Circulation: Cardiovascular Interventions

AHA SCIENTIFIC STATEMENT

Radial Access Approach to Peripheral Vascular Interventions: A Scientific Statement From the American Heart Association

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ABSTRACT: Transradial arterial access has transformed the field of coronary interventions, where it has several advantages over femoral access, such as reduced bleeding and access site complications, improved patient comfort, shorter time to ambulation after the procedure, reduced length of hospital stay, and potentially reduced mortality rates. Because of these benefits, as well as the concurrent expanding indications for various endovascular therapies, there is growing interest in adopting radial access for peripheral vascular interventions. However, radial access can present challenges, and specialized equipment for peripheral interventions through this route are under development. Nevertheless, a growing number of studies, largely comprising single-center and registry data, have broadly suggested that transradial arterial access is likely to be safe and associated with reduced bleeding and local access site complications for most peripheral interventions compared with transfemoral access. Large, prospective randomized trials are lacking, and the question of any effect on mortality rates has not been addressed. Whereas the field of transradial arterial access for peripheral vascular interventions is in development, it is clear that this approach, at least with available equipment, will not be suitable for all patients, and careful case selection is paramount. Furthermore, the remaining knowledge gaps must be addressed, and robust outcome data obtained, to allow full understanding of the factors that determine optimal patient, lesion, and equipment selection. Nevertheless, the use of transradial arterial access for peripheral vascular interventions holds great promise, particularly if the necessary technologic advances are rapid and favorable clinical trial data continue to emerge.

Key Words: AHA Scientific Statements ■ angioplasty ■ endovascular procedures ■ peripheral arterial disease ■ radial artery

Advances in catheter-based technologies, including lower-profile and longer-shaft microcatheters, next-generation vascular scaffolds, and a broad selection of coils and embolic agents, have expanded endovascular treatment options in recent years. Furthermore, a growing body of literature has shown the efficacy of endovascular therapies across a spectrum of conditions that were previously considered unsuitable for peripheral vascular intervention (PVI). Therefore, the indications for endovascular treatment of various visceral, peripheral, and other arterial and nonarterial conditions are increasing.

In parallel, transradial arterial access (TRA) has emerged as a transformative approach for endovascular interventions. Although the most compelling data relate to coronary interventions,[1–3] TRA has distinct advantages, such as reduced bleeding complications, improved patient comfort, shorter time to ambulation after the procedure, and reduced length of hospital stay.[1–4] However, TRA is not without disadvantages; for example, in most patients, TRA is limited to a maximum sheath size of 6-Fr. Nevertheless, as evidence supporting its effectiveness accumulates, TRA holds promise for improved outcomes and contributing to the evolution of minimally invasive techniques in peripheral interventions. We explore the contemporary role of TRA for PVIs, including relevant technical considerations and benefits in terms of potential improvements

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in procedural outcomes and complication rates (Figure 1). This scientific statement should be of particular relevance to all vascular interventional proceduralists and surgeons and all allied health professionals who work in catheterization laboratories or interventional suites.

EXPANDING INDICATIONS FOR PVIs

Underpinning the great interest in TRA for PVI is the substantial growth in procedural volumes and endovascular treatment options for a diverse range of noncoronary indications. Foremost among these is peripheral artery disease (PAD), which is a common condition associated with considerable morbidity and mortality.[5,6] Exercise, smoking cessation, and optimal medical therapy are management cornerstones,[6] but revascularization is often necessary to achieve symptom control or limb salvage. In this regard, recent data show an increasing number of endovascular interventions being performed for PAD, with increasing intervention complexity.[7] Numerous clinical studies support this volume increase. For example, the BASIL-2 trial (Bypass Versus Angioplasty for Severe Ischaemia of the Leg–2) showed superior outcomes with catheter-based intervention over surgical bypass for chronic limb-threatening ischemia with infrapopliteal involvement.[8] The BEST-CLI trial (Best Endovascular vs Best Surgical Therapy in Patients With Critical Limb Ischemia) showed comparable amputation and mortality rates with endovascular revascularization or bypass in patients lacking a suitable saphenous vein conduit for bypass.[9] Endovascular deep venous arterialization is safe and provides the only treatment option for patients with chronic limb-threatening ischemia and no other revascularization options.[10]

There has also been substantial growth in other areas of PVI. The use of catheter thrombectomy for stroke is becoming more common. Data show early revascularization up to 6 hours after symptom onset can significantly improve outcomes.[11] Even delayed intervention up to 24 hours after first symptoms may improve acute stroke outcomes for select patients.[12]

Elective embolization procedures are also increasing. Prostate artery embolization for benign prostatic hypertrophy and uterine artery embolization for fibroids offer patients alternatives to invasive surgery.[13,14] In addition, bleeding from solid organ injury resulting from trauma often can be managed by endovascular embolization.[15] Moreover, in polytrauma, especially involving pelvic injury, TRA can provide a safe route of vascular entry remote from the site of injury.

