Vascular access and closure for cardiovascular intervention

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INTRODUCTION

Selective coronary angiography initially required surgical cut down to access the brachial artery.1 Subsequently, in 1967 Melvin Judkins described a direct percutaneous approach via the femoral artery,2 an easily palpated vessel with high procedural success that would go on to become the default arterial access route. However, despite decades of experience with femoral access, vascular complications and bleeding remain a concern and are still a significant cause of mortality in cardiovascular intervention.3 Percutaneous coronary intervention (PCI) via the radial artery was first described by Kiemeneij in 1993,4 and early studies appeared to show a virtual elimination of access site complications.5 Initially the technique remained a niche interest of early radial pioneers, but usage in the United Kingdom has increased from 14% in 2005 to 84% in 2016 replacing the femoral artery as the most popular access site for intervention.6

Selection of radial or femoral arterial access

Radial artery access reduces vascular complications across all patient groups7 and is now recommended as the standard route for PCI.8 However, there are groups where the benefit is more pronounced. The superficial course and small calibre of the radial artery simplifies haemostasis allowing early ambulation9 and reducing cost10 making it ideal for patients who cannot tolerate prolonged bed rest, on anticoagulants or are undergoing PCI in the day case setting. A strong indication for radial PCI. However, there remain procedural reasons when femoral access is required (large-bore access for transcatheter aortic valve intervention (TAVI), mechanical circulatory support or complex coronary interventional procedures), and in a small proportion of patients unfavourable radial approach anatomy results in cross-over to femoral access. For this reason, interventional cardiologists must be familiar with best practice for both access sites.

Radial artery access: patient preparation

The right radial approach is most commonly used for ergonomic reasons. The right arm is placed alongside the body in a supine position supported by a dedicated arm board. Contralateral venous access should be obtained in case of vasovagal reaction requiring resuscitation and to allow administration of analgesia or sedation. The right groin should also be prepared in high-risk cases to facilitate rapid central venous and femoral arterial access if needed.

The left radial is a feasible alternative and is preferred if there is a requirement to image a left internal mammary artery (LIMA) graft or if the right radial pulse is absent. Accessing the left radial may be uncomfortable in larger patients while the left arm is at the patient’s side in which case the arm is extended at 80° for arterial cannulation and then positioned back across the body for the remainder of the procedure. Catheter orientation from the left radial approach more closely approximates that of the femoral approach and the operator is three times less likely to encounter subclavian tortuosity.13 This may account for evidence that the left radial route is associated with lower fluoroscopy time in elderly patients or with operators in training.14 In a randomised controlled trial of 1493 patients undergoing coronary angiography, there was no difference in operator radiation exposure from femoral or right radial access but it was higher with left radial access.15 There is often a requirement to stand closer to the patient to manipulate catheters from the left radial artery so if using this access, extension tubing to allow the operator to maintain distance should be used.

Routine preprocedural sedation is administered by 58% of operators.16 The radial artery has a muscular wall with numerous α-adrenergic receptors that make it prone to developing intense spasm.17 A randomised controlled trial of 2013 patients showed lower rates of spasm and femoral cross-over after fentanyl and midazolam18 so while not used universally it remains a useful adjunct in patients with high adrenergic states such as those with acute myocardial infarction or heightened anxiety.

It is no longer considered necessary to perform an Allen’s test to determine the patency of the ulnar-palmar arch prior to radial access19 and relying on this will likely exclude a significant
number of patients who would benefit from radial access unnecessarily. Multiple studies have used radial access in patients with an abnormal Allen’s test and none developed any clinical or subclinical consequences. Ischaemic complications have been described in patients with connective tissue disease and severe Raynaud’s disease, but are very rare and in these patients the balance of risk with the reduction in vascular complications should be considered when choosing access.

Radial artery access technique

The radial artery is usually accessed 2 cm proximal to the styloid process (figure 1). A small amount (1–2 mL) of local anaesthetic is administered initially at the puncture site to avoid distorting the anatomy. A short micropuncture needle is then advanced on a shallow trajectory until the anterior wall of the artery is punctured. A small calibre guidewire is then advanced through the needle with a rotating motion to avoid small side branches. At this point, the entry site can be further infiltrated with local anaesthetic and a skin nick made while the micropuncture needle is in situ to prevent inadvertent damage to the guidewire. The micropuncture needle is removed, and the sheath is inserted over the guidewire.

