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ORIGINAL ARTICLE

Transradial Secondary Access to Guide Valve Implantation and Manage Peripheral Vascular Complications During Transcatheter Aortic Valve Implantation

Matthew W.P. Jackson, MBChB, Douglas F. Muir, MD, Mark A. de Belder, MA, MD, Sonny Palmer, MBBS, DMedSci, W. Andrew Owens, MD, FRCS, Andrew Goodwin, PhD, FRCS, Umair Hayat, BM BCh, Paul D. Williams, BM BCh, MA, MD *

Cardiology Department, The James Cook University Hospital, Middlesbrough, United Kingdom

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Background Vascular complications from transfemoral (TF) secondary access during transcatheter aortic valve implantation (TAVI) are common. We compare our experience of transradial (TR) versus transfemoral secondary access during TAVI and describe techniques for performing iliofemoral arterial intervention from the transradial approach.

Methods All TAVI procedures with a single secondary access were included. Demographics, procedural details and 30-day outcomes were recorded. VARC-2 criteria were used for procedural complications. Procedures with TF primary access were stratified by the site of secondary arterial access.

Results Single secondary access was used in 199 cases, of which 20 were performed via non-TF access. Of the 179 TF primary access cases, 115 (64%) used TR secondary access and 64 (36%) used TF secondary access. In the TR cohort percutaneous vascular intervention was performed from the transradial approach in 19 cases (17%). Emergent TF secondary access was not required in any case. There were no differences in procedural time, radiation dose, contrast use, bleeding complications, stroke or mortality between the groups. There was one secondary access complication in the TF cohort and none in the TR cohort.

Conclusions Transradial (TR) secondary access during TAVI is safe and feasible and may reduce the secondary access site vascular complication rate. With appropriate equipment, most peripheral vascular complications can be managed entirely via TR access avoiding unplanned femoral arterial access. TR secondary access should be considered the default approach for non-TF TAVI cases and can be considered for all TF cases as long as dedicated equipment is available.

Keywords TAVI • Vascular complications • Transradial • Peripheral vascular intervention

Abbreviations: TAVI, Transcatheter aortic valve implantation; TF, Transfemoral; TR, Transradial

*Corresponding author at: The James Cook University Hospital, Marton Road, Middlesbrough TS4 3BW, United Kingdom. Tel.: 01642850850., Email: paulwilliams9@nhs.net

Introduction

Vascular complications during transcatheter aortic valve replacement (TAVI) remain the most common procedural complication despite smaller delivery systems and improved operator experience. In the PARTNER-2 trial, major vascular complications occurred in 7.9% of patients whilst 10.4% suffered life-threatening bleeding [1]. Although most commonly occurring at the primary access site, up to a quarter of vascular access site complications may be related to the secondary transfemoral (TF) access [2].

Secondary arterial access for TAVI procedures is usually obtained from the femoral artery, with the contralateral artery typically used for primary access during TF cases. Secondary access is used for multiple purposes: femoral angiography can help guide the puncture for primary femoral arterial access; placement of a pigtail catheter in the aortic root marks the annular plane and allows aortography to aid valve positioning and deployment and to assess for potential procedural complications; peripheral angiography at the end of the procedure can identify vascular complications and ensure adequate haemostasis; in the event of vascular complications, secondary arterial access can be used to perform peripheral intervention [3–7].

The transradial (TR) approach has rapidly gained in popularity for coronary procedures, and is associated with a dramatic reduction in the risk of vascular complications as compared to the femoral arterial approach [8]. Although root aortography is simple to perform from the radial approach, peripheral angiography and intervention may be more challenging as the majority of equipment is designed for use from the femoral artery. Existing case series have not had access to such equipment and required peripheral vascular intervention to be performed from the contralateral femoral artery, often via unplanned emergent femoral access [9–12]. Recently, dedicated equipment has been developed which enables peripheral vascular interventions to be performed from the TR approach [13–15] and these techniques may be applicable to TAVI procedures.

We compare our experience of TR secondary arterial access with conventional TF secondary access during TAVI and describe techniques for peripheral vascular intervention from the TR approach.

Methods

Cohort Selection

All consecutive TAVI cases performed between May 2015 and June 2017 using a single secondary access were retrospectively assessed. If two or more secondary access routes were planned, these cases were not included in the comparison cohorts and were documented separately. Cases using a single secondary access were divided by the route used providing peripheral vascular intervention could be performed by that route.

Default TR secondary access was used for all non-TF TAVIs during this time period. Default TR secondary access for TF TAVI procedures commenced in January 2016 and was performed in all patients with a palpable radial pulse. Prior to this, secondary access route was selected in a non-randomised fashion based on clinical grounds.

Patient demographics and procedural details were recorded for all cases. The Valve Academic Research Consortium (VARC)-2 criteria were used for procedural complications [16].

All patients were routinely tracked for mortality using the Office of National Statistics (ONS); 30-day mortality data was collected. Our regional test reporting system was used to detect hospital admissions with stroke within 30 days.