With these expanding treatment options and positive data, proceduralists have been exploring how to further improve endovascular access approaches and overall outcomes. Considering the data supporting TRA for coronary interventions, discussed below,[1,2] it is logical to explore TRA for PVI.

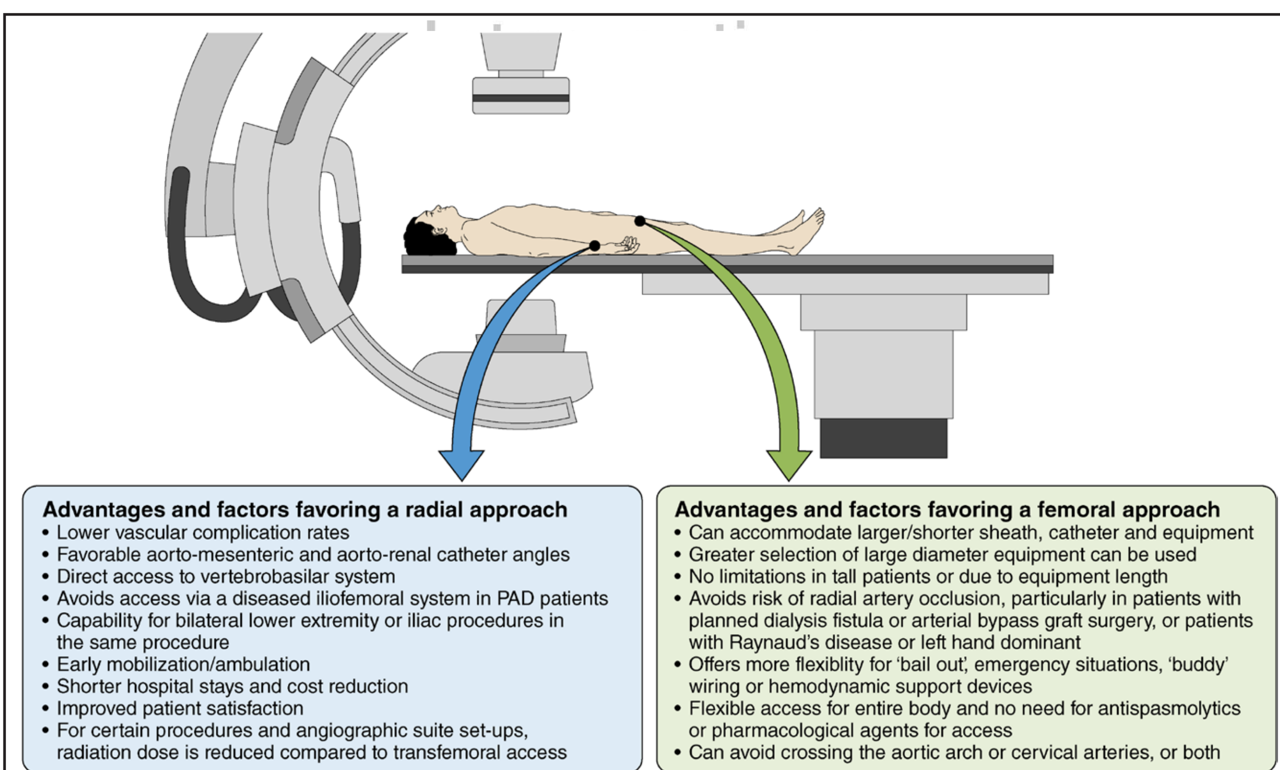

Figure 1. Advantages and disadvantages of transradial arterial access versus transfemoral arterial access for peripheral vascular interventions.
PAD indicates peripheral artery disease.

CONVENTIONAL TRANSFEMORAL ARTERIAL ACCESS FOR PVIs

Transfemoral arterial access (TFA), long the gold standard for arterial interventions, offers several advantages over TRA (Table 1). These include its versatility, because it can facilitate access to any arterial bed in the body. TFA can also accommodate a wide variety of sheath sizes, because the average femoral artery diameter is 7 to 9 mm, compared with the radial artery being 2 to 4 mm. In context, a 6-Fr sheath outer diameter is 2.6 mm, which can usually be accommodated by TRA. However, PVIs may require larger sheaths for interventions in the aortoiliac system or for certain devices (eg, >8 mm balloon-expandable stents or covered stents).