An alternative technique is to transfix the radial artery with a ‘through and through’ puncture. This is usually performed with a catheter-over-needle system. Here, the needle is advanced through both
the anterior and posterior wall of the artery. The needle is withdrawn, and the catheter pulled back slowly until arterial flow is seen. At this point, the guidewire is inserted. In a randomised trial of these two techniques in 412 patients, there was no difference in access site complications but the ‘through and through’ technique was associated with faster access and fewer attempts required. The radial artery is usually easy to palpate so ultrasound guidance is uncommon. However, a prospective randomised controlled trial of 698 patients has shown that routine
use of ultrasound almost halved the average number of cannulation attempts required from 3.1 to 1.7.22

**Overcoming difficulties with catheter advancement in the radial artery**

Radial spasm was the most common reason for trans-radial failure in a series of 2100 patients (1.6% of cases).23 The majority of radial operators (86%) use a spasmolytic agent following sheath insertion,16 and meta-analysis reveals that a combination of verapamil and nitroglycerin is the most effective.24 To reduce radiation exposure, it is permissible to initially advance the guidewire and catheters up the arm without fluoroscopy.25 However, if resistance or patient discomfort is felt, then an arm angiogram should be performed. Due to the frequency of anomalous anatomy (occurring in 14% of a series of 1540 patients), some operators routinely perform minimal contrast volume arm angiograms to avoid trauma or spasm in tortuous or small calibre arm vessels.26 Anatomical anomalies range from those that have a minimal effect on success rate such as high bifurcation of the radial artery (present in 7%) often associated with smaller calibre arteries and a tendency to spasm which resulted in failure in only 4.6% of cases, to full 360° radial loops present in only 2.3% but resulting in failure 37.1% of the time and requiring reducing before a guiding catheter can be advanced26 (figure 2).

Even if areas of adverse anatomy or spasm have been negotiated with a hydrophilic wire or a 0.014-inch angioplasty wire, it may not be possible to advance a guide catheter due to the ‘razor’ effect of the edge of the catheter on the arterial wall.27 To overcome this the distal end of the guiding catheter needs to be tapered. This can be achieved in a standard guiding catheter using two techniques, balloon-assisted tracking (BAT)27 and the ‘5 in 6’ technique (figure 3). These techniques have been used with high rates of success in different clinical situations and importantly can be used to maintain radial access in primary PCI with no increase in door to balloon times compared with switching to the femoral route.28

Finally, in one series 0.9% of radial access cases failed because of subclavian tortuosity25 and in another a retro-oesophageal right subclavian was present in 0.3% of cases29 (figure 4). In these cases, the angle of advancement can be made more favourable by asking the patient to take a deep inspiration. If the guidewire remains biased towards the descending aorta, then it can usually be directed with a Judkins right catheter towards the aortic root, which will be to the left of the descending aorta on a 30° LAO projection. There can be difficulty in catheter engagement of the coronary ostia, and it is often necessary to keep the 0.035 guidewire within the catheter to facilitate catheter manipulation and prevent kinking. Although the wire can be kept in the catheter right up to engagement of the coronaries, it is important to ensure that there is a free backflow of blood and normal arterial pressure trace before injecting any contrast. If there has been any difficulty advancing the catheter into the aortic root, catheter exchanges should be performed with a long 260 cm guidewire in the aortic root so that wire position is not lost.

**Management of radial access complications**

Vascular complications during radial access are rare and with early recognition and prompt management clinically significant sequelae can be avoided.10 (table 1). Dissection can occur from guidewire trauma or advancement of an oversized sheath or catheter in a small calibre artery. As these are retrograde to arterial flow they are usually self-limiting and require no specific treatment apart from careful observation. However, as they are usually accompanied by intense spasm (figure 4) they may require change to an alternative access. More significant arterial trauma can lead to vessel perforation, usually due to inadvertent advancement of a guidewire into