Transfemoral TAVI cases were routinely performed under local anaesthetic with transthoracic echocardiographic guidance unless clinical reasons required otherwise. Transaortic and transapical cases were performed under general anaesthetic with transoesophageal echocardiographic guidance. Edwards Sapien S3 (Edwards Life Sciences, Irvine, CA, USA) and Portico (St Jude Medical, MN, USA) valves were used. TF primary access closure was performed with two ProGlide devices (Abbott Vascular, Santa Clara, CA, USA).

Radial access was obtained using a 6-French Glidesheath (Terumo Medical Corporation, Somerset, NJ, USA). Access to the descending aorta from the radial artery during TF TAVI was typically obtained using a pigtail catheter in the ascending aorta and a hydrophilic guidewire (J-Tip Guidewire, Terumo Medical Corporation, Somerset, New Jersey, USA) (Video 1). Using a 260 cm 0.038″ wire, the pigtail catheter was then exchanged for a 5-French 125 cm Multipurpose (MPA) diagnostic catheter (Cordis, Milpitas, CA, USA) to allow selective iliofemoral angiography (Figure 1).

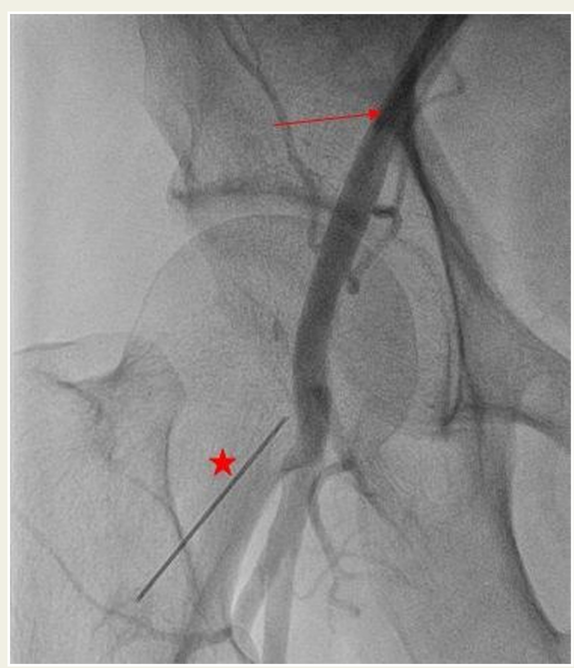

Figure 1 Selective iliac angiography prior to femoral artery puncture via an MPA catheter (arrow) in the right common iliac artery. A micro-puncture needle (star) has been placed at the level of the femoral head.

In cases felt to be at high risk of a peripheral vascular complication, a 6-French 125 cm MPA guide catheter (Cordis, Milpitas, CA, USA) was passed into the descending aorta or common iliac artery prior to large calibre sheath removal, facilitating angiography and intervention if required.

All TF TAVI cases that used TR secondary access in the series had a ''radial bailout kit'' available for peripheral vascular intervention. This included an 400 cm 0.018" wire (Plywire Soft Tip, Optimed, Sydney, NSW, Australia) and several long-shaft 0.018" compatible over-the-wire peripheral angioplasty balloons: 6 mm and 7 mm diameter Pacific Plus balloons (Medtronic, Minneapolis, MN, USA) with a 180 cm shaft, and 8 mm and 9 mm Advance 18LP 150 cm (Cook Medical, Bloomington, IN, USA) with a 150 cm shaft. This combination of equipment allowed access for intervention above or at the arteriotomy site.

Statistical Analysis

Proportions of categorical variables in the two cohorts were compared using a z-test for population proportions. Mean values for continuous variables in the two cohorts were compared using an un-paired t test.

Results

A total of 217 consecutive TAVI cases were performed during the study period. Eighteen (18) cases used multiple secondary arterial accesses for coronary or cerebral protection. There were 20 non-TF primary access TAVI cases (5 transapical, 12 transaortic, 3 subclavian); all underwent successful TR secondary access.

Therefore, 179 cases with TF primary access used single secondary access and constituted the main study group. The patient demographics are shown in Table 1 and the patient selection process is shown in Figure 2.

For the cases with TF primary access, TR secondary access was initially planned in 122 cases and TF secondary access in 57 cases. Seven (7) cases planned for TR secondary access converted to TF secondary access prior to the large bore femoral sheath insertion because of aberrant radial artery anatomy: small calibre radial artery (four cases); impassable radioulnar loop (two cases); arterio-venous fistula in situ (one case). For the purposes of analysis, these seven patients were included in the TF secondary access cohort.

One of the 57 cases planned for TF secondary access converted to TR secondary access prior to the large bore femoral

Table 1 Demographics.