The main disadvantage of TFA is vascular complications, with the prevalence of major complications from the coronary literature varying from 1% to 3%,[16] depending on factors such as exact definitions, operator experience, and patient features. These may include life-threatening retroperitoneal hematoma, particularly if TFA is performed above the inguinal ligament. Other complications include pseudoaneurysm or arteriovenous fistulas. Complication rates from TFA can be reduced, although not eliminated, by contemporary techniques, including ultrasound and the use of anatomic and radiologic landmarks, thus improving first-pass cannulation rates.[17] Nevertheless, certain patient factors increase the risk of TFA complications, such as obesity or presence of a large pannus, and TRA is an attractive option in these scenarios (Table 2).[18]

TRA: OVERVIEW AND RESULTS FROM THE CORONARY FIELD

TRA was initially adopted for arterial access because of the superficial position of the radial artery and its easy compressibility. TRA has matured as an approach, and several large studies and meta-analyses have proven it is superior to TFA for coronary artery diagnostic and intervention procedures, with reduced access site complications, bleeding, and mortality rates in certain cases.[1,2] Furthermore, TRA is superior to TFA in certain high-risk groups, such as women and the elderly.[19,20] Initial concerns with TRA, such as the learning curve, stroke risk, and higher operator/patient radiation dosing, have largely been debunked.[21–23] TRA allows patients to ambulate

Table 1. Suggested Indications and Lesion Types in Which Using TFA Rather Than TRA May Be Preferred When Performing PVI

Conditions	Reasons
Patient and lesion factors	
Absent radial pulse	Cannot access radial artery
Incomplete palmar arch, small or absent ulnar artery*	Risk of hand ischemia
Functional arteriovenous fistula or planning for arteriovenous fistula (eg, end stage renal disease requiring hemodialysis)	Need to preserve radial access
Potential need for radial artery as graft conduit (ie, for coronary artery bypass graft surgery)	Need to preserve radial access
Subclavian artery occlusion or stenosis	Cannot reach aortic arch in subclavian occlusion; in the case of severe stenosis or heavy calcific disease, need for intervention and manipulation to gain arch access may be associated with higher risk of stroke
Severe aortic arch atheromatous disease	May be associated with higher risk of stroke due to atheroembolization
Raynaud disease	Small radial artery size, prone to spasm with risk of occlusion and hand ischemia
Hostile iliac anatomy	Need for occlusion balloon or bailout covered stent is challenging with radial approach and needs large-bore access emergently
Tall patients, tortuous aortoiliac anatomy, distal lower limb target lesion	Need for longer delivery systems for endovascular devices; the shaft length for long sheaths is ≈110 cm, balloons are limited to 150 cm and stents to 135 cm
Technical and procedural factors	
Large-bore sheath interventions (7-Fr or larger [eg, larger balloon-expandable or covered stents])	Risk of radial artery occlusion due to higher sheath:artery size ratio and hand ischemia
Need for 2 wires for simultaneous vessel intervention	Requires ≥7-Fr sheath to perform kissing balloon or stent interventions
Left carotid interventions	Difficult to access from left radial approach
Typically for distal PAD lesions, where the site of intervention is potentially beyond the level approachable by available stent delivery catheter lengths using TRA	Given that the need for bailout stenting is always possible (eg, in the setting of dissection or perforation), it may be unsafe to undertake PVI using TRA if the lesion is beyond the level potentially approachable by available stent delivery catheter lengths; depending on the exact lesion location and anatomy, TFA may be preferable in these cases

Some of these conditions are absolute contraindications to TRA (eg, absent radial pulse), many are relative indications, and others are factors that should be considered in the selection of TRA versus TFA. Individual patient-specific factors and preferences are also important to consider in each case. Table 1 was created by the authors based on their experience, and also after synthesizing all the articles cited in this scientific statement. PAD indicates peripheral artery disease; PVI, peripheral vascular intervention; TFA, transfemoral arterial access; and TRA, transradial arterial access.