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**Table 1** Radial artery access complications

| Complication                  | Incidence   | Risk factors                                                                 | Prevention and management                                      |
|------------------------------|-------------|------------------------------------------------------------------------------|-----------------------------------------------------------------|
| Radial artery occlusion       | 5% (may be higher as usually asymptomatic) | Larger sheath size. Multiple cannulations. Prolonged compression with interrupted antegrade radial flow. No anticoagulation. | See table 2.                                                    |
| Radial artery spasm          | 5%          | Multiple puncture attempts. Larger sheath size. Multiple catheter exchanges. Small or tortuous arteries. Patient anxiety. | Consider ultrasound to reduce puncture attempts and guide sheath size selection. Consider sublingual GTN, spasmolytic cocktail and sedation. Minimise sheath and catheter size. Consider dedicated radial catheter (eg. Tigeril, Terumo) to minimise catheter exchanges. |
| Local (wrist) haematoma       | ≤5%         | Multiple puncture attempts, anticoagulation.                                  | Analgesia, ice, additional compression bracelet.                  |
| Forearm haematoma            | ≤2%         | Inadvertent guidewire perforation, anticoagulation.                          | Analgesia, ice, additional compression bracelet. Inflated blood pressure cuff at 20 mm Hg below arterial blood pressure for 15 min intervals. Monitor closely for signs of compartment syndrome which requires urgent surgical review. |
| Perforation                   | <1%         | Guidewire trauma to small branch or radial anomy. Use of hydrophilic wires without fluoroscopic guidance. | Perform arm angiogram if any resistance to guidewire advancement. Procedure can be completed if catheter or sheath in situ to prevent bleeding. Monitor closely for forearm haematoma and treat appropriately. |
| Pseudoaneurysm                | <0.1%       | Radial artery trauma: large sheaths, multiple puncture attempts, inadequate compression postprocedure. | Evaluate with ultrasound. Depending on size, consider prolonged compression with bracelet, ultrasound-guided thrombin injection or surgical treatment. |

GTN, Glyceryl trinitrate.
a small side branch or radial anomaly (figure 4). Previously, these would be managed with immediate manual compression; however, if the segment has been traversed with a guiding catheter the procedure can be completed as the presence of the catheter prevents excess bleeding from the perforation site which will usually seal without further intervention by the time the procedure is completed and the catheter withdrawn.31 Patients should be monitored closely afterwards for the evidence of forearm haematoma. If detected early, this can be managed with conservative measures but if not addressed can lead to compartment syndrome which is very rare (1:25 000) but requires urgent surgical fasciotomy.30

Limitations of radial access
The radial artery is usually between 2 and 3 mm in diameter and is generally larger in men than in women.32 This has the potential to limit the ability to perform complex intervention requiring larger bore (>6F) guiding catheters. Saito et al found in 260 patients that the radial artery diameter was smaller than the outer diameter of a standard 7F sheath (Terumo, Japan) (2.95 mm) in 29% of males and 60% of females.32 If a 7F guide catheter is required, one option is to use 7F Glidesheath (Terumo) which can accommodate a 7F guiding catheter but has an outer diameter of 2.79 mm (equivalent to a standard 6F sheath). Another is a 7F Sheathless guide catheter (Sheathless Eaucath; Asahi Intecc, Japan), and these have an outer diameter of 2.49 mm and have been used to successfully complete complex interventions including crush stent bifurcations and rotational atherectomy.33 Finally, the Railway system (Cordis, a Cardinal Health company) consists of dedicated introduction