	Non-transfemoral TAVI (n = 20)	Transfemoral TAVI (n = 180)		
		Planned transradial secondary access (n = 115)	Planned transfemoral secondary access (n = 65)	P
Age	83.6 +/− 7.9 (57 – 98)	82.0 +/− 6.2 (64 − 98)	84.9 +/− 5.0 (71 − 93)	0.227
Male	10 (50%)	65 (57%)	33 (51%)	0.459
CCS class > 3	6 (30%)	9 (8%)	5 (8%)	0.976
NYHA class > 3	16 (80%)	95 (83%)	55 (65%)	0.726
Atrial fibrillation	5 (25%)	29 (25%)	16 (26%)	0.928
Permanent pacing pre-procedure	3 (15%)	8 (7.0%)	3 (4.6%)	0.529
Left ventricular function < 30%	3 (15%)	21 (18%)	8 (12%)	0.298
Coronary artery disease	10 (50%)	61 (53%)	18 (28%)	0.001
Left main stem > 50%	1 (5%)	9 (7.8%)	0	<0.001
Previous MI	2 (10%)	21 (19%)	11 (17%)	0.818
Previous PCI	5 (25%)	28 (24%)	11 (17%)	0.246
Previous cardiac surgery	3 (15%)	23 (20%)	10 (15%)	0.441
Diabetic	4 (20%)	23 (20%)	16 (24%)	0.472
Smoking history	16 (80%)	63 (55%)	28 (43%)	0.131
Pulmonary disease	6 (30%)	29 (25%)	18 (28%)	0.819
Previous neurological event	2 (10%)	20 (17%)	10 (15%)	0.726
Poor mobility	0	15 (13%)	16 (25%)	0.057
Peripheral vascular disease	15 (75%)	21 (18%)	7 (11%)	0.183
Moderate or severe MR	0	20 (17%)	9 (14%)	0.535

Abbreviations: TAVI, transcatheter aortic valve implantation; CCS, Canadian Cardiovascular Society; NYHA, New York Heart Association; MI, myocardial infarction; PC, percutaneous coronary intervention; MR, mitral regurgitation.

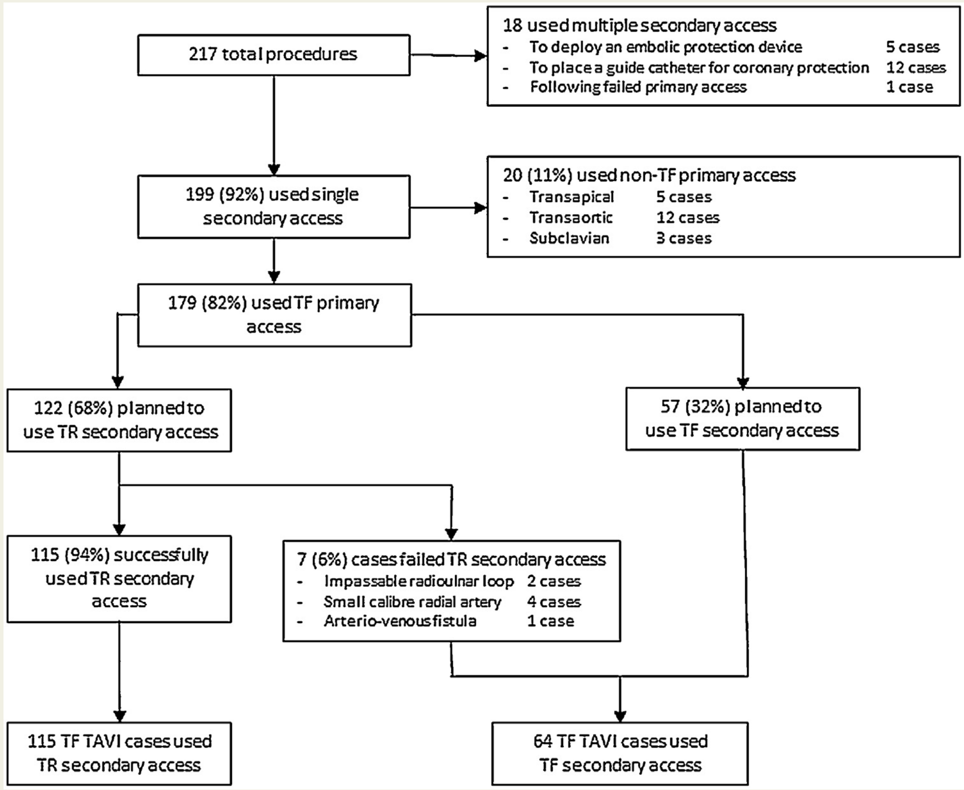

Figure 2 Patient flow.

sheath insertion because of an iatrogenic femoral artery dissection. However, at the time of this case, radial bailout kit was not available in our centre so this case was included in the TF secondary access cohort.

The study groups therefore comprised 115 TR secondary access cases and 64 TF secondary cases (Figure 2).

Of the 115 TR secondary access patients, selective iliac angiography was performed in 19 cases (17%) to guide primary femoral arterial access puncture for the large calibre sheath (Figure 1). In one case, the 125 cm guide catheter would not reach beyond the iliac bifurcation due to patient height and aortic tortuosity but good ilio-femoral visualisation was possible by an injection in the distal aorta. In 30 cases (26%) felt to be at high risk of vascular complications or closure failure, a 6-French guide catheter was placed in the descending aorta prior to removal of the large bore sheath in case intervention was required. In one case, the descending aorta could not be accessed from the right radial artery but was successfully accessed from the left radial. In none of the TR secondary access cases was unplanned or emergent TF secondary access required.