*Allen or Barbeau tests are no longer considered to be useful for assessing risk of hand ischemia.[3]

Table 2. Suggested Indications and Lesion Types in Which Using TRA Rather Than TFA May Be Preferred When Performing PVI

Conditions	Indications
PAD lesion types in which TRA may be preferred	TASC A or B lesions
	Stenosis rather than occlusion
	Shorter lesion lengths
	Above-knee lesions
Relative indications for TRA	Previous bilateral femoral artery surgery (eg, prosthetic grafts)
	Previous iliac bifurcation kissing stents or bifurcated aortic graft with planned pelvic or leg PVI
	Bilateral lower limb lesions planned for intervention in a single procedure
	Obesity
	No palpable femoral pulses
	Polytrauma with pelvic injury
	Need for high-dose antithrombotic therapy or concurrent anticoagulation (ie, for atrial fibrillation)*
	Previous major femoral access site complication†
	Other reasons for "hostile groin" (ie, fungal infection, skin breakdown, high femoral artery bifurcation)

Few of these factors are absolute indications or contraindications to choose a radial versus femoral or other approach. Several of these factors are also dependent on the target lesion site, whereas certain other of these factors may be of particular relevance to operators with limited TRA experience. PAD indicates peripheral artery disease; PVI, peripheral vascular intervention; TASC, TransAtlantic Inter-Society Consensus; TFA, transfemoral arterial access; and TRA transradial arterial access.

*There is a lack of reliable data to support or reject this relative indication.

†Whereas specific data are lacking, this potentially applies for both previous ischemic and bleeding complications.

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faster and enables early discharge to home. Shorter lengths of stay and lower complication rates ultimately represent fiscal benefits to the health care system.[24] TRA also correlates with increased patient satisfaction versus TFA.[3] Despite numerous differences between coronary versus peripheral procedures, these compelling data, which have changed clinical practice and led to the widespread adoption of TRA for coronary procedures, are important reasons for using TRA in PVIs.

TECHNICAL CONSIDERATIONS REGARDING TRA FOR PVIs

This scientific statement does not cover technical aspects specific to accessing the radial artery that are shared with coronary interventions, such as wrist dorsiflexion, use of arm boards, ultrasound guidance, or agents to reduce spasm and risk of hand ischemia (eg, verapamil, nitroglycerin, heparin), which are reviewed elsewhere.[3,25] Rather, we focus on technical aspects that are unique to noncoronary PVIs. The advantages and factors favoring either TRA or TFA are summarized in Figure 1. Situations where either TFA or TRA is preferred are presented in Tables 1 and 2, respectively. Potential complications of TRA are summarized in Figure 2.

When contemplating TRA in cases where either TFA or TRA may be an option, essential factors that require consideration are the anatomic location of the target lesion and the lesion characteristics. For neurointerventions, including in the carotid vessels, it is usually preferred to access the right radial artery, but a target lesion involving the left vertebral artery (or requiring passage through this artery) is a major potential exception. Left TRA is generally preferred for subdiaphragmatic PVIs because the vascular trajectory of right TRA traverses the innominate and vertebral arteries plus the arch, whereas left TRA only crosses the left vertebral artery, thus theoretically reducing the risk of cerebral embolization.[26] Furthermore, in patients with elongated aortic arches (eg, type III arch), accessing the descending aorta from the right radial artery may be difficult, and even in normally configured aortic arches, catheter passage into the descending aorta is usually more straightforward through the left TRA. As another major factor for subdiaphragmatic PVIs, compared with right TRA, left TRA reduces the distance to the target vessel or lesion by ≈10 cm.[27] Combining left TRA with a high radial puncture can help overcome limitations imposed by catheter length for subdiaphragmatic interventions.[27] For pelvic and lower limb interventions, the patient's height can be another critical factor, with distal lesions in tall patients usually requiring TFA because of catheter length limitations.

Compared with coronary interventions, PVIs often require larger sheath sizes, which can pose issues for TRA.

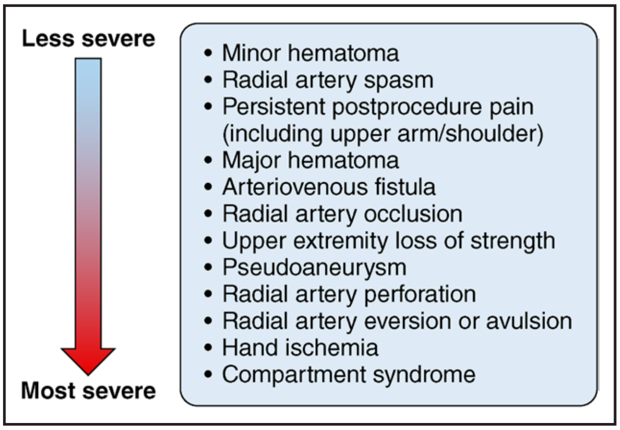

Figure 2. Potential access site complications that may arise from transradial arterial access.
The rates of access site complications vary depending on how assessments for complications are made, use of imaging for this purpose, and other factors. Not all patients are evaluated for asymptomatic or minimally symptomatic access site complications, so true complication rates are challenging to define.