Table 2 Strategies to prevent radial artery occlusion

| Strategy          | Description                                                                                                                                                                                                 |
|-------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Reduce sheath size | Use smallest possible radial sheath. If ultrasound guidance has been used, ensure that the diameter of the introducer sheath/radial artery is <1 mm.                                                              |
| Anticoagulation   | Give heparin at a dose of 5000 IU or 70 IU/kg. Patients with contraindications to heparin can be given bivalirudin 0.75 mg/kg.                                                                                |
| Patien haemostasis| **Step 1** Withdraw the arterial sheath 2–3 cm. **Step 2** Apply the haemostatic compression device, 2–3 mm proximal to the skin entry site, and tighten it or inflate it, then remove the sheath. **Step 3** Decrease the pressure of the haemostatic compression device to the point of mild pulsatile bleeding at the skin entry site. After 2–3 cycles of pulsatile bleeding, retighten the haemostatic compression device gradually to eliminate this pulsatile bleeding. **Step 4** Evaluate radial artery patency by using the reverse Barbeau’s test: 1. Place the plethysmographic sensor on the index finger of the involved upper extremity with the observation of pulsatile waveforms. 2. Compress the ulnar artery at the level of the wrist and observe the behaviour of the waveform. 3. Absence of plethysmographic waveform is indicative of interruption of radial artery flow. 4. If this occurs, the haemostatic compression pressure should be lowered to the point where plethysmographic waveform returns. This is evidence of antegrade radial artery flow. 5. Repeat stage 4 after 15 min to ensure there is still patent haemostasis as postprocedural changes in blood pressure commonly occur. |

Adapted from Rao et al25

Figure 5 Strategies to ensure correct site of femoral artery puncture. (A) Optimum puncture site within the CFA bordered by the inferior epigastric artery superiorly and the femoral bifurcation inferiorly. (B) Fluoroscopic-guided access on the same patient with a pair of forceps used to mark the intended puncture site. (C) Micropuncture used to confirm position with contrast injection before insertion of femoral sheath (insert—Cook Micropuncture kit consisting of 21G needle, 0.018-inch guidewire and 4F sheath). (D) Ultrasound guidance of femoral artery puncture. (see online supplementary video) (E) The femoral artery bifurcation viewed in long axis. (F) Short-axis view of CFA demonstrating an anterior wall puncture with needle tenting (arrow) and colour flow within needle. (G) Long-axis view confirming 0.035-inch guidewire in CFA. CFA, common femoral artery; PFA, profunda artery; SFA, superficial femoral artery.
and exchange inserts that allow conventional 7F guides to be used without a sheath.

**Radial artery closure**
The radial artery is easily compressible allowing immediate sheath removal independent of any anticoagulants given. Traditionally a compressive dressing or bracelet compression device (the most common being the TR band (Terumo) (figure 1) is used to give 2 hours of continuous compression. Radial artery occlusion has been reported in around 5% of cases after compression haemostasis but is likely under-reported as is virtually always asymptomatic. However, it is important as occlusion limits options for repeat arterial access and loss of a potential conduit in the future for coronary artery bypass grafting. Steps to reduce radial artery occlusion include anticoagulation and patent haemostasis and are listed in table 2.

**Ulnar artery and left distal radial artery access**
Ulnar artery access is a potential alternative to the radial artery. However, the ulnar artery is situated deeper in the forearm and runs alongside the ulnar nerve making inadvertent nerve injury and forearm haematoma a risk. A meta-analysis comparing radial and ulnar approaches with coronary angiography and PCI showed no significant difference in access-site complications, but access-site cross-over was significantly higher with ulnar access. More recently, Kiemeneij has described the technique of using the smaller left distal radial artery within the anatomical snuffbox for alternative access. The technique is technically challenging making it only suitable for selected cases but has the potential advantage of greater operator and patient comfort.

**Femoral arterial access: patient preparation**
The key to reducing femoral access site complications is ensuring that sheath insertion is within the optimal site in the common femoral artery (CFA). The CFA runs within the femoral sheath, adjacent to the femoral vein and nerve and is bordered superiorly by the inguinal ligament and inferiorly branches into the superficial femoral and profunda femoris arteries (figure 5A). Low punctures below the bifurcation result in more bleeding.

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**Table 3**  
**Femoral artery access complications**

