Clinical review

Radial artery access for coronary angiography and percutaneous coronary intervention

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The development of percutaneous procedures to diagnose and treat coronary artery disease has transformed the lives of many patients. Patients with limiting symptoms can now often be returned to full activity by percutaneous coronary intervention (PCI), with a low risk of procedure related cardiac events. PCI has obvious advantages over coronary artery bypass grafting, and, because increasingly complex disease can be treated in patients with previously prohibitive comorbidity, the demand for both diagnostic and interventional procedures increases every year.[1]

In percutaneous coronary procedures a sheath with a haemostatic valve is introduced into a peripheral artery under local anaesthetic. Preshaped catheters are passed through the sheath to the ostium of the relevant coronary artery, thus allowing the delivery of radiography contrast medium, angioplasty wires, balloons, and stents. After completion of the procedure, the catheter and sheath are removed and haemostasis is achieved by manual compression, an arterial closure device, or direct repair.

The femoral artery has traditionally been the preferred access site for coronary procedures, but this approach has several limitations. It is relatively contraindicated in the presence of severe peripheral vascular disease and in patients receiving anticoagulation treatment. A period of post-procedure recumbency is needed to avoid disruption of the arterial puncture site. This may be poorly tolerated by patients with left ventricular dysfunction, lung disease, or back and hip pain. Despite bed rest, the rate of complications at the femoral access site (haematoma, pseudoaneurysm, arteriovenous fistula, or need for blood transfusion or surgical arterial repair) is 2-8% after transfemoral PCI.[2 3] These factors together affect patients' satisfaction, morbidity, length of hospital stay, and costs and have driven the development of alternative vascular access for coronary procedures. In this review we summarise the literature on transradial coronary procedures and discuss the potential clinical implications and technical considerations of this vascular approach.

Sources and search criteria

We used Medline to search the literature for English language articles published before August 2003. We used the search terms "radial access," "radial artery access," and "radial PCI." We identified additional articles from the references of these papers.

Summary points

- Complications at the femoral artery access site occur in 2-8% of patients after percutaneous coronary intervention
- The incidence of complications at the radial access site is negligible in the presence of a satisfactory ulnar collateral circulation, even in patients treated with aggressive antithrombotic regimens
- Time to mobilisation, length of hospital stay, and costs are all reduced after transradial percutaneous coronary intervention
- Patients prefer transradial coronary angiography to the transfemoral procedure
- Complex angioplasty can be achieved by the radial approach

Rationale behind radial artery access

The hand receives a dual arterial supply from the radial and ulnar arteries, which come together to form deep and superficial palmar arches. The radial artery, unlike the femoral or brachial artery, is therefore not an end artery, and, in the presence of a satisfactory ulnar collateral supply, its occlusion does not compromise the vascular supply to the hand. Furthermore, the superficial course of the distal radial artery provides for easy compression (by device) of the artery (fig 1), so that patients can mobilise as soon as the arterial sheath is removed on completion of the procedure. Radial access thus has the potential advantages of reduced access site complications, rapid patient mobilisation, day case PCI, and reduced costs.

The adequacy of the ulnar collateral supply can be tested by the Allen test (fig 2). Maintenance of an arterial waveform recorded from an oxygen saturation probe placed on the index finger during compression of the radial artery provides objective evidence of a satisfactory collateral circulation.

Additional references are on bmj.com

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Fig 1 Compression of the radial artery puncture site by the Radistop device, which incorporates a backslab and compression block. Other compression devices are available

Complications at the access site

Many case series have reported low rates of complication at the radial access site,[4 5 w1-w3] and data are now available from several randomised trials comparing arterial access approaches.[2 6–9] In the access study, 900 (47.4%) of 1899 patients who had angioplasty in a 20 month period were randomised to radial, brachial, or femoral approaches.[2] Successful coronary cannulation was achieved in 93.0% *v* 95.7% *v* 99.7% of patients ($P<0.001$). Most failures were due to failure to puncture the artery; in all cases, successful coronary cannulation was achieved on crossover to an alternative access route. Once arterial access had been achieved, the rates of successful angioplasty did not differ (91.7% *v* 90.7% *v* 90.7%; $P=0.885$). Fluoroscopy or procedure time did not differ significantly, and neither did rates of major adverse cardiac events at one month. Major entry site complications (haemoglobin loss ≥ 2 g/dl or need for blood transfusion or vascular repair) occurred in significantly fewer patients in the radial group (0% *v* 2.3% *v* 2.0%; $P=0.035$).