Radial artery spasm and occlusion are challenges that can arise with TRA. Radial artery spasm occurs in >20% of patients, with younger age, female sex, diabetes, and lower body mass index being independent predictors of this complication.[28] Additional factors likely include small radial artery diameter, large sheath:artery ratio, and multiple catheter exchanges. The risk of radial artery occlusion is generally considered to be ≈5% to 6% (lower in contemporary studies), depending on the use of clinical examination versus duplex ultrasonography for diagnosis and the timing of assessment.[29] Small radial artery caliber and a sheath:artery ratio >1, female sex, smoking status, and older age are the strongest predictors of radial artery occlusion.[30,31] Factors that likely reduce the risk of radial artery occlusion include the use of hydrophilic sheaths, not exceeding 6-Fr sheath size, heparin administration (with high-dose unfractionated heparin [100 IU/kg] being superior to standard dose [50 IU/kg]),[32] and attention to optimal hemostatic techniques.[3,29] Radial artery occlusion can be clinically significant in patients with a dominant radial artery, incomplete palmar arch, or occluded ulnar circulation, and can lead to hand ischemia (Figure 2). Therefore, whereas the need for sheath size >6-Fr using the radial artery is not an absolute contraindication, it is an important potential factor against TRA.

Equipment availability is another technical consideration that is interrelated with target lesion location and characteristics, and, in some cases, the patient's height. Proceduralists and the angiographic team should be familiar with all available equipment, and when planning for possible TRA for PVI, and again during the "time-out" immediately before commencing the intervention, should pose the question: "Do we have the necessary catheters, wires, and other equipment to successfully intervene on this lesion using TRA, and what is our bailout strategy?"

SYSTEMATIC REVIEW OF LITERATURE FOR RADIAL ACCESS IN PVIs

The following is a systematic review of key literature for TRA in more commonly performed PVIs.

Neurovascular Interventions

While TFA is still used in most neurointerventional cases, the use of TRA is rapidly increasing and there are obvious situations where it may be preferred; for example in patients with basilar artery occlusion, or those with severe abdominal aortic calcifications or aneurysms. TRA is particularly attractive for outpatient procedures, because patients can be ambulated immediately after the procedure. However, there are many cases where there is no clear access preference, and in other situations TFA has been the preferred traditional access. Nevertheless, a growing number of neurointerventionalists are beginning to use TRA as the default access route.

As already discussed, compared with TFA, TRA somewhat limits the diameter of devices that can be used. For certain neurointerventions requiring larger equipment (particularly mechanical thrombectomy catheters for clot retrieval in acute stroke), this may be a limiting factor. Certain retrospective acute ischemic stroke intervention data have suggested superior reperfusion rates, fewer catheter passes, and improved functional outcomes with TFA (with >90% 8- or 9-Fr access) compared with TRA (100% 6-Fr access).[33] However, the field is evolving rapidly, and numerous smaller devices for neurointervention dedicated to TRA have been developed, including a sheathless balloon guide catheter for stroke thrombectomy.[34] Apart from this and other key considerations (Tables 1 and 2 and Figures 1 and 2), the 2 main factors when choosing an access site for neurointervention are expected procedure time and risk of iatrogenic emboli to the brain.

Procedure Time

Neurointerventions should be as brief as possible. With longer durations of both emergent and elective procedures, the risk of several complications increases, most notably thrombus formation on catheters and wires with subsequent thromboembolism and cerebral infarction.[35] Procedure time correlates closely, albeit not perfectly, with vascular tortuosity along the access pathway.[36] Thus, the access site should be chosen to minimize the vascular tortuosity needing to be traversed. In some instances, the optimal access site to minimize procedure time will be TRA; in other cases, TFA will be preferable. Although certain single-center publications suggest TRA procedure times may be shorter, these publications are potentially biased in patient selection.[37] No robust data exist to suggest the overall superiority of either access route, and the selection of the optimal access site should be individualized.