| Complication                  | Incidence | Risk factors                                                                 | Management                                                                 |
|-------------------------------|-----------|------------------------------------------------------------------------------|--------------------------------------------------------------------------|
| Local (groin) haematoma       | 1%–12%    | Puncture outside CFA, multiple access attempts, laceration of branch vessel, high or low BMI, anticoagulation. | Careful prolonged manual compression to push out the residual haematoma and achieve haemostasis. |
| Pseudoaneurysm                | 1%–6%     | Low puncture, short press, inexperienced manual compression.                   | Evaluate with ultrasound. Depending on size, consider ultrasound-guided press, ultrasound-guided thrombin injection and surgical treatment. |
| Retroperitoneal haemorrhage   | 0.2%–0.9% | High puncture with failure of closure device. Excess anticoagulation.         | Diagnosis: Hypotension and flank pain. CT angiography or contralateral angiography to locate bleeding source and guide management. Management initially with intravenous fluid/blood product resuscitation. Percutaneous management possible but vascular surgical opinion mandated followed by percutaneous or surgical management. |
| AV fistula                    | <1%       | Often from a low puncture where a femoral venous vessel overrides the superficial femoral artery. | Diagnosis with a systolic murmur, right heart overload. Seek vascular surgical opinion. |
| Acute vessel closure          | <1%       | Associated with large intimal dissection and small calibre, diseased femoral vessels, large shear to femoral artery ratio and the use of VCDs. | Urgent vascular surgical review but percutaneous solutions with peripheral balloons and stents may be feasible. |
| Infection                     | 0.25%     | Associated with diabetics, use of VCDs. Typically blood culture positive for Staphylococcus aureus. 6% mortality. | Meticulous aseptic technique. Avoidance of VCDs when infection risk is high. |

AV, arteriovenous; BMI, body mass index; CFA, common femoral artery; VCD, vascular closure device.
pseudoaneurysm and arteriovenous fistula formation due to the smaller artery size, superficial relationship of the femoral vein tributaries and absence of bony prominence for compression. High punctures above the inguinal ligament in the external iliac artery are not compressible risking retroperitoneal haemorrhage.

Historically, operators have relied on a combination of palpation, surface anatomy and fluoroscopic landmarks to puncture the CFA. The point of maximal pulsation allows easy vessel cannulation and in one study correlated 93% of the time with the location of the CFA. The skin crease is readily identified but is frequently (72% of cases) located below the bifurcation. Using the bony landmarks of the anterior superior iliac spine and the pubic tubercle as a proxy for the inguinal ligament, a puncture 2–3 cm below the mid-inguinal point has been proposed; however, the correlation of the bony landmarks in cadaveric studies is poor.

There is some evidence that a fluoroscopy-guided approach can reduce femoral vascular complications. Studies have shown that 95% of the time the bifurcation of the CFA is at or below the mid-femoral head leading to a proposed mid-femoral head fluoroscopic target zone (figure 5B). Some operators advocate the use of a micropuncture kit (Cook Medical) to minimise complications. The evidence base for this is limited and observational studies have not shown clear benefit. However, this is intuitively attractive as it allows a 4F sheath to be placed and femoral sheath angiography undertaken to confirm position before a larger sheath is introduced (figure 5C).

Surrogate anatomical markers for the identification of the CFA can be misleading in cases of anatomical variation. In particularly challenging anatomy such as morbid obesity or peripheral vascular disease, it may be better to consider the radial approach. If this is not possible, then direct visualisation of the CFA with ultrasound guidance should be performed (figure 5).

Ultrasound-guided femoral arterial access

Ultrasound allows for real-time visualisation of vessel cannulation. As far back as 2002, the National Institute for Health and Care Excellence concluded that the evidence base for ultrasound-guided central line insertion was sufficiently robust to mandate its use in this setting across the National Health Service in England and Wales. Ultrasound guidance in femoral vascular access was compared with traditional techniques in randomised controlled trials, and a recent meta-analysis involving 1422 subjects showed a 49% reduction in overall complications and a 42% improvement in the likelihood of first-pass success. Although TAVI operators are increasingly recognising its utility, uptake in the general interventional community has been slow as demonstrated in a recent small survey where only 13% of interventionists used it for femoral access. There is a learning curve associated with ultrasound-guided puncture; nevertheless usage is likely to grow given its proven efficacy in reducing vascular access complications.

Femoral artery access technique

Femoral access is uncomfortable for the patient so consider sedation, especially if gaining large-bore access. Local anaesthetic is infiltrated, initially with a 25G needle to form a skin bleb, then using a 22G needle to just above the CFA and the tissue track. After making a small nick in the skin, an 18G needle is introduced at an angle of between 30° and 45° until it rests above the CFA where it may be observed to ‘dance’ with the arterial pulse. A single anterior wall puncture is made and once good pulsatile flow through the needle is established, then the needle is lowered to become more coaxial with the vessel and a 0.035-inch J tip guidewire introduced followed by a sheath.

