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Update on Transradial Access for Percutaneous Transcatheter Visceral Artery Embolization

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Transfemoral access (TFA) is a widely used first-line approach for most peripheral vascular interventions. Since its introduction in cardiologic and neurointerventional procedures, several advantages of transradial access (TRA) over TFA have been demonstrated, such as patient preference, lower complication rates, early ambulation, and shorter hospital stay. However, studies reporting the safety and efficacy of this approach for peripheral vascular interventions performed by interventional radiologists are relatively few. This review aimed to summarize the technique and clinical applications of TRA in percutaneous transcatheter visceral artery embolization and the management of complications.
Keywords: *TRA; TFA; Visceral artery embolization; Review*

INTRODUCTION

Since the introduction of transradial access (TRA) in cardiology in 1989 (1), evidence favoring TRA over transfemoral access (TFA), in terms of patient preference, quality of life, lower complication and morbidity rates, and shorter hospital stay, has been presented (2-8).

Most studies on TRA were based on cardiology and neurointerventional procedures, and studies of the use of TRA in body and peripheral interventions performed by interventional radiologists are relatively few (4, 7-15). In this review, we aimed to compare the difference between TRA and TFA, provide the detailed technique and clinical applications of TRA in percutaneous transcatheter visceral artery embolization, and discuss the management of complications.

Comparison of TRA vs. TFA

Femoral Access

Percutaneous puncture of the right common femoral artery is performed during anterior wall puncture using palpation or ultrasound guidance with a micropuncture kit or an 18-gauge arterial cannulation needle using a modified Seldinger's technique. The puncture site for the femoral artery should be below the inguinal ligament to control bleeding and prevent bleeding into the pelvis.

Radial Access

Preprocedural radial artery assessment is performed using the Barbeau test. With the patient's left arm abducted to 75–90°, the left radial artery is accessed by performing a single-wall puncture under ultrasound guidance. Customarily, the operator stands on the patient's right side during the procedure, with the monitors on the patient's left. If a left radial approach is planned, the operator can maintain routine room/monitor setup by reaching over the body to the patient's immobilized left arm, or by draping the left hand across the lower chest in a "Napoleonic" pose. The technical details are described in the following TRA technique.

Advantages of TRA over TFA

First, TRA is associated with a lower risk of access

site complications; the patient-friendly compression device enables faster hemostasis and recovery, leading to shorter hospital stay (4, 5). Fewer bleeding and vascular complications were reported in the majority of studies on cardiology, neurointervention, and body/peripheral interventions (4, 6, 16).

Second, TRA is more convenient for patients as their legs can freely move during the procedure and is also feasible in patients with obesity. A cushion can be placed below the patients' knees except during lower extremity procedures. TRA allows for greater overall patient satisfaction and was preferred by 73–79% of patients who were indicated for noncoronary interventional procedures (7, 8, 16). TRA provides a new patient-centric model and represents the best practice for developing a health care landscape (8).

Third, TRA is a more favorable approach for certain anatomical landmarks, such as selection of mesenteric, uterine, or iliofemoral arteries. For example, the mesenteric vessels generally arise at an acute angle from the aorta, making TRA (antegrade approach) easier to perform than TFA (retrograde approach). In addition, angiography in the prone position is possible with TRA, enabling the performance of combined single-session transarterial embolization and percutaneous procedure from a posterior approach, such as kidney or pelvis ablation or biopsy, without repositioning (17, 18). However, fine manipulation might be difficult due to angulation at the aortic arch and the relatively long length of the catheter.

Fourth, improved cost benefits are observed due to the cost savings from TRA owing to the use of alternative hemostasis devices without the use of femoral closure devices (16, 19).

Disadvantages of TRA over TFA

First, TRA requires the use of long catheters/wires. Catheters receive less support and may be vulnerable to respiratory motion. Procedures like stenting or angioplasty can be limited by the maximum diameter of catheters and sheaths. A longer microcatheter length makes it difficult to use particles larger than 900 µm due to frequent catheter occlusions, according to Poiseuille's rule (10).

Second, as the left radial artery is accessed, the room settings may not be familiar. A learning curve is required before the benefits and efficiencies become clear (8).

Third, TRA may be affected by the patient's anatomy. For example, being tall, having a tortuous aorta, or having long arms may affect TRA.

Fourth, radial artery cocktails are necessary for TRA to prevent vasospasm and thrombus. During the administration of the cocktails, the operators should be concerned about the potential for hypotension and bradycardia associated with verapamil administration.

Technical and Clinical Success Rates of TRA vs. TFA

The technical and clinical success rates of TRA are generally comparable to those of TFA in the majority of procedures: transarterial embolization for hepatic malignancy (7, 8, 11, 13), mesenteric arterial procedures (4), prostate artery embolization (20), or uterine fibroid embolization (10). Very recently, Nakhaei et al. (10) compared the clinical and technical outcomes of TRA uterine artery embolization (UAE) with those of the TFA approach. There were 91 patients in the TFA group and 91 patients in the TRA group, with one crossover to TFA due to vasospasm (1 of 91; 1%). There were similar low rates of minor access site complications (6.6% [6 of 91] in the TFA group vs. 5.5% [5 of 91] in the TRA group).

Radiation Dose and Fluoroscopy Time

The radiation dose and fluoroscopy time remain controversial. Although some studies have claimed increased radiation dose and/or fluoroscopy time during TRA (11, 12, 21), several studies reported no significant difference in radiation dose or fluoroscopy time between TRA and TFA (8, 13-15, 22).

Operator radiation exposure could be reduced with TRA due to the positioning of the radiation shield and the longer distance between the operator and radiation source (8).