Procedural details for each cohort can be seen in Table 2. There was no significant difference between contrast volume, radiation dose product, screening time or procedural duration between the TR and TF secondary access cohorts.

Procedural complications are shown in Table 3. There were three deaths within 30 days: device failure during transapical TAVI (one case), annular rupture during transfemoral TAVI using TF secondary access (one case), suspected arrhythmic death post-discharge following uncomplicated transfemoral TAVI using TR secondary access (one case). There were no deaths related to primary or secondary arterial access.

There were eight cases of VARC-2 life-threatening bleeding. There were six cases (5.2%) in the TR secondary access cohort: three were related to the primary access site (two cases of occlusive femoral dissection requiring open surgical repair after failed balloon tamponade, and one case of external iliac artery trauma by the delivery sheath guidewire requiring vascular surgical repair); three cases were non-access site related due to LV perforation and tamponade. In the three patients with a primary access site bleed all peripheral intervention options were felt to be exhausted and a covered stent was not felt to be appropriate treatment. No patient in the transradial group had ongoing bleeding which could not be controlled via balloon tamponade from the transradial access site. As a result, unplanned femoral arterial access was not required in any patients in the TR access group and no patients suffered a secondary access complication.

Two life-threatening bleeds (3.1%) occurred in the TF secondary access cohort: one due to annular rupture and one due to complications at both the primary and secondary access site. The latter patient had initial secondary access via the right femoral artery but was complicated by a non-occlusive femoral dissection which could not be negotiated. The right radial artery was used for aortography whilst the TAVI procedure

Table 2 Procedural details.

	Non-transfemoral TAVI (n = 20)	Transfemoral TAVI (n = 179)		
		Planned transradial secondary access (n = 115)	Planned transfemoral secondary access (n = 64)	P
Local anaesthetic	1 (5%)	113 (98%)	64 (100%)	0.535
Conversion to general anaesthetic	0	4 (3.5%)	1 (1.6%)	0.447
Pre-deployment BAV	2 (10%)	26 (23%)	8 (13%)	0.089
Valve implanted				
Edwards Sapien XT	0	1 (0.9%)	11 (17%)	<0.001
Edwards S3	20 (100%)	76 (66%)	48 (75%)	0.280
Portico	0	36 (31%)	5 (7.8%)	0.018
Valve not deployed	0	2 (1.7%)	0	
Median valve diameter	26 mm	26 mm	26 mm	
Post dilatation	0	19 (16%)	5 (7.8%)	0.095
Tamponade	0	3 (0.9%)	1 (1.6%)	0.638
Post-procedure pacing	1 (5%)	6 (5.2%)	2 (3.1%)	0.503
Percutaneous closure device failure	0	4 (3.5%)	1 (1.6%)	0.447
AR ≥ grade II post procedure	0	4 (3.5%)	3 (4.7%)	0.704
Contrast load (ml)	91.5 +/− 68.5 (30–360)	95.7 +/− 41.8 (40–260)	104.0 +/− 76.5 (20–450)	0.212
Radiation dose area product (Gycm^2)	20.1 +/− 10.4 (8–45.2)	25.3 +/− 21.2 (0.7–152)	25.6 +/− 29.6 (5.4–187.3)	0.472
Screening time (mins)	13.1 +/− 11.5 (3.3 − 46.2)	14.3 +/− 8.9 (4.5 − 56.5)	13.0 +/− 11.0 (2.5–68.1)	0.791
Procedural time (mins)	137 +/− 62.9 (55 − 259)	105.2 +/− 47.9 (50 − 380)	96.2 +/− 61.6 (35–380)	0.843

Abbreviations: TAVI, transcatheter aortic valve implantation; BAV, balloon aortic valvuloplasy; AR, aortic regurgitation.

was performed from the left femoral artery. The patient then suffered life-threatening bleeding from the primary access site following removal of the main access sheath; a ''radial bail-out'' kit was not available during this case and therefore further secondary access was secured with a low left superficial femoral artery (SFA) puncture to facilitate successful balloon tamponade. However, an Angioseal closure device placed in the SFA deployed intraluminally, occluding the vessel and requiring open surgical patch repair.

One patient in the TF secondary access cohort suffered a peri-procedural stroke; no strokes occurred in the TR secondary access cohort.

Management of Peripheral Vascular Complications

In 7 of the 64 (11%) cases with TF secondary access, balloon tamponade was performed to achieve haemostasis following primary access sheath removal. Four (4) cases used the cross-over technique from the contralateral femoral; in one case (described above), intervention was performed from a distal ipsilateral SFA puncture. In one further case, a safety wire was deployed from the contralateral femoral but no further vascular intervention was required.

In 19 of the 115 (17%) cases with TR secondary access peripheral vascular intervention was performed: balloon tamponade for ongoing bleeding (seven cases); balloon dilatation and aspiration thrombectomy at the primary access femoral artery following suboptimal peri-procedural anticoagulation (one case); balloon tamponade prophylactically following sheath removal (one case); deploying a 'safety' wire in response to ongoing bleeding which resolved without further intervention (seven cases); attempting to treat an occlusive dissection (two cases); attempting to treat a femoral artery occluded by an Angioseal vascular closure device (one case).

