristics.

	n=255
Age (year)	59.8 ± 9.8
Male	196 (76.9%)
Race:	
Chinese	183 (71.8%)
Indian	34 (13.3%)
Malay	25 (9.8%)
Others	13 (5.1%)
Diabetes mellitus	99 (38.8%)
Hypertension	176 (69%)
Dyslipidaemia	215 (84.3%)
Smoking (including ex-smokers)	99 (38.8%)
Previous PTCA	72 (28.2%)
Anticoagulation*	7 (2.6%)
Unfractionated heparin	1 (0.4%)
Low molecular weight heparin	3 (1.2%)
GP IIbIIIa inhibitors†	3 (1.2%)

* Excluding routine heparin use for transradial angiography or intervention.

† 1 Abciximab, 1 Eptifibatide, 1 Tirofiban (all 0.4% each).

PTCA = Percutaneous transluminal coronary angioplasty.

Table II. Procedural characteristics.

	n=255 (unless otherwise stated)
Reason for transradial access	
Operator preference	235 (92.2%)
Ileofemoral disease	9 (3.5%)
Aortic disease*	5 (2.0%)
Groin infection	3 (1.2%)
Failed femoral access	1 (0.4%)
Failed femoral and brachial access	1 (0.4%)
On anticoagulation (iv heparin)	1 (0.4%)
Site of attempted transradial access	
Right radial artery	252 (98.8%)
Left radial artery	3 (1.2%)
Success of transradial procedure†	235 (92.2%)
Radial sheath size (n=247)‡	
5F	6 (2.4%)
6F	238 (96.4%)
7F	3 (1.2%)
Tempo of case	
Elective	253 (99.2%)
Emergent	2 (0.8%)

* 4 aortic aneurysms, 1 ascending aorta dissection.

† Success in performing angiography or attempting angioplasty.

‡ Excluding 8 cases where there is failure of radial puncture.

were 141 cases of transradial intervention (117 cases were done as adjunctive angioplasties, 24 cases were elective angioplasties). The procedural characteristics are shown in Table II. Our main reason in choosing transradial access was due to operator preference (92.2%); otherwise they were performed mostly for failed transfemoral access. The vast majority of cases (99.2%) were elective. The right radial artery was used in 98.8% of cases, and a 6F sheath was most commonly used (93.3%).

The success of the transradial procedure was defined as success in performing coronary angiography, or if intervention was required, in allowing an attempt at angioplasty. In 20 patients (7.8%), a transradial procedure was unsuccessful; the reasons can be classified into three categories. The first reason was failed radial puncture, which occurred in eight patients. The second reason was the inability to pass the guide wire or coronary catheter to the ascending aorta, despite a successful radial puncture; this occurred in four patients. This was due to an anomaly of the radial artery, such as a radial loop, or to a small calibre vessel (Fig. 3). The third reason was due to failed cannulation of the coronary arteries, in eight patients. This was caused by either a right subclavian artery that was either tortuous or had an aberrant origin, making it difficult to manipulate the catheter into the coronary ostium (Fig. 4).

Specific details regarding both transradial angiography and intervention are shown in Table III. Coronary angioplasty and stenting was completed successfully in most patients (94.3%); the use of stenting was widespread (86.5%).

Major complications peri- or post-procedurally related to transradial access were extremely uncommon, as seen in Table IV. There was one case of a major forearm haematoma that occurred just after the completion of the procedure. This was due to the inadvertent exit of the hydrophilic Terumo guide wire out of a small branch of the radial artery, causing a small perforation and extravasation of blood (Fig. 5). A contributory factor was the use of the GP IIb/IIIa inhibitor eptifibatide in this patient. This complication settled with arm elevation and pressure bandage; the radial pulse remained strong and duplex of the arm showed no radial artery pseudoaneurysm. At follow-up, the patient remained well with no vascular sequelae. It was also reassuring to see that there were no major adverse events such as stroke, especially as we are manipulating the guide wire and catheter in close proximity to the right common carotid artery.