Iatrogenic Embolism

The risk of iatrogenic embolism is closely related to procedure time, vascular tortuosity along the access path, and atherosclerotic burden. Clinically overt stroke as a result of iatrogenic periprocedural embolism is rare, but so-called "silent hits" or "covert brain infarcts" on magnetic resonance diffusion-weighted imaging (DWI) are reported in 5% to 23% of diagnostic angiograms.[38] In more complicated interventions requiring numerous equipment exchanges and deployment of stents, this burden is likely higher. Whereas these "DWI hits" were once thought to be of little relevance, there is growing evidence suggesting they negatively affect long-term cognitive outcomes.[39,40] In a recent survey among neurointerventionalists, >40% thought that the presence of even a single DWI hit was unacceptable after a neurointerventional procedure, and would choose severe access site complications such as a hematoma requiring surgical evacuation over a DWI hit.[40] Overall, it seems prudent to minimize both procedure-related overt brain infarcts and silent DWI hits. It is not clear which access route is preferable to minimize procedure-related infarcts: 1 single-center study that analyzed 200 digital subtraction angiograms suggested more silent DWI hits with TRA (18%) compared with TFA (5%).[41] Even with TFA, however, DWI hits have been reported to occur in 17% of diagnostic angiograms.[42] Additional neurointerventional research is needed to better define the factors that signify the optimal access route in a particular patient.

Renal, Mesenteric, Uterine, and Other Arterial Interventions in the Abdomen or Pelvis

Both in terms of technical success and complications, multiple studies suggest that TRA is noninferior to TFA for renal, mesenteric, uterine, and other abdominal cavity arterial interventions. However, most of these studies were retrospective and likely involved various biases, including selection and proficiency bias.

A number of single-arm retrospective studies that enrolled patients undergoing differing interventions in the abdominal cavity suggest that TRA is safe and well tolerated.[43,44] Each of these studies included a mixture of procedures, such as renal artery intervention, hepatic embolization or transarterial chemoembolization (delivering chemotherapy directly to a tumor while blocking its blood supply), uterine artery embolization, and selective internal radiation therapy (Y90 therapy), including mapping and administration. Crossover rates from TRA to TFA were as low as 1.8%.[43] Multivariate analysis in 1 study showed that the only significant predictor for crossover to TFA was the type of endovascular intervention (ie, renal/visceral interventions and endoleak repair).[43] Distal radial arterial access was also demonstrated to be feasible and safe for noncoronary PVIs in these arterial beds.[45]

These findings have been broadly replicated in studies dedicated to specific interventions. For example, a randomized controlled trial comparing TRA with TFA for uterine artery embolization showed equivalent efficacy and safety.[46] Retrospective studies comparing TRA with TFA for trauma-related endovascular interventions have shown that TRA is noninferior to TFA with regard to technical success.[15] Findings were again replicated in studies dedicated to patients undergoing hepatic interventions. For example, a systematic review and meta-analysis of TRA versus TFA for endovascular hepatic interventions showed longer procedural time in the transradial group, but no significant difference in success rate, fluoroscopy time, radiation dosage, contrast volume, or overall complication rates.[47] Comparison studies between TRA and TFA showed similar technical success using TRA for transarterial chemoembolization for patients with hepatocellular carcinoma,[48] although a single-center randomized crossover-controlled trial demonstrated a strong patient preference for TRA.[49] Operator radiation dose exposure was lower during transarterial chemoembolization for hepatocellular carcinoma with patients in a feet-first position with left TRA performed through an abducted left upper arm.[50]

Advantages and Disadvantages of TRA for PVI in the Abdominal and Pelvic Cavities

Multiple studies have shown that patients prefer TRA to TFA access for abdominal cavity PVIs.[44,47–49] Furthermore, the orientation of the celiac trunk and mesenteric arteries from the aorta lead to coaxial catheter cannulation and greater guide support using arm access compared with TFA.[15,27] TRA is useful for renal artery procedures because these vessels are usually directed inferiorly,[27] leading to coaxial engagement and more guide catheter support using TRA. Distance and arterial diameter are specific limiting factors for TRA when performing endovascular visceral interventions.[27] Failure to cannulate the target visceral artery because of inadequate catheter length can occur in tall patients undergoing endovascular procedures using TRA,[15] because the longest available catheter is often 150 cm.[15] This limitation especially applies to the pelvic vasculature.[15] There are little data specific to TRA for arterial interventions in patients with acute gastrointestinal bleeding, but given the acknowledged reduction in bleeding events for TRA as compared with TFA, this indication might be particularly well suited to a radial approach.

