First case series of the transradial approach for neurointerventional procedures in pediatric patients

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OBJECTIVE The transradial approach (TRA) has been widely adopted by interventional cardiologists but is only now being accepted by neurointerventionalists. The benefits of the TRA over the traditional transfemoral approach (TFA) include reduced risk of adverse clinical events and faster recovery. The authors assessed the safety and feasibility of the TRA for neurointerventional cases in the pediatric population.

METHODS Pediatric patients undergoing cerebrovascular interventions since implementation of the TRA at the authors' institution were retrospectively reviewed. Pertinent patient information, procedure indications, vessels catheterized, fluoroscopy time, and complications were reviewed.

RESULTS There were 4 patients in this case series, and their ages ranged from 13 to 15 years. Each patient tolerated the procedure performed using the TRA without any postprocedural issues, and only 1 patient experienced radial artery spasm, which resolved with the administration of intraarterial verapamil. None of the patients required conversion to the TFA.

CONCLUSIONS The TRA can be considered a safe alternative to the TFA for neurointerventional procedures in the pediatric population and provides potential advantages. However, as pediatric patients require special consideration due to their smaller-caliber arteries, routine use of ultrasound guidance is advised when attempting the TRA.

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THE transradial approach (TRA) for neurointerventional procedures has recently garnered interest as an alternative to the traditional transfemoral approach (TFA) in adult patients.^{2,4,13,17,22} Over the past few decades, radial access for coronary angiography has become widely used by interventional cardiologists due to its reduced access site complications, lower costs, and patient preference.^{6,10,11} Use of the TRA for neurointerventional procedures, which has only recently been advocated, has not been as extensively investigated. Over the past 2 decades, a small number of groups have documented the successful use of the TRA for diagnostic cerebral angiography, stenting, and coil embolization.^{5,12,13,17} While the TFA is safe, the TRA confers several advantages, including reduced time for immobilization, decreased rates of bleeding complications, shorter hospital length of stay, and increased patient comfort.^{4,14,17,18,22}

Although the benefits of the TRA have been well reported in adult patients, there are few reports in the literature regarding its use in the pediatric population. In the interventional cardiology literature, there is to our knowledge only one published retrospective study reporting the successful use of the TRA for coronary angiography in the pediatric population.⁷ The paucity of literature regarding the TRA for neurointerventional procedures in the pediatric population is likely due to the following factors: 1) the rarity of pathologies requiring cerebrovascular intervention, 2) the narrow caliber of the radial artery, and 3) the perceived difficulty in navigating the cerebrovasculature through the TRA.²² At our institution, we have implemented the use of the TRA in most adult diagnostic and interventional cases. More recently, we have transitioned to the use of the TRA in the majority of diagnostic cases and select interventional cases in our pediatric patient popula-

ABBREVIATIONS TFA = transfemoral approach; TRA = transradial approach.

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FIG. 1. Ultrasound image of the right radial artery: Note the large caliber of this patient's radial artery (2.5 mm), which makes it suitable for a neurointerventional procedure with a TRA using a 6-Fr sheath.

FIG. 2. Right radial artery access for the TRA. This patient's right arm was positioned supine and the wrist was extended. The proximal radial artery was accessed using a single-wall technique, and a 6-Fr sheath was secured using a clear adhesive dressing. Note that for orientation the patient's thenar eminence is in the upper left corner of the figure. Figure is available in color online only.

tion. Here we present what is to our knowledge the first reported case series in which the TRA was used for neurointerventional cases in the pediatric population and the safety and efficacy of this approach were evaluated.

Methods

Since the implementation of the TRA at our institution in 2018, 4 pediatric patients (age < 18 years) have undergone an intervention using the TRA. This retrospective study was approved by the Institutional Review Board.

Technique

Each patient was positioned supine on the angiography table, and because all 4 cases were interventional all patients underwent general endotracheal anesthesia. The distal forearm as well as the bilateral groin regions were prepped and draped in case femoral access would eventually be required for radial spasm, inability to catheterize target vessels, or need for additional catheters. With the use of ultrasound guidance, the radial artery was cannulated with a single-wall technique (Fig. 1). A 6-Fr vascular sheath was placed over the 0.025-inch guidewire and secured with transparent adhesive dressing (Fig. 2). After the sheath was in place, 2.5 mg of verapamil and 200 µg of nitroglycerine were injected. After intraarterial injection, radial artery angiography was performed to ensure the artery would not go into vasospasm following access (Fig. 3). The catheters were placed on heparinized saline solution drips throughout the remainder of the procedure. Intravenous heparin (70 units/kg) was administered to maintain activated clotting times between 250 and 300 seconds.

A coaxial system of a 6-Fr Benchmark 071 guide catheter or ENVOY guide catheter (Codman-DePuy Synthes) along with a 5-Fr Sim-2 select catheter (Penumbra) was used. The Sim-2 catheter was initially advanced over a 0.035-inch Glidewire into the subclavian artery under fluoroscopy, with the table in a 10° counterclockwise position. The Sim-2 catheter was then placed either off the aortic valve or in the descending aorta.