Figure 3 shows one of seven cases utilising a similar technique to obtain haemostasis through balloon tamponade from the TR secondary access site. Following removal of the large bore femoral sheath, ongoing bleeding was noted despite ProGlide deployment. A 125 cm 6Fr MPA guide catheter was placed in the right external iliac artery and angiography demonstrated the bleeding point (Figure 3A). The vessel was wired using a Sion Blue wire (Asahi Intecc,

Table 3 Complications.

	Non-transfemoral TAVI* (n = 20)	Transfemoral TAVI* (n = 179)		
		Transradial secondary access (n = 115)	Transfemoral secondary access (n = 64)	
All-cause 30-day mortality	1 (5%)	1 (0.9%)	1 (1.6%)	0.682
VARC† bleeding				
• Life-threatening	0	6 (5.2%)	2 (3.1%)	0.674
• Major	0	4 (3.5%)	3 (4.7%)	0.704
• Minor	0	8 (7.0%)	7 (11%)	0.373
• Primary access	0	15 (13%)	11 (17%)	0.379
• Secondary access	0	0	1 (1.6%)	0.184
Other complications				
LV‡ perforation	1 (5%)	3 (2.6%)	0	0.190
Annular rupture	0	0	1 (1.6%)	0.184
Device failure	1 (5%)	1 (0.9%)	0	0.190
Stroke				
• In hospital	1 (5%)	0	1 (1.6%)	0.184
• 30 days	0	0	0	

*Transcatheter Aortic Valve Implantation.
†Valve Academic Research Consortium.
‡Left Ventricle.

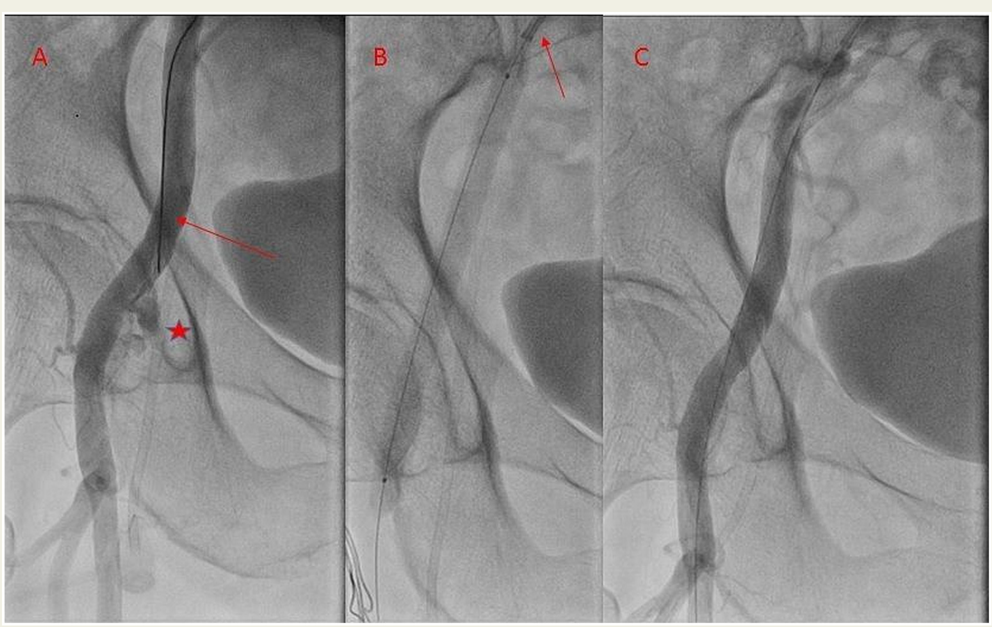

Figure 3 Balloon tamponade for ongoing bleeding following sheath removal.
A – Ongoing bleeding following sheath removal (star). A coronary angioplasty wire (arrow) is passed distally. B – 6 mm Pacific Plus peripheral angioplasty balloon in the femoral artery delivered via an MPA guide catheter (arrow). C – Angiogram showing haemostasis after prolonged balloon inflation.

Aichi, Japan) 0.014″ coronary angioplasty guide wire; the guide catheter was advanced distal to the dissection and the Sion Blue wire was exchanged for a Plywire (Optimed) 400 cm long soft-tip 0.018″ peripheral angioplasty wire. An 8 mm Pacific Plus (Medtronic) 180 cm shaft over-the-wire balloon was then inflated (Figure 3B), sealing the dissection after a single 5-minute inflation and restoring haemostasis (Figure 3C). A further two cases were performed successfully using the same technique. The fourth case used this technique 'prophylactically' following difficult vascular access due to the patient's body habitus rather than in response to ongoing bleeding. There was no bleeding complication. A further two cases deployed a 'safety' wire in response to ongoing bleeding after sheath removal but further ProGlide deployments achieved haemostasis without the need for balloon inflation.