DISCUSSION

Transfemoral arterial access for coronary angiography or angioplasty is the norm for most cardiologists. Although this carries the advantage of ease of access as a result of the superficial location of the large calibre femoral artery in the groin, it can also potentially cause rare vascular complications, such as pseudoaneurysms, arteriovenous fistula, arterial occlusion, nerve injury and most seriously, retroperitoneal bleed. These morbidities

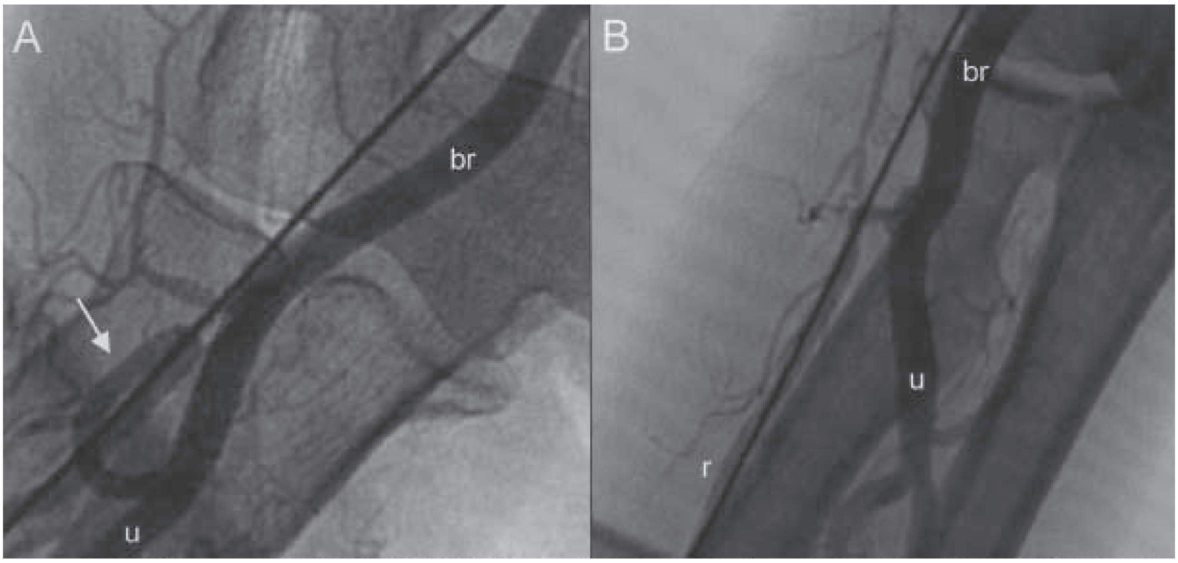


Fig. 3 Radial artery anomalies. A) Arrow shows radial loop which the guide-wire was unable to negotiate. B) Radial artery is of small calibre, making it impossible to pass a coronary catheter through it. (br = brachial artery; r = radial artery; u = ulnar artery.)