TRA Technique

Barbeau Test

Before TRA is performed, all patients undergo a modified Allen's test with a pulse oximeter, also known as the Barbeau test (23). It is essential to evaluate the collateral circulation of the hand through Barbeau test, to avoid ischemic hand complications. A pulse oximeter is placed on the patient's thumb, the radial pulse is identified, and the waveform is analyzed. The radial artery is then compressed, and the pulse oximeter waveform is again analyzed for up to 2 minutes and graded. Depending on the type of waveform, a registered ulnopalmar patency has the following four types: A) no damping of pulse tracing immediately after compression, B) damping of pulse tracing, C) loss of pulse

tracing followed by recovery within 2 minutes, and D) loss of pulse tracing without recovery within 2 minutes (Fig. 1). According to Barbeau et al. (23), this test is more sensitive than the Allen's test in determining suitable candidates for TRA by direct comparison in 1010 patients. A Barbeau type D waveform is the only true contraindication of TRA. It increases the risk of hand ischemia in the case of radial obstructive complication secondary to poor ulnar compensation.

Setup

Generally, either the right or left radial artery on the same side as the target vessel can be selected for interventional procedures above the diaphragm. However, for interventional procedures below the diaphragm, left
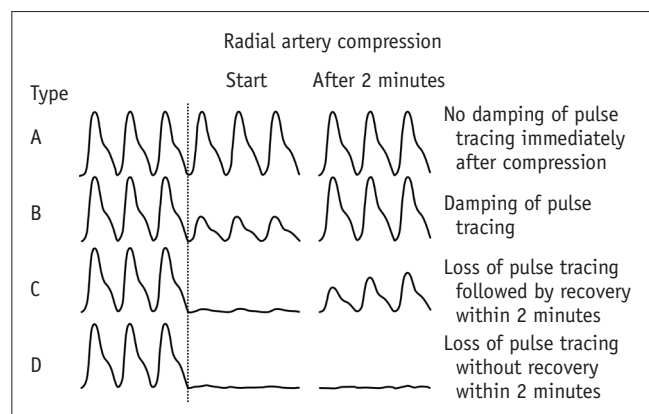

Fig. 1. Barbeau test and four types of Barbeau waveforms.

radial artery access is preferred over right-sided access. In terms of a shorter distance to the target vessel from the left wrist and ascending aortic curvature, left radial access is more advantageous. In addition, the risk of cerebral emboli or thrombus formation is theoretically limiting because the guiding catheter or sheath is not positioned across the great vessels during the procedure.

The arm can be positioned in several ways according to the operator's preference and angiography suite situation. One option is to position the arm at 75–90°, almost perpendicular to the table (Fig. 2A). This allows easier access to the vessel but makes catheter exchanges somewhat awkward. In our practice, the preferred method is to position the arm at the patient's side in a position similar to that of the patient's groin, thereby allowing for catheters/wires to be positioned over the patient's draped body similar to that during traditional TFA (Fig. 2B). Moreover, femoral crossover is possible during the procedure, particularly in patients with aortic disease and tortuosity, anatomical variants, or smaller-caliber radial arteries.

The wrist should be supinated and slightly hyperextended, and a towel roll or a commercially available radial arm board can be used to support the wrist. Prone positioning, which allows the left radial artery to be accessed and positioned in a way similar to that of the right common femoral artery, can be used in patients with chronic back pain, who are unable to lie supine (24). Typical femoral access groin

Fig. 2. Position of left arm for TRA.
A. Arm positioned at 75–90°, almost perpendicular to table for easier vessel access with ultrasound. Proper positioning of left wrist was achieved by using long arm board and left radial artery was punctured. **B.** Arm was then repositioned against patient's side. Arm positioned at patient's side in position similar to that of patient's groin, which allows catheters/wires to be positioned over patient's draped body in way similar to that in traditional transfemoral access.

drapes are used. The pulse oximeter is left in place on the left thumb during the procedure.

Radial Artery Access

When a local anesthetic (2% lidocaine) is administered, the radial artery is punctured with a 21-gauge needle under ultrasound guidance (Fig. 3). The recommended puncture site is 2–3 cm cephalad to the radial styloid. Then, a 0.018-inch wire is advanced into the radial artery. If there is any resistance, the wire is pulled back and readjusted. If the wire cannot be advanced, arteriography with aliquots of contrast agent is performed. A specialized radial access sheath with a hydrophilic coating is then used. The dilators on these sheaths are tapered to 0.018 inch to allow for immediate sheath placement without an incision or wire

exchange. In our practice, the 7-cm-length Prelude radial sheath introducer (Merit Medical Systems) is commonly used. The commercially available hydrophilic radial sheaths are listed in Table 1. According to Rathore et al. (25), the use of hydrophilic sheaths decreases the incidences of radial artery spasm and pain during TRA. The majority of diagnostic and interventional procedures can be performed using 5- to 6-Fr sheaths.