Figure 4 shows a case of thrombotic occlusion of the primary access femoral artery following suboptimal periprocedural anticoagulation. Following uncomplicated deployment of a 29 mm Edwards Sapien S3 valve via the left femoral artery, removal of the primary access sheath was complicated by poor distal flow. A long MPA guide was placed in the left common iliac artery and angiography performed, demonstrating extensive thrombus (Figure 4A). The occlusion was crossed using a Whisper Extra Support wire (Abbott Vascular, Santa Clara, CA, USA) and Corsair microcatheter (Asahi Intecc, Aichi, Japan) support. Initial attempts to perform aspiration thrombectomy using a GuideLiner guide catheter extension (Vascular Solutions Inc, Minneapolis, MN, USA) were unsuccessful as the device would not pass through the thrombus. Using a 6 mm peripheral angioplasty balloon, the guidewire was exchanged for a 400 cm Plywire (OptiMed) and balloon dilatation restored flow (Figure 4B, C). Successful aspiration thrombectomy was performed removing extensive thrombus (Video 2) and restoring excellent flow to the distal vessels (Video 3). No femoral secondary access or surgical intervention was required.

Figure 5 shows one of two cases of flow-limiting femoral artery dissection. Following removal of the large bore delivery sheath and ProGlide deployment, there was significant bleeding. A further ProGlide was deployed; haemostasis was achieved but the femoral pulse became impalpable. Access to the descending aorta from the right radial artery proved impossible due to tortuosity and calcification. Left radial access was obtained and a 6Fr MPA catheter was passed into the left common iliac artery (Figure 5A). Angiography demonstrated an occlusive femoral artery dissection (Figure 5A). Multiple 0.014″ coronary angioplasty wires including dedicated chronic total occlusion wires could not be passed into the true lumen, even with over-the-wire balloon (Figure 5B) and micro-catheter support. Open vascular surgical repair under general anaesthetic was performed after percutaneous options were exhausted. The guide catheter was left in situ and completion of angiography post-repair confirmed vessel patency. During the second case, the guide catheter was again placed into the external iliac artery from the radial approach but multiple guidewires would not find the true lumen; open surgical repair under local anaesthetic was required.

Discussion

Our case series shows TAVI can be performed safely using TR secondary access with no increase in radiation dose, screening time or procedural duration. We also show that with appropriate equipment major vascular complications related to femoral primary access can be managed entirely via the TR approach.

It has been reported that up to a quarter of vascular complications during TAVI result from the use of femoral secondary arterial access [2]. The introduction of transradial coronary angiography and angioplasty has reduced bleeding and access site complications in coronary interventions [8].

Figure 4 Thrombotic occlusion of femoral artery treated percutaneously.
A – Angiography via MPA guide catheter in the iliac artery, showing extensive thrombus and poor flow. B – Balloon dilatation of the femoral artery. C – Angiography showing restoration of distal flow following balloon dilatation. D – Femoral angiography following aspiration thrombectomy.

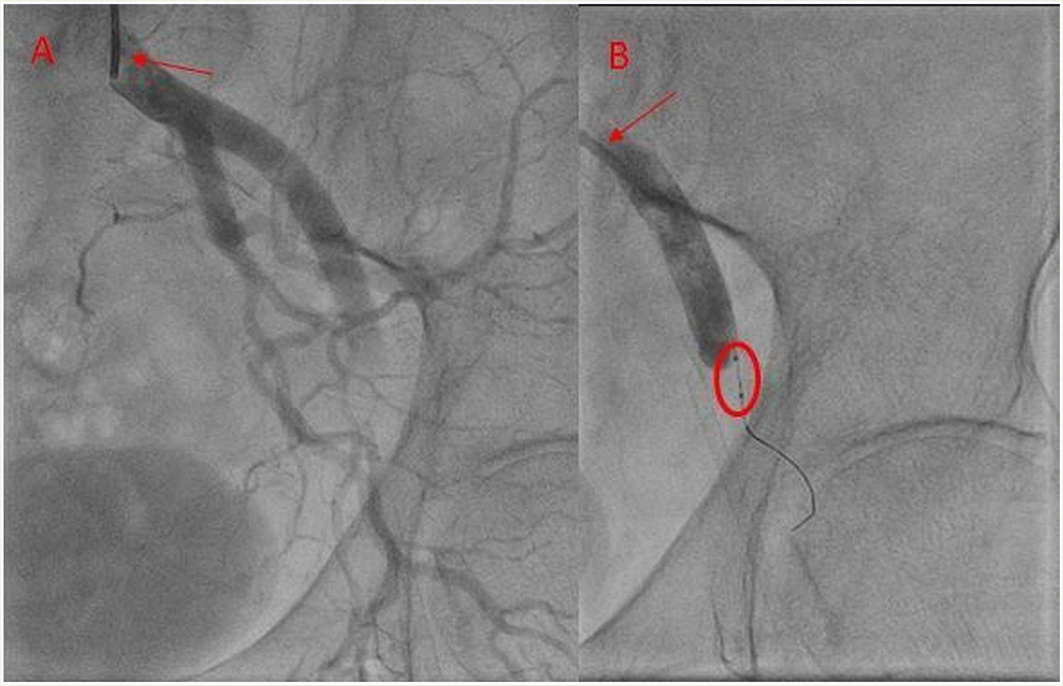

Figure 5 Occlusive femoral artery dissection requiring surgical intervention.
A – Angiography via MPA guide catheter in the iliac artery (arrow), showing occlusive dissection following sheath removal.
B – Image demonstrating the attempts to wire the vessel. Note the MPA guide catheter in the iliac artery (arrow) and over the wire balloon (circle) for additional support.