Iliofemoral, Femoropopliteal, and Inferopopliteal Interventions

TFA historically has been used for lower limb diagnostic angiography and interventions, because it provides easy access and the ability to complete successful revascularization of various lesions and complexities.[27] However, the fact that PAD often spares the upper extremities, and the extensive literature supporting the safety of TRA for coronary interventions,[1,2] provides an important rationale for using radial access for lower limb PVIs. Furthermore, unlike TFA, a unique feature of TRA is the ability to treat bilateral lower limb lesions in the same procedure.

TRA for PAD evolved first from pilot feasibility studies, followed by various observational studies with relatively small size and power. The recent randomized TRIACCESS study compared TRA, TFA, and transpedal arterial access (TPA) for the treatment of symptomatic superficial femoral artery stenosis, with 60 patients randomized to each group.[51] Technical success was achieved in 96.7%, 100%, and 100% using TRA, TFA, and TPA, respectively. Secondary access sites were used in 30% of patients in the TRA and TPA groups, but only in 3.3% of patients in the TFA group. Radiation exposure was lower with TPA than TRA or TFA, and, as a key finding, the cumulative rates of access site complications in TRA, TFA, and TPA groups were 3.3% (0 major), 16.7% (3.3% major), and 3.3% (3.3% major), respectively (P=0.009). The authors concluded that femoral artery intervention can be performed safely and effectively using any access, but TRA and TPA are associated with fewer access site complications, whereas TPA was associated with reduced radiation exposure.[51] These findings have been reinforced by meta-analyses comparing TRA with TFA[52,53]: Meertens et al,[53] including 19 studies comprising 638 patients undergoing lower extremity interventions, demonstrated a significantly lower risk of complications with TRA versus TFA.

Limitations of TRA for lower limb arterial interventions include short equipment length, lesion complexity, operator experience, and patient anatomy (eg, long arms and upper body). However, improvements in equipment are progressively reducing the importance of these limitations. For example, extended-length devices have been used for popliteal and below-the-knee lesions, including the use of atherectomy, with improved technical success.[4,54] Nevertheless, previous studies demonstrated that patients with a Transatlantic Intersociety Consensus lesion classification of A or B have higher lesion success compared with patients with a D classification (Table 2).[18,55] Although, a recent prospective study demonstrated technical and clinical success in more complex lesions.[4]

CONTEMPORARY ROLE AND SUGGESTIONS AND CONSIDERATIONS REGARDING RADIAL ACCESS FOR PVIs

As has been the case with the transition from TFA to TRA for coronary interventions, dedicated techniques, technologies, and relevant training are essential for enhanced adoption. The necessary concepts can be divided into obtaining access and ergonomics of the angiographic suite setup, ensuring appropriate equipment size (mostly length), and conceptualizing the potential technical advantages and modifications of this new approach.

Regarding access itself, ultrasound-guided radial artery puncture involves equipment and techniques well understood by all specialties involved in PVI, which are widely available in hospitals with cardiac catheterization laboratories. If necessary, brief refresher type crosstraining on TRA and closure with the interventional cardiology team (eg, doctors, nurses, technicians) could be accomplished easily. Distal TRA remains a less common approach for coronary interventions and may impose further restrictions on equipment size (eg, longer catheter shaft and perhaps low upper limit in catheter diameters). Hence, distal TRA may be considered later or on a smaller scale for PVI, after adequate patient selection.

The ergonomics of the PVI angiographic suite will change somewhat with TRA because of the different location of the operators and support table; the feet-first patient position will require another arrangement, if used. For lower limb PVIs, there would not be a need to work as close to the X-ray source as when TFA is used, because of distance and easier X-ray shielding. This major benefit of TRA for patients and staff should be considered an important practical motivation factor.

Regarding equipment, most PVI catheters are already compatible with the 5- to 6-Fr sheath sizes that are commonly used for TRA. Further miniaturization of specific equipment, such as atherectomy devices, covered stents, and other less commonly used equipment, will be important, but does not appear to be a major obstacle. Consideration should be given to the miniaturization of an aortic occlusion balloon, which is an important safety item for iliac PVIs. Smaller-caliber balloons for balloon valvuloplasty, which could also be used for iliac procedures, are available in Europe, and international expansion of this technology would allow its broad adoption. The improved availability of long hydrophilic sheaths and catheters compatible with the different distances to PVI target lesions, particularly for lower limb PAD interventions, will help increase uptake of TRA. Device supply chain considerations and the costs required to produce specialized equipment to perform PVIs using TRA will inevitably be an important market factor that influences this evolving field.