Once the sheath is placed in the radial artery, an antispasmodic medication cocktail is administered intra-arterially directly though the access sheath. Nitrates, calcium channel blockers, and heparin are typically used to prevent arterial spasm and reduce vascular tone. Although there is no consensus on the ideal mixture, a combination of 2000 units of heparin, 200 μg of
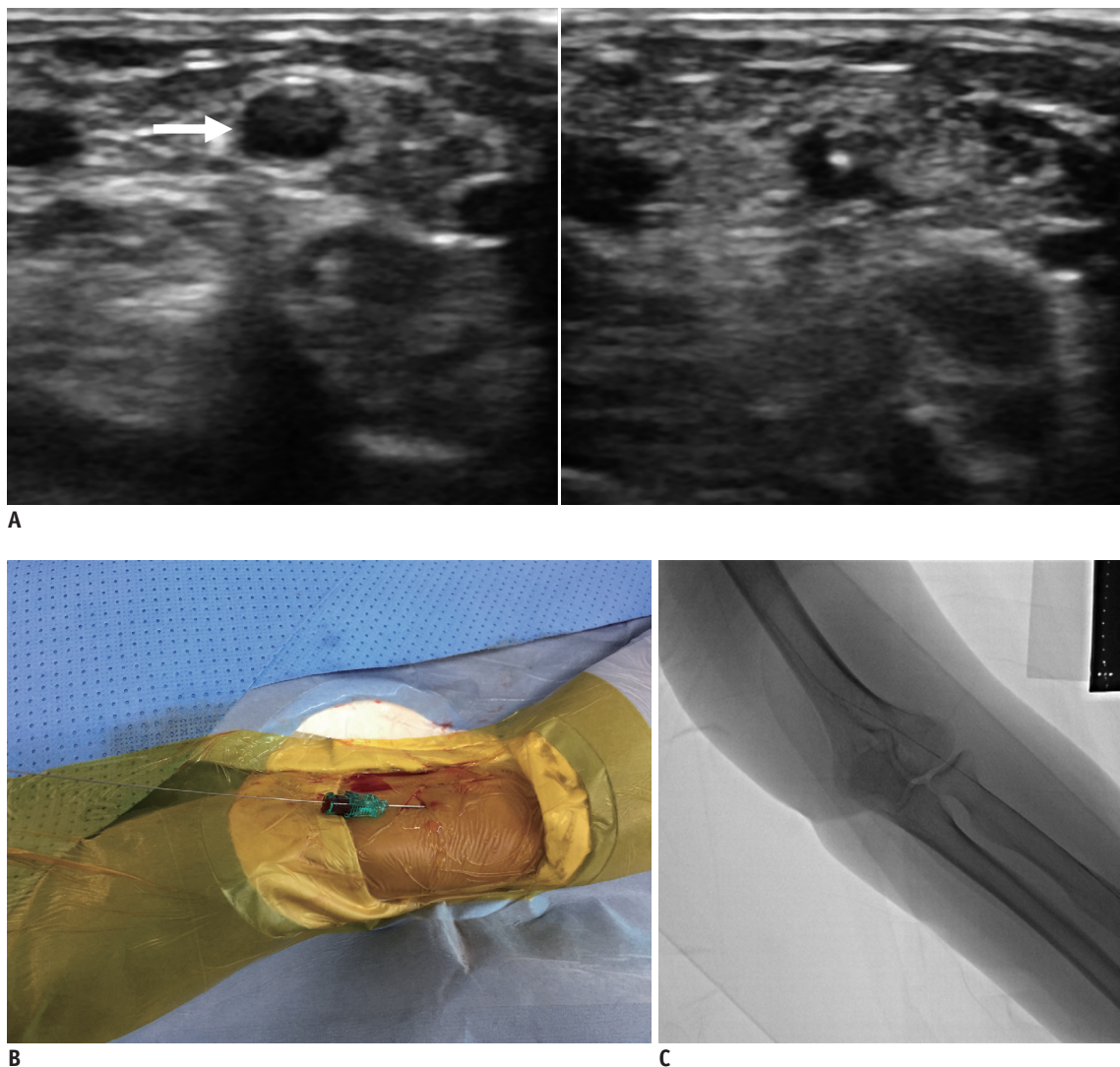
A

B

C

Fig. 3. Radial artery puncture.
A. Diameter of radial artery (arrow) is measured at 3.2 mm on ultrasound image. Radial artery is punctured with 21-gauge needle following single-wall technique under ultrasound guidance. **B, C.** 0.018-inch wire is advanced into radial artery.

nitroglycerin, and 2.5 mg of verapamil is hemodiluted with aspirated blood to 20 mL, and administered through the sheath. Verapamil causes a significant burning sensation upon injection; hence, continuous hemodilution and slow injection are recommended. The use of verapamil is relatively contraindicated for some patients with left ventricular dysfunction, hypotension, and bradycardia.

Snuffbox TRA Technique

Although TRA has many advantages, in case of Barbeau D waveform, small radial artery (< 2 mm), and a patient with chronic renal failure scheduled for arteriovenous fistula formation for hemodialysis, TRA is not feasible. Recently, as an alternative access, distal transradial artery access from the anatomical snuffbox on the dorsal side of the hand has been proposed (26). A patient's left wrist is comfortably placed near the right groin in mild pronation. Before placing a sterile drape, the distal radial artery diameter and flow are evaluated by ultrasound, and Barbeau test is performed in each patient. During the vascular access procedure, the operator stands on the patient's right side. Lidocaine is administered from the vascular puncture site to the skin at the anatomical snuffbox. The distal radial artery is accessed under ultrasound guidance using a 5-Fr transradial kit (Prelude, Merit Medical Systems; or Radifocus, Terumo) (Fig. 4). After ensuring access, a combination of 2000 IU of heparin, 200 µg of nitroglycerin, and 2.5 mg of verapamil is hemodiluted with 20 mL of

Table 1. Radial Access Sheaths

Device	Company
Prelude radial	Merit Medical Systems
Glidesheath, Glidesheath Slender	Terumo
Flexor Radial Introducer	Cook Medical
Rain, Avanti	Cordis

Fig. 4. Snuffbox radial artery access technique.

aspirated blood and administered through the sheath to prevent vasospasm and thrombosis. An additional 1000 IU of heparin is administered every 60 minutes after 90 minutes. The snuffbox approach has several advantages over conventional TRA. First, an occlusion at the distal radial artery potentially maintains antegrade flow through the superficial palmar arch, preventing ischemia and hand disability. Second, no need for compression around the wrist for hemostasis makes the wrist free to move, which limits venous congestion of the hand. Third, in case of vasospasm and hematoma from unsuccessful needling which make further trials difficult, an operator could easily move to the conventional radial approach. Fourth, for patients with chronic kidney disease, the distal radial artery access spares the site for future arterio-venous fistula (27).