Logically, the same may be true during TAVI procedures, especially as the elderly patient cohort currently eligible for TAVI are at high risk of developing femoral arterial complications.

Transradial secondary access readily allows aortography to guide valve implantation. For non-TF TAVI cases, this is the sole purpose of secondary arterial access and so TR access can be considered as the default approach. In our series, all non-TF cases were performed using TR secondary access, thus avoiding any TF arterial access, and there were no secondary access complications.

However, a significant concern for TF primary access cases is that the use of TR secondary access may limit options for imaging the iliofemoral tree and managing vascular complications, which typically require crossover techniques from the contralateral femoral artery. Securing emergency femoral arterial access in the setting of a vascular complication is highly undesirable and potentially may result in additional vascular complications.

There are two published series examining the use of TR secondary access during TAVI. Allende and colleagues reported 462 consecutive patients undergoing TAVI; 335 used TF secondary access and 127 used TR secondary access. A total of 75 vascular complications occurred in 70 patients (15%) and 23% of them were related to secondary access. There were significantly fewer secondary access complications in the transradial cohort (0% vs 5%); this translated to significantly fewer secondary access related major and/or life-threatening bleeding events (0% vs 3%). However, the management of primary access site complications from the TR approach was not reported.

Wynne and colleagues reported on 282 patients undergoing TAVI, 250 (89%) of which used TF primary access [9]. Transradial secondary access was used in 74% of all cases including 29 of 31 non-TF TAVIs. There was one TF secondary access site complication (a false aneurysm requiring surgical repair) and no TR secondary access complications. Significant iliofemoral vascular complications occurred in 24 cases (9.6%). In five (2%) cases, significant iliofemoral bleeding required balloon tamponade via an 8 French sheath in the contralateral femoral artery; in three of these cases, this access had to be secured emergently as the initial access was transradial, thus highlighting the issues with routinely using TR secondary access without equipment designed for peripheral intervention. The secondary access complication in our TF cohort occurred following similarly unplanned femoral access in response to significant bleeding, demonstrating the potential risks with this strategy.

In our cohort, in contrast to previous reports, we possessed dedicated interventional equipment which enabled peripheral intervention via the TR approach. In all cases with uncontrolled bleeding, haemostasis was successfully achieved via the TR approach with balloon tamponade including one case of life-threatening bleeding; during insertion of the initial 8-French sheath to secure primary access, the guidewire caused vessel trauma and a large abdominal wall haematoma. Initial haemostasis was obtained using iliac artery balloon occlusion via the