If the sheath will not advance over the guidewire, exclude a kinked guidewire and readjust wire position if feasible. If scar tissue is the problem, consider sequential dilatation with smaller dilators or exchange for a more supportive guidewire through the dilator. If there is resistance to advancement of the guidewire or catheter, then an angiogram should be taken. Unlike the radial artery, spasm or anomalies of the femoral artery are not usually encountered. However, there may be a tortuous iliofemoral system (figure 6A). This may need to be negotiated with a hydrophilic 0.035-inch guidewire. If catheter advancement or

Table 4: Vascular closure devices used following femoral arterial access

| Product         | Company          | Closure method                               | Access site closure | Further instructions for use                                                                 |
|-----------------|------------------|----------------------------------------------|---------------------|------------------------------------------------------------------------------------------------|
| Angio-Seal      | Terumo           | Active approximation between intravascular anchor and collagen plug | 6–8F                | http://www.terumomedical.com/products/closure/angi-seal-vascular-closure-devices/angi-seal.html |
| StarClose SE    | Abbott           | Active approximation using an extravascular nitinol clip | 5–7F arterial       | https://www.vascular.abbott/us/products/vessel-closure/starclose-se-vascular-closure-system.html |
| Perclose Proglide| Abbott Vascular  | Active approximation using pretied suture device | 5–21F (arterial) Venous (5–24F) | https://vascular.abbott.com/perclose-proglide-learning-center-intl.html |
| MANTA           | Essential Medical| Passive approximation using an unanchored extravascular plug | 10–25F arterial     | http://www.essemiclosure.com/ |
| Prostar XL      | Abbott           | Large bore closure with active approximation using an anchor/plug mechanism | 8.5–10F arterial    | https://www.vascular.abbott/us/products/vessel-closure/prostar-xl-percutaneous-vascular-surgical-system.html |
| Inseal InClosure| InSeal Medical   | Active approximation using a self-expandable nitinol frame covered with a biodegradable membrane | 14–21F arterial     | http://www.insealmedical.com/ |
manipulation is not possible, exchange over a diagnostic catheter for a stiffer guidewire (eg, Amplatz Extra-Stiff, Cook Medical) and consider the use of a long armoured sheath (eg, Super Arrow-Flex, Teleflex Medical).

Femoral vascular complications
Vascular complications remain the Achilles heel of femoral access. The use of larger sheaths and more potent antithrombotic medication mean that vascular complications are two to three times higher after PCI than with diagnostic angiography. Known risk factors for vascular complications include age >70 years, female sex, body surface area <1.6 m², renal failure, urgent procedures, complex disease and use of glycoprotein IIb/IIIa inhibitors. In addition, punctures outside the target zone of the CFA result in a higher level of complications. Arterial dissection is usually caused by advancement of equipment without guidewire support (figure 6B). As they are retrograde they will usually settle with conservative management. Perforation has the potential to be a serious complication if it is not detected promptly (figure 6C). If bleeding occurs into the retroperitoneal space where it may be detected late and will not be controllable with compression, it is associated with a mortality of 10%. An overview of femoral access complications and their management is provided in table 3.

Femoral artery closure
Manual compression remains the the most common method of femoral access closure worldwide. It is highly effective for small sheaths but does mean prolonged patient immobilisation. Since the 1990s, there have been ongoing developments of vascular closure devices (VCD) and the latest generation now provide faster haemostasis compared with manual compression. They have not however been proven to reduce vascular complications and indeed concern remains that rare complications such as ischaemia or infection are increased by their use. Compared with manual compression, randomised controlled trial data show no superiority for VCD in risk of bleeding and meta analyses reveals that VCD have a significantly shorter recovery time but higher rates of groin infection (0.6% vs 0.2%, p = 0.02) and a trend towards increased risk of ischaemic complications (0.3% vs 0%, p = 0.07) and need for vascular surgery (0.7% vs 0.4%, p = 0.10). With the increasing use of large bore femoral access for TAVI and adjunctive haemodynamic support, there has been renewed interest in optimising large bore vessel closure. Traditionally, large femoral arteriotomy sites have been closed surgically or with prolonged manual compression. Manual compression is less effective and prone to complications in this setting and so ‘preclosure’ with a suture-mediated VCD has become commonplace. Perclose Proglide (Abbott) and Prostar XL (Abbott) are the two most commonly used suture-based preclosure devices. The Prostar XL has a longer learning curve, a sliding suture which must be hand tied and needles which move from intravascular to extravascular. Both devices appear equally efficacious in experienced hands. The MANTA (Essential Medical) is a new anchor/plug-based device and has shown promising early results. Irrespective of the closure device used, a deep puncture into a small heavily diseased vessel through anterior wall calcium all predict a higher risk of device failure.