Catheter Selection

In most cases, a 125-cm 5-Fr ultimate radial catheter (Merit Medical Systems) and a standard 0.035-inch hydrophilic guide wire (Radifocus, Terumo) are used to navigate the subclavian region and engage the descending aorta (Fig. 5). The unique shape and longer length of the ultimate catheters (Merit Medical Systems) make it easier for them to engage the target mesenteric vessels or iliac vessels. Generally, 150-cm length microcatheters are recommended when using diagnostic catheters that are longer than 100 cm.

Patent Hemostasis Technique

To minimize the risk of postprocedural radial artery thrombosis, nonocclusive patent hemostasis is a fundamental principle. Nonocclusive patent hemostasis is achieved using a radial compression device. There are several commercially available devices, which are listed in Table 2. The most commonly used radial compression device in our practice is the PreludeSYNC (Merit Medical Systems) (Fig. 6). The curved section of the clear plate is placed on the thumb side of the wrist. After aspirating the sheath, the sheath is withdrawn approximately 2.5 cm. The center of the "crosshairs" is placed over the arteriotomy site (location where the sheath entered the artery, approximately 1–2 mm proximal to the skin puncture site). The band should be fastened securely around the wrist without any slack, but it should not be extremely tightened. The bulb is slowly inflated with 20 mL of air, and the sheath is simultaneously removed. Once the sheath is completely removed, air is injected constantly into the bulb until the bleeding has
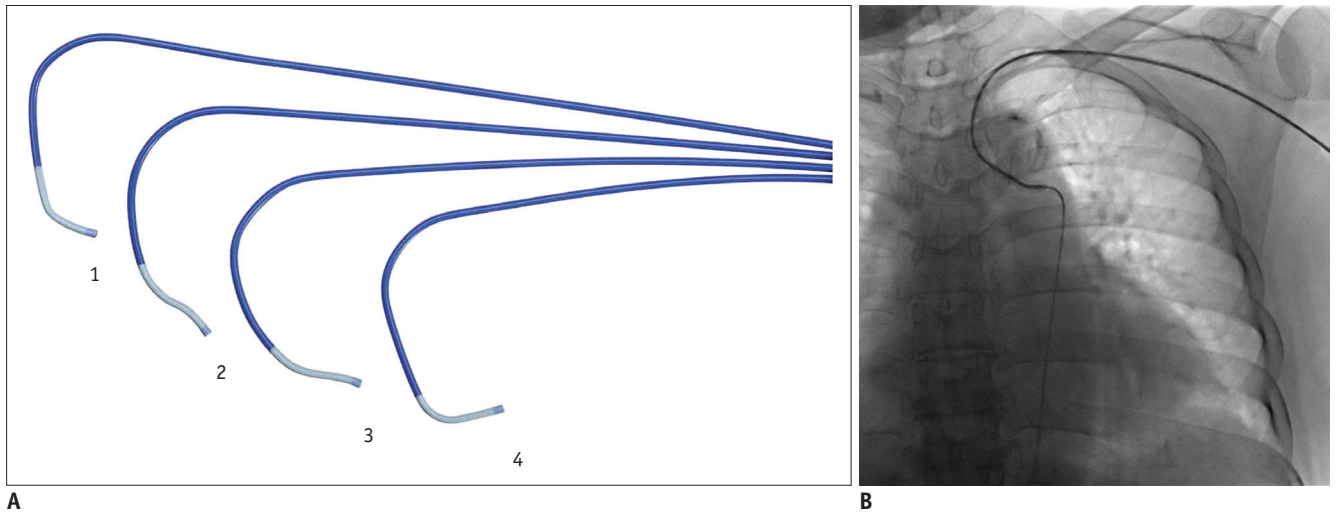
A

B

Fig. 5. Catheter selection for TRA.
A. Four types of ultimate catheters. **B.** 125-cm 5-Fr ultimate 1 radial catheter (Merit Medical Systems) and standard 0.035-inch hydrophilic guide wire (Radifocus, Terumo) are used to navigate subclavian region and engage descending aorta.

Table 2. Radial Compression Devices

Device	Company
PreludeSYNC, PreludeSYNC distal	Merit Medical Systems
TR band	Terumo
TRAcelet	Medtronic
RadiStop	Abbott Vascular

Fig. 6. PreludeSYNC (Merit Medical Systems) and nonocclusive patent hemostasis technique. Note that center of "crosshairs" is placed over arteriotomy site (location where sheath entered artery, approximately 1–2 mm proximal to skin puncture site).

stopped. Then, the air is slowly deflated until a strong radial pulse is palpated or until bleeding is observed at the access site. Nonocclusive patent hemostasis is subsequently maintained for 90 minutes, at which time the device is removed. If bleeding or "oozing" is observed from the puncture site during the removal process, the bulb is reinflated for 30 minutes, and the process is repeated. Once the device is successfully removed, a sterile dressing is placed. A repeat evaluation of the access site and radial pulse is performed for all patients before discharge from the interventional radiology clinic.

Clinical Applications

Transarterial Chemoembolization for Hepatic Malignancy

Although TFA is the most widely used transarterial chemoembolization (TACE) approach for hepatocellular carcinoma (HCC), a growing number of TACE procedures for HCC via TRA are performed because of the emerging evidence favoring TRA over TFA in recent studies in terms of higher patient satisfaction, lower radiation exposure, and lower complication rates (8, 12, 28, 29).