The patients likely to benefit most from the reduced rate of access site complications associated with the radial approach are those treated with the most aggressive antithrombotic regimens. Choussat et al examined outcomes among the 150 (3.5%) patients who received the platelet glycoprotein IIb/IIIa receptor inhibitor abciximab out of 4231 PCI procedures at a single centre during a 28 month period.[3] No major access site complications (resulting in haemoglobin loss ≥ 2 g/dl, blood transfusion, vascular repair, or prolonged hospitalisation) occurred in the radial group compared with a rate of 7.5% in the femoral group ($P=0.04$). Access site complication rates of zero have also been described in case series of transradial PCI for acute myocardial infarction that used glycoprotein IIb/IIIa inhibitors.[10 11 w4] Even in this patient group, therefore, the complication rate at the radial access site is negligible.

Femoral artery (collagen plug or suture) closure devices may offer some of the advantages of radial access in terms of reduced access site complications, early mobilisation, and day case PCI. Deployment failure rates are, however, relatively high at about 4% for collagen based devices and 10% for suture devices.[12 13 w5 w6] This may have contributed to the significantly higher rate of femoral access site complications after PCI seen in patients managed with arterial closure devices compared with manual compression in one large observational study.[14] Furthermore, when femoral access with device closure was compared with radial access in three prospective studies of PCI, access site bleeding complications occurred more often (up to 3.7%) in the femoral group, with a zero complication rate in the radial group.[12 15 16]

Length of hospital stay and costs

One of the main advantages of radial access over the femoral route is rapid mobilisation of the patient and earlier discharge from hospital. The reduction in bed occupancy might be expected to reduce expenditure per patient and increase turnover of patients. In a randomised trial of transradial versus transfemoral diagnostic coronary angiography, hospital stay was indeed significantly shorter (3.6 *v* 10.4 hours; $P<0.0001$) in the radial group.[8] Hospital costs were also lower ($2010 *v* $2299 (£1107 *v* £1266; €1670 *v* €1911); $P<0.0001$). The 5-6 hour duration of post-procedure bed rest in this study is longer than the 2-4 hour period used in current UK practice.

Among 210 patients who had coronary angiography, with follow-on PCI in 43% of cases, both first ambulation (4.9 *v* 9.9 hours; $P<0.001$) and discharge (31.4 *v* 42.0 hours; $P<0.05$) occurred earlier in patients randomised to radial access than in the femoral group.[6] In the access study, mean hospital stay after transradial, transbrachial, or transfemoral angioplasty

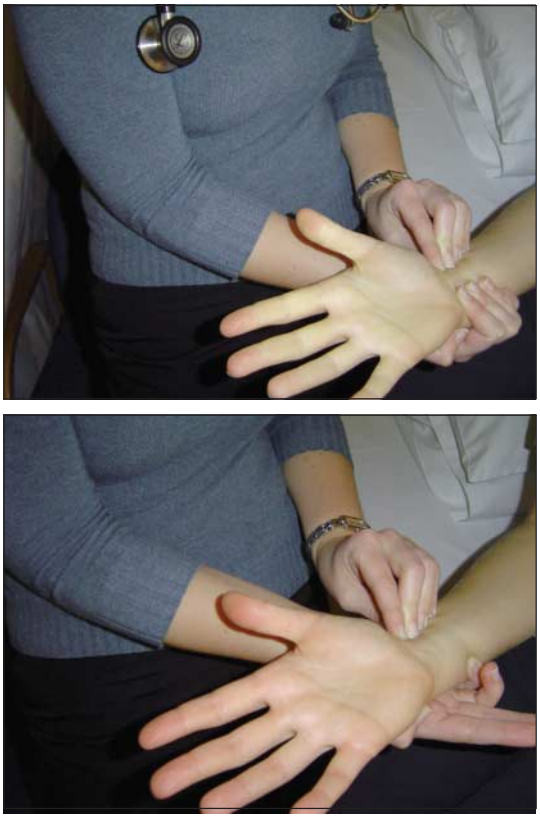

Fig 2 Allen test. Top: the palm is rendered ischaemic by clenching and opening the hand during compression of the radial and ulnar arteries; bottom: the test is positive (normal) if the palm coloration returns to normal within 10 seconds of release of compression of the ulnar artery while radial artery compression is maintained