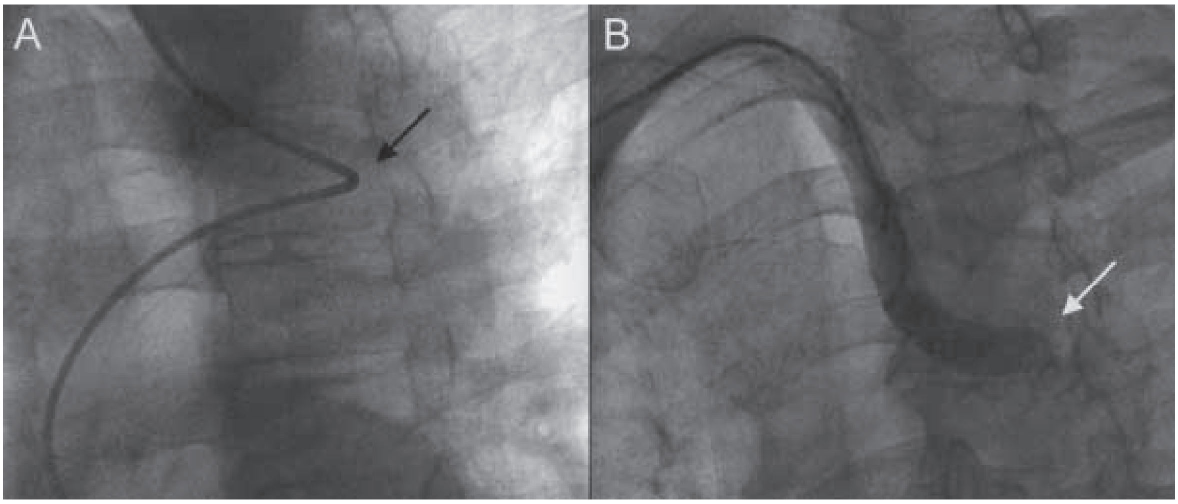


Fig. 4 Aberrant right subclavian artery (ARSA). A) Left anterior oblique (LAO) projection showing the characteristic angle in the catheter (black arrow). B) Angiographic view in the LAO projection, with contrast injection showing the origin of the ARSA ostium (white arrow) in the distal part of the horizontal aorta.

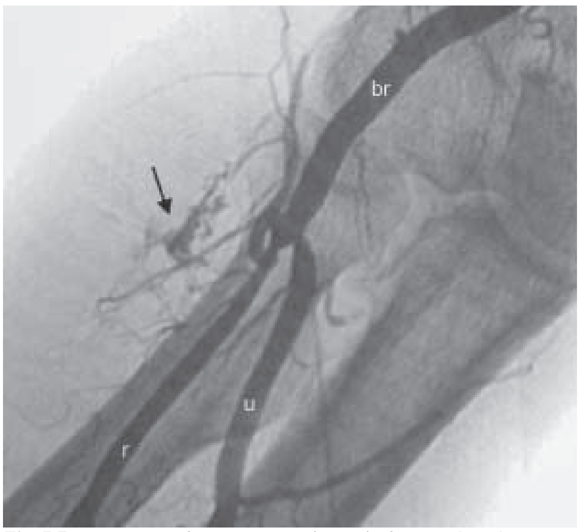


Fig. 5 Extravasation of contrast seen (arrow) after accidental passage of guide wire out of a small radial artery branch in a patient on eptifibatide, causing a major arm haematoma. (br = brachial artery; r = radial artery; u = ulnar artery.)

are usually not life-threatening, but they are troublesome for patients, often prolonging hospitalisation and sometimes requiring blood transfusion or surgical repair. In addition, transfemoral approach may also be unsuitable in some patients for a variety of reasons; these include severe aortoileofemoral obstructive disease, abdominal aortic aneurysm, groin infection or gross obesity.

Transradial access is an excellent alternative to femoral puncture. This artery has a superficial course, and there are no nerves or veins of significant size near the usual site of puncture. The hand's dual arterial supply from the radial and the ulnar artery adds an extra level of safety to the arterial puncture; should any thrombotic or traumatic arterial occlusion occur, this usually does not endanger the viability of the hand due to the presence of an adequate collateral blood supply. In critically ill patients who had prolonged

Table III. Details regarding transradial angiography and intervention.