Radial access is obtained using the standard technique and medications as described above, and hydrophilic 5-Fr transradial sheaths are used. Under direct fluoroscopic visualization, a 0.035-inch angled J-tip Glidewire (150–230 cm in length) and a 5-Fr, 110-to-125 cm diagnostic catheters are advanced coaxially into the descending aorta, and selective catheterization and angiography of the celiac trunk, hepatic artery, and superior mesenteric artery are performed. For super-selective catheterization and angiography, a microcatheter (135 or 150 cm in length; 1.9–2.8 Fr in diameter) is used (8, 13, 30, 31). TACE is performed using lipiodol emulsion (Lipiodol Ultra-Fluid, Guerbet) and doxorubicin hydrochloride, followed by the administration of gelatin sponge particles (150–350 μm) mixed with contrast material until flow stasis of the tumor-feeding arteries is achieved (Fig. 7). Pua et al. (30) reported successful cone-beam CT acquisition during the

TACE via the TRA approach with arm repositioning using the swivel arm board (100% success rate). Shiozawa et al. (29) retrospectively compared TRA with TFA in hepatic intra-arterial therapy and demonstrated comparable efficacy (98.3% technical success with TRA). Yamada et al. (8) and Hung et al. (12) suggested that TRA was the preferred access for the majority of patients and was associated with less radiation exposure to the operator. Another prospective single center study by Iezzi et al. (13) demonstrated that the technical success of hepatic chemoembolization via the TRA approach was obtained in all patients (100%). There was no switch from radial access to femoral access during any procedure (crossover rate: 0%). TRA treatments required a significantly longer preparation time for the procedure (p < 0.008); TRA procedures were also characterized by longer puncture, fluoroscopy, and total examination times, with higher mean radiation doses and volumes of administered contrast medium, although these differences were not statistically significant.

Lately, TRA was also applied to radioembolization for hepatic malignancy, and patients exhibited a strong preference for TRA without significant differences in radiation dose, fluoroscopy time, or procedure-related complications (7, 15).

Renal Artery Embolization

Percutaneous transcatheter arterial embolization (TAE) is a safe and effective method for managing renal bleeding. For example, percutaneous image-guided renal artery TAE is a widely accepted treatment for patients with renal trauma and renal angiomyolipomas (Fig. 8) (32). Recently, the role of TAE in renal cell carcinoma has been well defined. TAE of renal cell carcinoma was advocated as a means to 1) reduce tumor vascularity and intraoperative blood loss, 2) debulk the tumor in nonsurgical candidates, and 3) palliate symptoms such as flank pain and hematuria (33). More
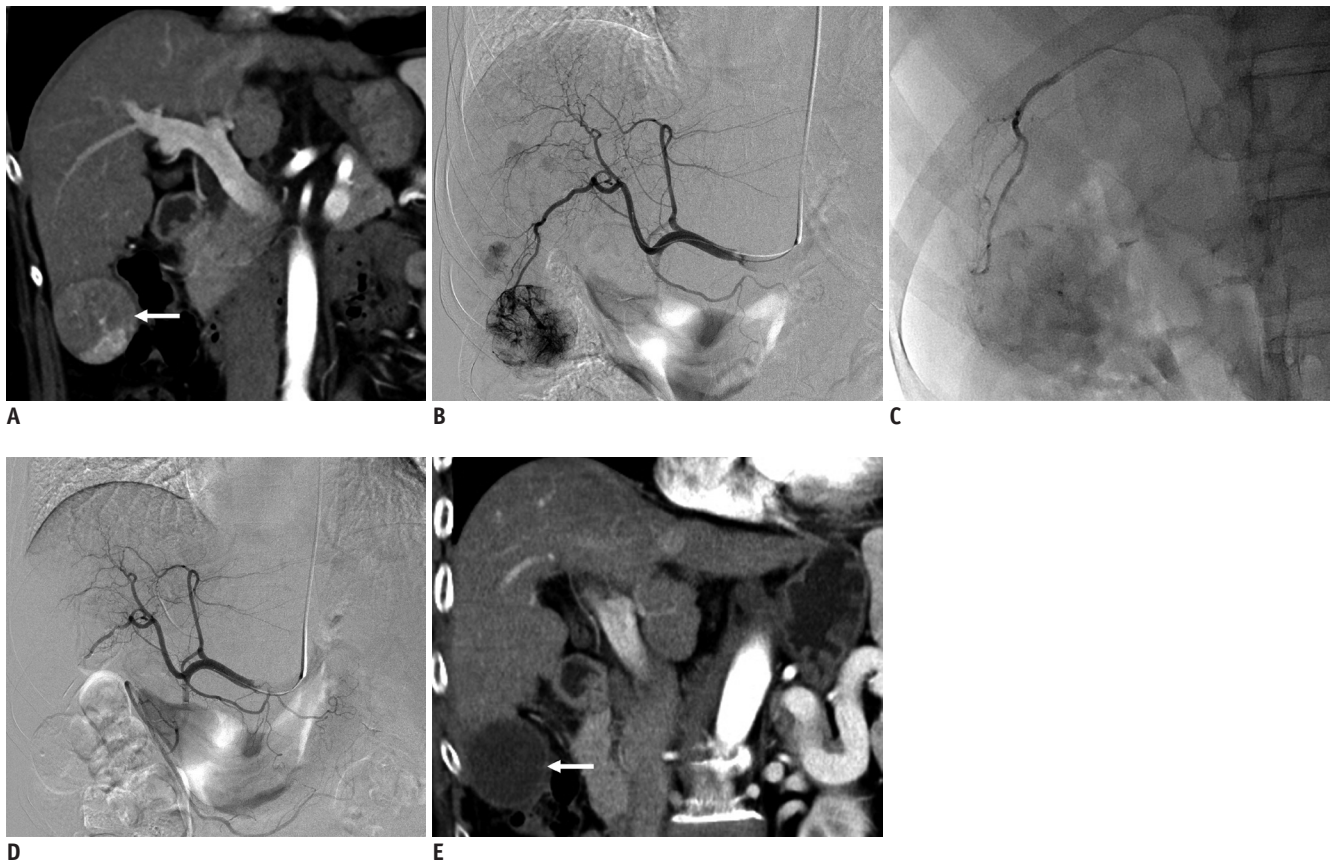