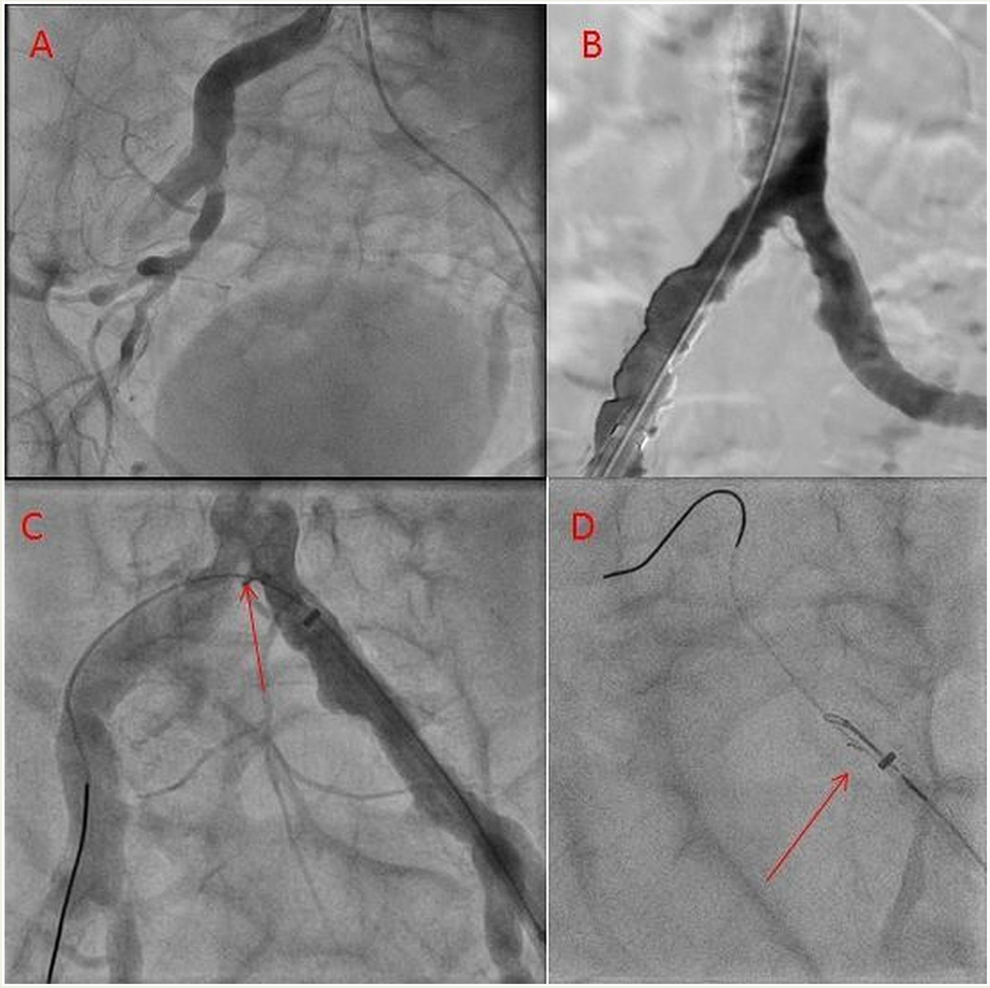

Figure 6 Attempted management of occlusive femoral dissection via contralateral femoral artery.
A – Occlusive femoral dissection following right femoral artery sheath removal. B – Digital subtraction angiography showing tightly angulated aorto-iliac bifurcation with heavy calcification. C – Angioplasty wire 'cheese-wired' into calcification (arrow) causing damage to peripheral angioplasty balloon. D – Gooseneck snare (arrow) retrieving remnants of balloon into sheath.

transradial approach prior to vascular surgical exploration. There were also two cases of occlusive dissection in the TR cohort which required surgical intervention; in these cases, a guide catheter was positioned proximal to the occlusion via the TR approach and all percutaneous options were exhausted prior to the decision to operate. This meant that, unlike the experience of Wynne and colleagues, no patient required unplanned femoral arterial access following successful TR access (either because intervention was successful or no further interventional options would be made available by additional TF access) thus minimising the potential for further vascular complications.

In addition to potentially reducing vascular complications, TR secondary access has other advantages over contralateral TF access. The relatively straight approach into the iliac artery from above removes the need to negotiate the iliac bifurcation, a manoeuvre that can be difficult especially in calcified peripheral vasculature (10,11). In our TF secondary access cohort, there was one case where a peripheral angioplasty balloon became trapped on the tightly angulated, heavily calcified common iliac bifurcation resulting in damage to the balloon (Figure 6A-D); in a second case, it proved impossible to deliver a guide into the contralateral femoral artery due to calcific tortuosity. As a result, even in cases where bilateral femoral access has been established, we now preferentially perform intervention from the radial approach as this offers rapid access to the primary access site. This can be expedited further by having the guide catheter positioned in the iliac artery before removal of the primary access sheath allowing intervention to be performed as soon as a complication is identified.

There are, however, several potential limitations of TR secondary access. Firstly, radial, subclavian or aortic arch tortuosity may make accessing the descending aorta difficult. In cases felt to be at high risk of vascular complications, we ensure that access to the peripheral vasculature is possible by passing a pigtail or multipurpose catheter around the arch and into the descending aorta prior to sheath removal.

A second issue is that there is still a very limited range of interventional equipment available of sufficient length to be delivered to the peripheral vasculature via the radial artery. To allow delivery of 180 cm long balloon catheters a 0.018" diameter guidewire of a minimum length of 400 cm is required. Current available options include the 400 cm Plywire Soft Tip (OptiMed) and the 380 cm Roadrunner Extra Support guidewire (Cook Medical). Although these wires are supportive, they have poor handling characteristics.

Balloons and stents with long catheter shafts are also required. A length of 180 cm is ideal, but 150 cm catheters will reach the common femoral artery in most patients. The Pacific Plus and Extreme range (Medtronic) includes catheters with a 180 cm shaft and balloon diameters up to 7 mm. The Advance (Cook Medical) range includes catheters with a 170 cm shaft and balloon diameters up to 7 mm and a 150 cm shaft and balloon diameters up to 9 mm. These can all be easily passed through a 6-French coronary guide catheter although it should be noted that there may be some resistance to withdrawal of winged larger balloons (8–9 mm).

Nitinol self-expanding stents with 180 cm shafts include VascuFlex (Braun, Berlin, Germany) and Sinus-Superflex-518 (Optimed) and these can be delivered by a 6-French catheter. However, there are, unfortunately, currently no covered stents with long enough catheter shafts to be deployed in the common femoral artery from the transradial approach.

We did not have a complication that required deployment of a covered stent in our TR cohort. Our strategy in this eventuality would be iliac artery balloon occlusion performed via the transradial approach to gain haemodynamic control and stabilise the patient, allowing careful non-emergent additional femoral access to be obtained to facilitate delivery of the covered stent.

Conclusion

Transradial secondary arterial access can be safely performed during TAVI with a low risk of access site complications. Most peripheral vascular complications can be managed from the transradial approach, avoiding the need for unplanned femoral arterial access. Transradial secondary access can be considered as the default approach for non-TF cases and may be considered for all TF primary access cases as long as dedicated interventional equipment is available.

Appendix A. Supplementary data

Supplementary data associated with this article can be found, in the online version, at https://doi.org/10.1016/j.hlc.2018.02.025.

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