The selective catheter and Glidewire were removed after satisfactory placement of the guide catheter into the artery of choice for the intervention.

After the intervention was complete, the sheath was removed and a transradial (TR) band (Terumo) was applied over the puncture site. A pulse oximeter was placed on the right thumb. The vascular sheath was removed under compression from the TR band to achieve patent hemostasis.

Results

The average patient age was 14 years (range 13–15 years). There were 3 boys and 1 girl. Patient information is summarized in Table 1. Each patient was evaluated by ultrasound and was deemed eligible for TRA. There was no instance in which a patient was deemed ineligible for TRA on the basis of ultrasound findings. Conversion to TFA was not necessary in any case. The indications for intervention were juvenile nasopharyngeal angiofibroma in 2 patients, right internal carotid artery pseudoaneurysm in 1 patient, and arteriovenous malformation in 1 patient. Each of these patients underwent embolization via the TRA, and each patient had a right radial artery diameter between 2 and 2.5 mm. Only 1 patient suffered a minor complication of a right radial artery vasospasm, which resolved with administration of intraarterial verapamil and did not necessitate conversion to the TFA. Each patient achieved hemostasis after application of a rigid TR band over the puncture site. After the procedure in all patients, the pulse oximetry waveform remained normal and the radial artery remained patent as assessed by palpation.

Discussion

Approximately 40% of interventional cardiology procedures are performed via the TRA route in the United

FIG. 3. Digital subtraction angiography following right radial injection, anteroposterior view. The right radial artery was injected with contrast medium. Brachial artery (A), radial artery, which is less opaque due to washout of the injected contrast (B), and ulnar artery (C).

States, while slightly more than 80% of similar procedures are conducted via the TRA in Japan and in Europe.^{2,22} Large multicenter studies, such as the RIVAL (Radial Versus Femoral Access for Coronary Intervention) trial, have been conducted in order to assess the benefit of the radial artery approach in cardiovascular procedures.^{6,10} For example, the radial approach is associated with a lower risk of access-site complications and hemorrhagic issues.^{1,3} Complications specific to the TRA are radial artery stenosis and occlusion, but even these complications are rare and usually are clinically silent due to the collateral circulation provided by the ulnar artery.⁹ While the benefits of TRA in adult patients have been reported in the interventional cardiology literature, to our knowledge there are no previously reported case series or retrospective trials demonstrating the safety and efficacy of the TRA for neurointerventional procedures in the pediatric population.^{6,10}

The lack of TRA use for interventional procedures in the pediatric population likely has multifactorial causes. First, not all patients have vascular anatomical features that make them candidates for the TRA. Anatomical characteristics such as the size and tortuosity of the artery may

TABLE 1. Summary of patients undergoing TRA for neurointerventional procedures

Case No.	Patient Age (yrs)	Sex	Indication	Complications	Fluoroscopy Time (mins)
1	14	M	JNA	None	103
2	14	M	Rt cerebellar AVM	None	61
3	15	F	Rt ICA pseudo-aneurysm	Radial artery vasospasm	27
4	13	M	JNA	None	86

AVM = arteriovenous malformation; ICA = internal carotid artery; JNA = juvenile nasopharyngeal angiofibroma.

prohibit the use of TRA as well as the ability to implement a multicatheter system required for support during interventional cases. In addition, the TRA has only recently been advocated in neuroangiography cases. A few centers reported the use of the TRA in the early 2000s, but only recently have authors again advocated its use.^{4,13,16} Further investigation into the use of the TRA in pediatric patients is crucial, as patient preference and comfort are greater concerns for pediatric patients who might find it more difficult than adults to remain immobilized and tolerate the lengthier immobilization time associated with the TFA. Pediatric patients undergoing the TFA often require post-procedural sedation for lower-extremity immobilization.

While the TRA is associated with a decreased risk of adverse clinical events compared with the TFA, special consideration is required in pediatric patients due to the smaller caliber of the radial artery. Multiple randomized controlled trials have demonstrated that the routine use of ultrasound guidance in pediatric patients undergoing radial artery cannulation increases the first-pass success rate.^{8,20,21,23} In addition, the benefit of ultrasound guidance extends to transradial cannulation for the purposes of cardiac catheterization, though its use in cerebrovascular interventions has not yet been investigated.²¹ We believe that for pediatric patients undergoing neurointerventional procedures, ultrasound guidance plays a significant role in identifying amenable arteries as well as easing the transition to the TRA for neurointerventionalists, especially those new to the TRA. While ultrasound guidance has not been demonstrated to reduce the incidence of procedure-related complications, its use may increase the first-pass success rate and decrease the number of attempts and thus facilitate the eventual transition from the TFA to the safer and quicker TRA.