Fig. 7. Clinical applications of TRA on TACE for hepatic malignancy.
A. Coronal contrast-enhanced CT shows 5-cm hepatocellular carcinoma (arrow) in segment 6 of liver. **B.** Hepatic arteriography showing multiple hypervascular tumors in both lobes of liver. **C.** After selection of tumor feeder using microcatheter, drug-eluting bead loaded with doxorubicin/nonionic contrast suspension is slowly injected until near stasis. **D.** Post-embolization hepatic arteriography showing complete devascularization of tumor in liver. **E.** Coronal contrast-enhanced CT image 1 month after TACE showing complete response (arrow). TRA = transradial access, TACE = transarterial chemoembolization
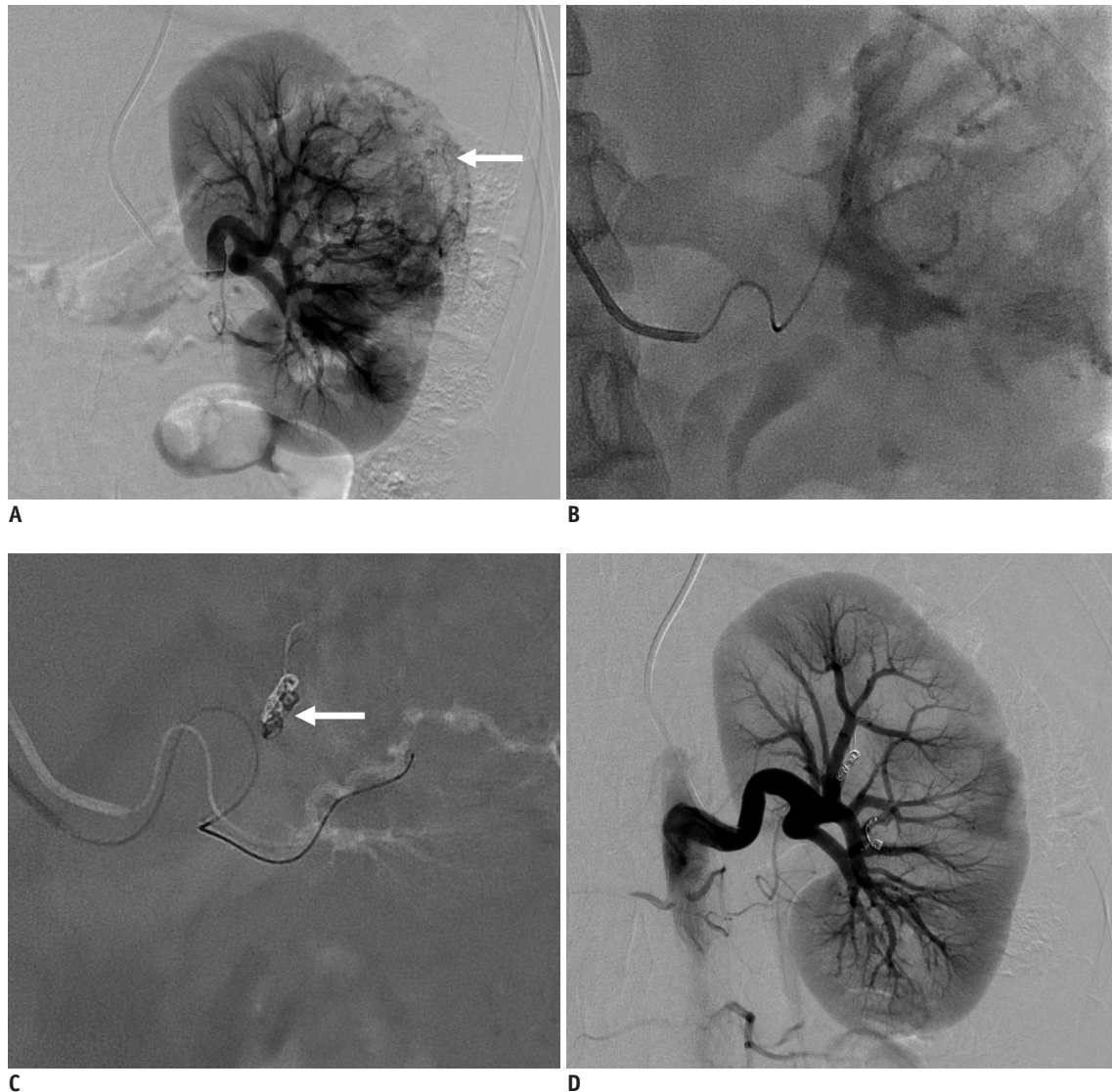
Fig. 8. Clinical applications of TRA on embolization of renal angiomyolipoma.
A. Left renal arteriography showing hypervascular tumor in right kidney upper pole (arrow). **B.** After selection of tumor feeder using microcatheter, permanent embolic agents (polyvinyl alcohol particle) are slowly injected until near stasis. **C.** Super-selective embolization of tumor feeder with microcoil (arrow). **D.** Post-embolization left renal arteriography showing complete devascularization of tumor and preserved perfusion in renal parenchyma.

recent studies have shown that percutaneous renal artery angiography and embolization could employ the radial approach to create a vascular access (18, 34-36). Abrams et al. (36) reported the first case of successful adaptation of TRA in renal artery embolization for hemorrhagic angiomyolipoma in a pregnant patient, in whom femoral access or pelvic radiation was undesirable. In another study by Srinivasa et al. (18), prone TRA was found to be a safe and feasible method for performing combined arterial and posterior percutaneous interventions without the need for repositioning.