Additional clinical studies and randomized trials are required to investigate the various steps and indications of new techniques in TRA for PVI. The primary goal is to affirm the reduction of access site complications and shortened ambulation times compared with TFA. Enhanced radiation safety might be another aim; equipment-oriented comparisons in efficacy and safety outcomes should also be expected. In addition, cost-effectiveness comparisons that include demonstrating the financial viability of this approach are needed. A simpler way to perform PVIs, with higher patient satisfaction and enhanced access closure safety, might favorably affect the overall view of PAD angiographic imaging and interventions, because PAD generally remains underdiagnosed and undertreated. Nevertheless, several practical challenges need consideration when designing future studies of TRA for PVI. These include choosing the best outcome measure (eg, access site complications, brain hits on DWI). Furthermore, study enrollment may become difficult, as the growing number of proceduralists who perform high volumes of TRA PVIs may be reluctant to randomize patients to TFA.

CONCLUSIONS

The rapidly expanding field of TRA for PVIs is at an exciting stage of evolution, similar to TRA in the coronary field of ≈2005 through 2010, but with a few major differences. When the coronary field was at this stage of evolution, there was no exemplar or other discipline in which TRA was already known to be superior to TFA, the majority of coronary interventionalists and other catheterization suite staff were facing a steep learning curve to upskill in TRA, and the available equipment and methods of accessing the radial artery were markedly underdeveloped. When considering TRA for PVI, many of these issues have been overcome, and a clear road map is available for how to implement TRA most effectively. In appropriate patient groups (ie, those undergoing coronary interventions), TRA is the preferred and safest access route.

What remaining issues must be overcome before TRA becomes the preferred access route for PVIs? Apart from relatively easily solved issues, such as training staff and developing a greater range of dedicated equipment, the major barrier is a lack of robust, prospective, randomized controlled data indicating the superiority of TRA for PVI. However, at a minimum, TRA for PVI can be expected to be associated with a reduction in bleeding and access site complications compared with TFA. Whether TRA for PVI will also translate into reduced mortality rates (as in the acute coronary intervention field) remains to be seen and can only be answered with the aforementioned large, prospective randomized controlled trials. This broadly positive outlook begs the question: Should TRA be adopted as the preferred access route for all PVIs? After careful consideration, we suggest not. Our concern, as in the coronary field, is that patient selection is crucial, and TRA will never be the universally preferred access. Indeed, as discussed in this scientific statement, regardless of how TRA continues to evolve, TFA will likely remain the preferred access for certain patients (Table 1). By working systematically in a collaborative fashion to address and resolve the aforementioned issues facing TRA for PVI, we can minimize any risks of patient harm that could arise if a widespread switch to TRA for PVI is made prematurely. Moreover, by tackling the remaining issues and knowledge gaps methodically, researchers and proceduralists will gain collective knowledge on optimal patient and device selection to ensure that the best possible outcomes can be achieved with TRA, and that the full potential of this approach can be realized.

ARTICLE INFORMATION

The American Heart Association makes every effort to avoid any actual or potential conflicts of interest that may arise as a result of an outside relationship or a personal, professional, or business interest of a member of the writing panel. Specifically, all members of the writing group are required to complete and submit a Disclosure Questionnaire showing all such relationships that might be perceived as real or potential conflicts of interest.

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(*Continued*)

Writing Group Disclosures Continued

Writing group member	Employment	Research grant	Other research support	Speakers' bureau/ honoraria	Expert witness	Ownership interest	Consultant/ advisory board	Other
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This table represents the relationships of writing group members that may be perceived as actual or reasonably perceived conflicts of interest as reported on the Disclosure Questionnaire, which all members of the writing group are required to complete and submit. A relationship is considered to be "significant" if (a) the person receives $5000 or more during any 12-month period, or 5% or more of the person's gross income; or (b) the person owns 5% or more of the voting stock or share of the entity, or owns $5000 or more of the fair market value of the entity. A relationship is considered to be "modest" if it is less than "significant" under the preceding definition.

*Modest.

†Significant.

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This table represents the relationships of reviewers that may be perceived as actual or reasonably perceived conflicts of interest as reported on the Disclosure Questionnaire, which all reviewers are required to complete and submit. A relationship is considered to be "significant" if (a) the person receives $5000 or more during any 12-month period, or 5% or more of the person's gross income; or (b) the person owns 5% or more of the voting stock or share of the entity, or owns $5000 or more of the fair market value of the entity. A relationship is considered to be "modest" if it is less than "significant" under the preceding definition.

*Modest.

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