did not differ significantly, possibly because the rate of vascular access site complications was low (<2.5%) in all groups.[2] By contrast, in two randomised studies of transradial versus transfemoral PCI, Mann et al reported significantly reduced access site complication rates (0% *v* 4%), post-procedure hospital stay (2.1 *v* 2.6 days; P<0.04 and 1.4 *v* 2.3 days; P<0.01), and total hospital charges ($14 374 *v* $15 796; P<0.05 and $20 476 v $23 389; P<0.01) in transradial patients.[7 9] They also found that transradial coronary stenting was cheaper than using the femoral approach with closure by the Perclose device.[12]

Patients' preference

Patients prefer radial access to the femoral approach.[6 8] This reflects the early mobilisation possible with this technique. Among 200 stable patients randomised to coronary angiography by either the radial or femoral approach, day one and week one measures of bodily pain, back pain, and walking ability all favoured the radial group (P<0.01).[8] Furthermore, those patients who had had angiography by both approaches expressed a strong preference for the radial approach, with 80% preferring the radial approach and only 2% preferring the femoral approach (P<0.0001).

Implications of radial access for day case PCI

Approximately 45 000 PCI procedures were done in the United Kingdom in 2002, a fourfold increase over the preceding 10 years.[1] The increasing number of PCI procedures, together with pressure to reduce bed occupancy and hospital costs, has driven the development of day case angioplasty.[17 18 w7 w8] The virtual absence of major access site complications combined with rapid mobilisation makes transradial PCI ideal for day case PCI. Most elective PCI patients can potentially be managed as day cases with no early bleeding or cardiac complications.[17 18 w7] A day case transradial PCI programme would need to be flexible to cope with failed radial access—for example, by crossover to the contralateral radial artery—and unscheduled admission in about 15% of cases.[18] Nevertheless, hospital beds currently used for these patients could be made available for the large number of patients with acute coronary syndromes who consume vast resources during their frustrating wait for transfer for "urgent" coronary angiography and revascularisation.

Technical considerations

Radial access is contraindicated in the 10-27% of patients with a negative Allen test[8 19] and in patients with arteriovenous fistulas for haemodialysis. Repeat transradial access is usually possible,[w9 w10] as is the use of a previously catheterised radial artery for a surgical conduit.[w11] Temporary, asymptomatic radial artery occlusion occurs in about 5% of cases after radial access, with persistent occlusion in half of these.[2 w12] Exceptionally, ischaemic complications of the hand can occur in these patients if they have an inadequate collateral circulation, and this highlights the importance of appropriate selection of patients. The occlusion rate is reduced by periprocedural administration of heparin and increased by a sheath:radial artery diameter ratio >1.[20 21 w13]

Failure to cannulate the coronary arteries selectively occurs in 1-7% cases.[2 6] This is most commonly due to failure to puncture the radial artery, but may also be caused by radial artery spasm or dissection, subclavian tortuosity or stenosis, or aortic root dilatation. In the event of failed radial access, the ulnar artery can be used provided a satisfactory radial collateral supply to the hand can be demonstrated by a normal reversed Allen test (return of normal palm coloration within 10 seconds of release of compression of the radial artery while ulnar artery compression is maintained).[22 w14] Radial artery spasm is reduced by the use of hydrophilic sheaths.

The radial artery is smaller than the femoral artery, so guide catheter size is usually restricted to 6 French (1 Fr = 0.33 mm), although operators have used 7 or 8 Fr on occasions. Concerns that use of 6 Fr guide catheters may limit radial PCI to "straightforward" cases are unfounded. Only the simultaneous deployment of two

A patient's perspective

When I had my first angioplasty just over a year ago the entry point was the right groin, and I assumed that it would be the same for my second treatment. I was informed by Dr Archbold that he was going to enter via my wrist. This came as a surprise, but I thought it couldn't be any worse than the other treatment. The procedure took about 20 minutes and was no more uncomfortable than going to the dentist. You all know how the groin treatment works, so I will describe what I feel are the plus points for the wrist entry. The preparation is easier and involves no shaving. I did not have to lie awkwardly to allow the surgeon access. I could feel the wire at some points going up my arm, but it was not at all painful.