Prostatic Artery Embolization

Prostatic artery embolization (PAE) is an emerging therapy for the treatment of lower urinary tract symptoms secondary to benign prostatic hyperplasia (Fig. 9) (37). TRA has been investigated as a potential alternative to TFA for PAE procedures in a case report and case series in which embolization was technically successful (bilateral) in all cases (38, 39). The authors of both studies concluded that PAE via TRA was technically feasible and proposed the advantages of this approach, which ranged from immediate ambulation to relief from lower back pain by elevating the patients' legs during prolonged procedures.
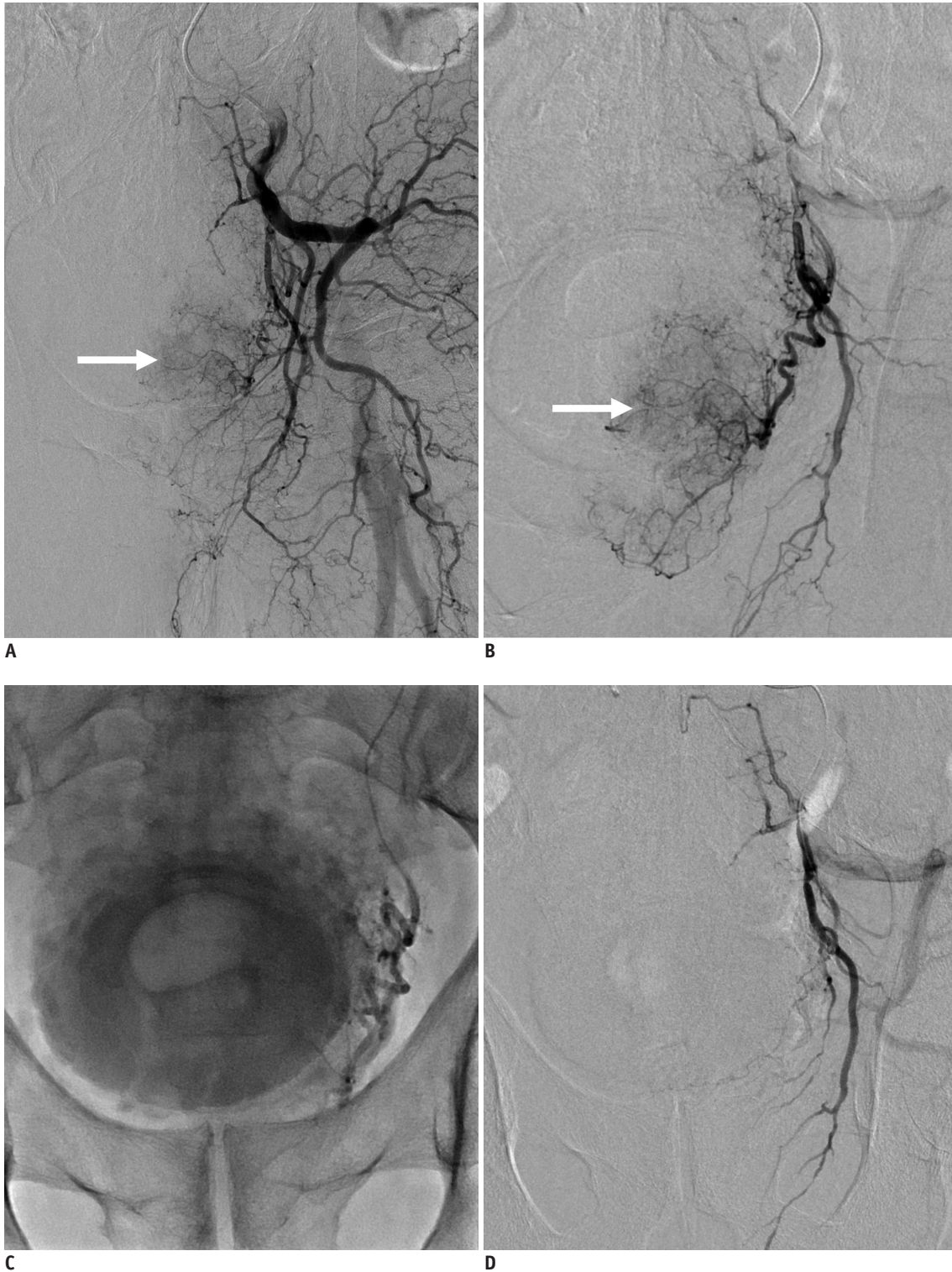
Fig. 9. Clinical applications of TRA on prostate artery embolization.
A. Left internal iliac arteriography showing enlarged prostate with prominent vascularity (arrow). **B.** Selective left prostate artery angiography showing hypertrophied vasculature within prostate gland (arrow). **C.** After selection of prostate artery using microcatheter, permanent embolic agents (polyvinyl alcohol particle) are slowly injected until near stasis. **D.** Post-embolization left prostate artery angiogram shows complete devascularization of hypertrophied vasculature within prostate gland.

A recent retrospective single-center study that compared the outcomes of PAE procedures via TRA and TFA also demonstrated that transradial/transulnar access is a safe and feasible method for performing PAE with a safety profile comparable to that of TFA (20). Although their results may be associated with progression along the procedure learning curve, the potential for decreased PAE procedure times, fluoroscopy times, and radiation skin entry is promising.