Vascular closure devices
Guidelines support the use of VCD to provide faster haemostasis and early ambulation but not to reduce vascular complications and they also mandate a femoral angiogram to assess suitability. A rotational angiogram is recommended for the femoral sheath to identify the puncture position, vessel calibre, adjacent plaque disease and so clarify suitability for device closure. The two most commonly used VCD are the Angio-Seal (Terumo) and the Perclose Proglide (Abbott). The vascular complication rates of these are similar, but operator experience and familiarity is important. The Angio-Seal comes in 6F and 8F sizes and is popular due to its relatively short learning curve and high success rate. The mechanism relies on an intravascular biodegradable anchor which actively approximates with a collagen plug. The anchor should resorb within 3 months. The principle concern relates to the residual material left behind risking infection or ischaemia. The Perclose Proglide (Abbott) is a suture-based active approximator that aims to mimic a surgical suture. It has a longer learning curve and higher failure rate than the Angio-Seal but can be predeployed and used as a single unit or as multiple devices so is also suitable for large bore closure. It uses a pretied polypropylene monofilament suture that allows successful closure to be assessed on the table while maintaining wire access with a standard 0.035” wire. An overview of current VCD is shown in table 4.

Large bore femoral artery closure
With the increasing use of large bore femoral access for TAVI and adjunctive haemodynamic support, there has been renewed interest in optimising large bore vessel closure. Traditionally, large femoral arteriotomy sites have been closed surgically or with prolonged manual compression. Manual compression is less effective and prone to complications in this setting and so ‘preclosure’ with a suture-mediated VCD has become commonplace. Perclose Proglide (Abbott) and Prostar XL (Abbott) are the two most commonly used suture-based preclosure devices. The Prostar XL has a longer learning curve, a sliding suture which must be hand tied and needles which move from intravascular to extravascular. Both devices appear equally efficacious in experienced hands. The MANTA (Essential Medical) is a new anchor/plug-based device and has shown promising early results. Irrespective of the closure device used, a deep puncture into a small heavily diseased vessel through anterior wall calcium all predict a higher risk of device failure.
CONCLUSIONS
Safe arterial access and closure is a fundamental of interventional cardiology. Transradial access has emerged from a niche interest to the access site of choice in a large number of centres in more than 75 countries worldwide and proficiency in it is essential in all those undertaking cardiovascular interventions. However, despite its success, there remains a small proportion of cardiovascular interventions that still require femoral access due to the need for large calibre access or procedural or anatomical constraints. As experience in femoral access decreases, there is the potential for a paradoxical increase in femoral complications. This does not seem to have occurred during the widespread adoption of radial access in the United Kingdom but given that femoral access is now often only performed in challenging situations it is vital that those undertaking cardiovascular interventions must maintain proficiency in managing femoral arterial access as well as becoming familiar with new developments such as ultrasound guidance.

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Key messages
- Vascular access site complications are a significant source of morbidity and mortality in cardiovascular intervention performed from the femoral artery.
- Strategies to improve femoral puncture in the ‘safe zone’ of the common femoral artery should be employed routinely of which ultrasound guidance is the most effective.
- Compared with femoral artery access, radial artery access results in fewer access site complications and a reduction in mortality in patients with acute coronary syndrome.
- Radial artery access presents procedural challenges that can be overcome with experience and specialist techniques.
- Radial artery access is now the predominant access site for percutaneous coronary intervention, but there remain situations when femoral arterial access is required so interventional cardiologists should be proficient at both.

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