As the treatment finished, Dr Archbold attached what I can best describe as a wristwatch type thing to my wrist, covering the entry wound; he injected air into this, which sealed the wound. I could get off the trolley on to my bed virtually unassisted. This is so much better than the old method.

I felt well on returning to the ward, apart from a slightly heavy arm, which soon subsided as the air pressure was reduced inside the dressing. The nursing staff only had to reduce the air pressure in my dressing periodically until the wound had stopped bleeding. I did not have to have a nurse pressing quite hard on my groin for 20 minutes, and there was no associated bruising. I did not have to lie in one position for six hours, and I could get up and use the toilet. Overall, I feel the wrist entry was a lot less intrusive and generally more pleasant than the groin entry method.

Patient treated at London Chest Hospital in 2004

Additional educational resources

Radial Force (www.radialforce.org)—a site from a group of enthusiasts for the radial artery approach for percutaneous coronary intervention that includes sections on technique and publications and a discussion forum

Almany SL, O'Neill WW. *Radial artery access for diagnostic and interventional procedures*. Ann Arbor, MI: Accumed Systems, 1999. (www.accumedsystemsinc.com/resources/radial_artery_access_manual.pdf)—a review article that describes preparation of patients, technique, and post-procedure care for radial artery access

Training courses

Transradial cardiac procedures (Crewe Hall)—organiser: J Nolan, University Hospital North Staffordshire; contact: Rachel.Grace@uhns.nhs.uk

Transradial PCI: basic technique, advanced applications (Southwest Cardiothoracic Centre, Plymouth)—organiser: J G Motwani, SWCC; contact: joseph.motwani@phnt.swest.nhs.uk

stents, large bore rotablation, and some distal protection devices demand a larger guide catheter. By contrast, the pressure wire, intravascular ultrasonography, individual stents, and the "kissing balloon" technique for the treatment of bifurcations can all be accommodated by modern 6 Fr guide catheters such that the ability to manage complex coronary anatomy with these catheters is well established. Indeed, high procedural success rates have now been reported for transradial PCI using 5 Fr guide catheters in selected patients.[23 24]

Implications for training

The radial approach provides angiographers with a technique for vascular access when femoral access is contraindicated or cannot be obtained. The necessary skills are simpler to acquire than those for the brachial technique. Procedure failure rates, time to sheath insertion, fluoroscopy time, and duration of procedure are all significantly reduced after experienced femoral operators have done 20 transradial coronary angiograms.[20 25] Ascent of the "learning curve" is likely to be slower for trainees new to coronary angiography. Several training courses offer useful advice to inexperienced radial operators. When considering PCI, operators generally build experience with low risk, elective procedures before tackling more complex cases.

Conclusions

The radial artery is the access route of choice for most coronary procedures. It is not appropriate in the minority of patients with a negative Allen test or in procedures that need >6 Fr guide catheters. The radial approach virtually eliminates access site complications after PCI, even in patients treated with aggressive antithrombotic regimens, and allows rapid mobilisation of the patient. Transradial PCI thus has major advantages both in unstable patients with acute coronary syndromes and in elective cases. Transradial procedures are attractive to patients, who prefer them to the femoral approach, and to managers, as they are associated with reduced costs. Physicians will increasingly encounter patients who have had PCI via the radial artery; post-procedure recovery in the future is likely to be on a cardiac day case ward furnished with armchairs rather than beds.

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Interactive case report

Abnormal liver function after an unplanned consultation

This case was described on 31 July and 7 August (*BMJ* 2004;329, 273 and 342). Debate on the management of the patient continues on bmj.com/cgi/content/full/329/7460/273#responses). On 28 August we will publish the outcome of the case together with commentaries on the issues raised by the management and online discussion from the patient and relevant experts.