UAE

UAE has been performed for more than two decades using TFA, with very low complication rates and good technical and clinical outcomes (40). Currently, many studies have demonstrated that UAE via TRA has some advantages: improved safety and feasibility in patients with obesity or coagulopathy, early ambulation, and early discharge (9, 41). In 2014, Resnick et al. (9) demonstrated the feasibility of TRA for UAE and showed that TRA is a safe alternative to TFA. However, this study did not provide a comparison between TFA and TRA in terms of its efficacy in treating uterine fibroid embolization. Mortensen et al. (42) compared 39 TFA and 27 TRA uterine fibroid embolization procedures and showed comparable fluoroscopy time. Nakhaei et al. (10) compared 91 TFA and 91 TRA uterine fibroid embolization procedures and demonstrated comparable technical and clinical outcomes between the two approaches. They also reported that TRA for UAE has a certain limitation, which is related to the length of the catheter. First, the use of a longer microcatheter makes it difficult to use particles larger than 900 µm due to the frequent occurrence of catheter occlusions. The recommended particle size for UAE is 500–700 µm (43), and a larger particle size is only used when the uterus is extremely large. The second potential limitation of TRA for pelvic procedures is that even a 125-cm parent catheter may not reach the uterine artery via a radial approach if the woman is very tall or has long arms. Hence, the radial artery should be accessed a few centimeters proximally or the parent catheter should be placed in the anterior division of the internal iliac artery and the microcatheter should be navigated to the uterine artery.

Potential Complications and Management

In the majority of patients who underwent TRA, access site complications are predictable and easy to treat (44). New complications associated with TRA, like forearm pain

or loss of upper extremity strength, should be evaluated further in order to determine their impact on patients' function and quality of life (45). However, the treatment of complications after TRA depends on the experience of the interventional cardiologist performing the procedure. Potential access site complications during percutaneous procedures performed with a TRA are summarized in Table 3.

Radial Artery Occlusion

The most common complication of TRA is radial artery occlusion (RAO), which occurs in about 1–10% of patients (46, 47). Endothelial injury of the radial artery and decrease in blood flow after sheath and catheter insertion appear to contribute to thrombus formation and are predisposing factors for RAO (45, 46). In addition, a repeat radial artery cannulation can promote intimal hyperplasia and increased intima-media thickness (48, 49), resulting in negative remodeling of the arterial wall and further predisposition to RAO (50). In most cases, RAO occurs immediately after the procedure, and up to 50% of patients have spontaneous recanalization of the artery within 1–3 months (51, 52). Majority of patients with RAO are asymptomatic. This is due to the dual supply of blood to the hand and the usually rich network of collateral circulation: the radial and ulnar arteries undergo multiple anastomoses before they are connected to the hand through the superficial and deep palmar arches. Although RAO is a usually subclinical condition and can be managed conservatively, in some cases, active treatment such as long-term anticoagulation and balloon angioplasty may be needed (53-56). In Zankl et al.'s study (53), patients with early symptomatic RAO were treated with enoxaparin or fondaparinux for 4 weeks. After 1 month, 87% of patients had a recanalized radial artery.

Table 3. Potential Access Site Complications during Percutaneous Procedures Performed via Transradial Access

Radial artery occlusion
Radial artery spasm
Persistent postprocedural pain
Upper extremity loss of strength
Hematoma
Radial artery pseudoaneurysm
Arteriovenous fistula formation
Radial artery perforation
Radial artery eversion during sheath removal
Hand ischemia
Compartment syndrome

Radial Artery Pseudoaneurysm

Radial artery pseudoaneurysm presents as a rare complication in less than 1% of these procedures (16). The known risk factors for radial pseudoaneurysm include the use of glycoprotein IIb/IIIa inhibitors and an elevated body mass index. Extremely elderly patients may also be at increased risk. Other potential factors that can be hypothesized from the more common femoral artery pseudoaneurysm include the use of larger sheaths, periprocedural use of antiplatelet agents, use of anticoagulants, and hypertension (57). There is no standard treatment for radial pseudoaneurysm. Treatment options range from percutaneous thrombin injection, surgical repair, ultrasound guided compression, external compression devices, and close monitoring for spontaneous resolution (58-60).

Radial Artery Perforation

Iatrogenic radial artery perforation has been reported in 1% of patients who underwent coronary intervention via radial access (61, 62). Uncontrolled bleeding from a perforation may lead to compartment syndrome threatening the arm and requiring emergent fasciotomy (63). Previously described risk factors for radial artery perforation include female sex, short height, hypertension, excessive anticoagulation, and aggressive wire manipulation (63, 64). Multiple protocols for management of radial artery perforation have been reported, including blocking the brachial artery flow by sphygmomanometer cuff and reversing any anticoagulation, insertion of the long-sheath or catheter, balloon tamponade, and covered stent placement (64-69).

Repeat TRA

Despite the increasingly frequent adoption of TRA in visceral artery intervention, few investigators have examined the feasibility, efficacy, and safety of repeat transradial catheterization. The technical success rates of the repeat transradial procedure were comparable with those of the initial procedure; high-volume centers reported repeat TRA with success rates of > 95% (70-72). A study by Yoo et al. (70) reported the changes in radial artery diameter after transradial procedures. The mean radial arterial diameter was 2.63 ± 0.35 mm before the initial procedure and 2.51 ± 0.29 mm 4.5 months after the first procedure ($p < 0.05$). They demonstrated that the inner diameter of the radial artery after the transradial procedure decreased significantly at the time of long-term follow-up, and the frequency of RAO was greater after repeated use than after first-time use. However, the repeated use of the same radial artery is effective when considering its high procedural success and low complication rates in the majority of patients.

CONCLUSION

In conclusion, the technical and clinical outcomes and complication rate of TRA for various types of visceral artery embolization are comparable to those of TFA. The main advantage of this approach is early ambulation after the procedure, following early discharge from the hospital, and higher patient satisfaction. Its potential limitations are the lack of adequate materials (relatively long catheters and microcatheters) that can easily reach the ostium of each visceral artery via radial access. Moreover, the diameter of the radial artery and total body height of the patient are important prognostic factors that can influence the success of the procedure.

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