Transradial angiography (n=211)	
TRA + TRI	117 (55.5%)
TRA only	94 (44.5%)
Procedural time	20.1 ± 10.5
Fluoroscopy time	5.2 ± 3.9
Transradial intervention (n=141)	
TRA + TRI	117 (83.0%)
TRI only	24 (17.0%)
Use of stenting	122 (86.5%)
Use of adjunctive devices	
None	0 (98.6%)
Rotablational atherectomy	1 (0.7%)
'Percusurge' distal protection	1 (0.7%)
Success of angioplasty	
Complete success	133 (94.3%)
Partial success*	3 (2.1%)
Failed - angioplasty stopped	5 (3.5%)
Total no. of vessels angioplastied	172
LAD	74
LCx	46
RCA	52
Average no of vessel angioplastied	1.2 ± 0.5
Procedural time	41.8 ± 18.6
Fluoroscopy time	13.9 ± 7.5

* When the no of vessels angioplastied successfully is less than total vessels attempted..

TRA = transradial angiography; TRI = transradial intervention.

LAD = Left anterior descending artery; LCx = Left circumflex artery.

RCA = Right coronary artery.

Table IV. All complications and major adverse cardiac events up to three-month follow-up.

Procedural Complications	(n=235)
None	233 (99.1%)
Major arm haematoma	1 (0.4%)
Spasm of radial artery	1 (0.4%)
In-hospital Complications	(n=234)*
None	218 (93.2%)
Minor bruising or haematoma	14 (6.0%)
Major arm haematoma	1 (0.5%)
Thrombophlebitis	1 (0.5%)
In-hospital MACE	(n=234)*
None	233 (99.6%)
Non-Q myocardial infarction	1 (0.4%)
Stroke	0 (0%)
Death	0 (0%)
Follow-up Complications within three months	(n=234)*
None	213
No follow-up data available	21†

* No data for 1 patient due to loss of case record.

† No data as these patients did not return for follow-up (mostly patients from foreign countries).

MACE = major adverse cardiac event.

cannulation of the radial artery, the incidence of ischaemic damage to the hand is minimal despite the frequent occurrence of arterial occlusion[4].

Before attempting transradial access, it is important to ascertain that the modified Allen's test is normal (positive), thus confirming an adequate collateral arterial supply from the ulnar artery. This test is performed by asking the patient to repeatedly clench his hand to squeeze the blood out, while the examiner compress both the radial and ulnar artery. The test is considered positive, if there is restoration, or slight increase, of the normal red colour of the fingertips within 10 seconds, after release of only the ulnar artery. The majority of patients should have a positive Allen's test; in a study by Benit et al in 1,000 patients undergoing cardiac catheterisation, 73% had a normal modified Allen's test[5]. An alternative method is to apply a pulse oximeter to a finger of the hand chosen for arterial cannulation, and then to compress the radial artery. If the pulse wave persisted, the test can be considered positive or normal[6]. The same radial artery can be used in most cases for repeated cannulation. A study of repeated transradial cannulation in Japanese patients by Sakai et al found that transradial access in the same arm could be performed three to five times in most patients. A third transradial procedure was possible in 90% of men and 80% of women, and a fifth procedure was possible in 70% of men and 50% of women. The main reasons for failure were due to a faint or absent radial artery pulse or failed puncture. This may be due to thickening of the tunica intima of the radial artery from sheath insertion injuries, leading to gradual narrowing of the arterial lumen. The fact that the failure rate was higher in women may be a reflection of the generally smaller radial artery diameter in females[7].

Radial approach failure occurs in 1-9% of cases; the main causes are due to failed radial puncture, anatomic variations of the radial artery and small calibre vessels[8-12]. Radial vasospasm is now rarely a problem with the use of routine intra-arterial verapamil. Yokoyama et al performed ultrasonography of the radial artery in 115 patients before transradial procedures, and found anatomic variations in 11 patients (9.6%): tortuous arteries with maximum angulation of more than 45%, stenosis, hypoplastic radial arteries and radioulnar loop. Despite these, transradial access was successful in the majority of patients, except for those with hypoplastic arteries[13].

Another important cause is the failure of selective coronary ostium catheterisation as a result of major tortuosities of brachial and subclavian arteries, or major aortic arch dilatation. One major cause causing particular problems for the right radial artery operator is the presence of an aberrant right subclavian artery anomaly (ARSA), which is the most common congenital aortic arch anomaly, with a reported prevalence of 0.4-2%. The ARSA arises from the distal and posterior aspect of the horizontal part of the aortic arch at its junction with the descending aorta. This condition is usually asymptomatic, and discovered incidentally during cardiac catheterisation. The presence of an ARSA is suspected when catheterisation of the ascending aorta proves difficult, and it can be confirmed by contrast injection. In the anterior-posterior (AP) or left anterior oblique (LAO) projection, the wire or catheter exits the origin of the ARSA pointing towards the left, and engages the ascending aorta with a sharp angulation. The presence of an ARSA makes cannulation of the coronary ostium, especially the left, difficult and in some cases, impossible. In their retrospective study of 3,730 transradial patients, Abhaichand et al reported finding an ARSA in 11 patients (incidence of 0.4%); however, the transradial procedure was completed successfully in 10 of those patients by selecting appropriate catheters(14).

For transradial access, the right radial approach is often preferred over the left due to its more comfortable proximity to the operator. Securing haemostasis after removing the radial sheath post-procedure is usually much more straightforward than in transfemoral procedures. The superficial radial artery is easily compressible with the use of tourniquets, or with special radial compression devices such as the "Stepty-P". Any subsequent bleeding can be easily detected and resolved with immediate local pressure by the patient. Vascular complication rates with transradial access are extremely low. Kiemeneij et al, in a study comparing percutaneous transluminal coronary angioplasty (PTCA) from various routes, found a 2% incidence of major access site bleeding complications with the femoral approach and a 2.3% incidence with brachial access, whereas there was none encountered in the radial group. Radial artery occlusion was found in 5% of patients at hospital discharge, and was still present in 3% of patients at one-month follow-up. However, there were no clinical symptoms associated with these, due to the adequate collateral supply from the ulnar artery. Therefore radial artery occlusion after transradial access is not considered to be a major event(8).

With regard to angioplasty, transradial intervention (TRI) is an excellent alternative to the usual transfemoral route for angioplasty, although this technique has a steep learning curve. Kiemeneij et al had demonstrated that TRI performed by experienced radial operators yielded similar results when compared with transfemoral and transbrachial PTCA. There were no differences in PTCA success, procedural and fluoroscopy times, guiding and balloon catheters use and length of hospital stay in these three groups. However, coronary cannulation failure occurred more frequently in the radial approach (7%) compared to the femoral route (0.3%), due to the failed radial artery puncture and failure to advance the guide wire towards the ascending aorta(8). TRI can be advantageous in patients with acute coronary syndrome (ACS) where aggressive antithrombotic and antiplatelet therapy is often instituted, leading to a higher potential for access site bleeding complications. Mann et al compared the use of radial and femoral access sites for PTCA in 142 patients with ACS, and found identical 96% primary success rate in both groups. The use of abciximab did not differ significantly (15% in radial group, 10% in femoral group). However, there was no access site bleeding complication in the radial group, as compared to the femoral group (4%)(15). TRI for acute myocardial infarction patients also appeared to be feasible and safe in selected patients, with the main clinical advantage of reducing severe access site bleeding site complications(16).

CONCLUSION

The transradial technique is gradually gaining popularity, and is in fact, the primary mode of access in some cardiology centres. In particular, patient comfort is increased with early ambulation possible, often allowing earlier hospital discharges and therefore reducing costs. The incidence of access site vascular complications is also greatly reduced, even with the concomitant use of anticoagulants or antiplatelet agents. There is also minimal financial investment required to use this new technique. Most patients who have undergone cardiac catheterisation from both the leg and wrist will strongly prefer the transradial route(17). Our own experience demonstrates transradial access for coronary angiography or angioplasty to be a safe, effective and elegant alternative to transfemoral access, and is suitable for a wide variety of patients.

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