In this study, pediatric patients underwent ultrasound-guided inspection of the right radial artery prior to cannulation of the artery. Diagnostic cases require at least a 4- or 5-Fr sheath. The outer diameter of the sheath is in the range of 1.5–1.7 mm. Therefore, we recommend that the vessel diameter be greater than 1.7 mm for diagnostic cerebral angiograms. Most interventional cases require a 6-Fr sheath, for which the vessel diameter must be at least 2 mm or greater. It is preferred to have an artery-to-sheath ratio greater than 1. If the artery is smaller in size than the

TABLE 2. Patient exclusion criteria

Exclusion Criteria
Radial artery <2 mm, A/S <1
Difficult aortic arch configuration
Aberrant subclavian artery

A/S = artery-to-sheath ratio.

outer diameter of the sheath or catheter, the ratio will be less than 1, which increases the likelihood of access issues.¹⁹ Therefore, the lower limit for radial artery size we use is 2 mm. The caliber of the artery, and not the age of the patient, is what determines whether the TRA can be utilized. Performing an Allan or Barbeau test is not necessary to determine the patency of radial artery circulation.¹⁵ The patient's anatomy also plays a role in arterial access selection as patients with a difficult aortic arch configuration or aberrant subclavian artery would not be good candidates for right-sided radial access. Our exclusion criteria are summarized in Table 2. In addition, an existing arterial line in the right radial artery does not rule out the use of the TRA. In these cases, we include the radial site in the sterile preparation and insert a wire through the existing arterial line sheath, then remove the existing sheath and place the larger 6-Fr sheath over the wire as long as the radial arterial diameter is in the desirable range.

Valgimigli et al. conducted a large randomized multicenter superiority trial comparing TRA with TRA in adult patients with acute coronary syndrome. The authors found that the group of patients who underwent procedures using the TRA had a significant reduction in the rate of adverse clinical events, particularly major bleeding events and 30-day mortality.²⁴ In investigating the utility of the TRA in the context of cerebral angiography, Snelling et al., in their retrospective review of 141 patients, found that this approach could be performed without any major complications.²² The most common minor complication observed was radial artery spasm, which in some cases necessitated crossover to the TFA. However, most cases of radial artery spasm were resolved with the administration of antispasmodic agents.

Irving et al. published a retrospective cases series in which they implemented the TRA for coronary angiography in 12 patients ranging in age from 12 to 18 years. One patient underwent intervention while the others underwent angiography alone. The TRA was successful in 85% of their patients. In 2 of the patients the procedure could not be completed due to unsuccessful cannulation and absent palpable pulse after lidocaine cream application. Three patients developed radial spasm, and in one of these patients the procedure had to be aborted.⁷ As we recommended earlier in the *Discussion*, ultrasound guidance can improve the first-pass success rate, and verapamil and nitroglycerin injection can aid in reducing radial artery spasm.

The rationale for implementing the TRA for pediatric neurointerventional cases involved the decreased access site complication rate of the TRA compared with that of the TFA, as well as reduced postprocedural immobiliza-

tion times and the need for postprocedural sedation with TRA versus TFA. While we now prefer the TRA as a first option in all pediatric cases, the decision to convert to the TFA is readily made in patients in whom the TRA is deemed inappropriate.

Study Limitations

While our case series demonstrates the potential of the TRA as a safe alternative to the TFA, there are several limitations to our study. The age of patients in this case series ranged from 13 to 15 years, placing them in the adolescent age range. We cannot comment on the safety and feasibility in a younger age group. While we report the total fluoroscopy time for each patient, a more useful measurement would be the fluoroscopy time per vessel catheterization in the diagnostic portion of the procedure. However, this parameter was unfortunately not measured due to the retrospective nature of this study. Furthermore, future studies should include more information about the radiographic data to further delineate the ideal diameter range of the radial artery amenable to the TRA, depending on the type of intervention. The retrospective nature of this case series also makes it more susceptible to bias. Larger prospective studies comparing the TRA with ultrasound and the TFA would greatly clarify the potential benefits of the TRA. Furthermore, larger studies should also include children younger than those in the current study to allow investigation of the feasibility of the TRA in smaller-caliber radial arteries.

Conclusions

In this case series, we demonstrated that the TRA is a feasible and potentially safe alternative to the TFA in neurointerventional procedures in the pediatric population. With consistent use of ultrasound in our pediatric patients, we were able to successfully cannulate the radial artery. While not yet widely adopted by neurointerventionalists, the TRA confers several advantages over the traditional TFA, including a reduced risk of adverse events and hastened postprocedural recovery. We believe that with increased exposure and practice of the technique, and more prospective studies comparing the transradial and transfemoral approaches, the TRA will be considered a safe approach for pediatric neurointerventional cases.

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Disclosures

The authors report no conflict of interest concerning the materials or methods used in this study or the findings specified in this paper.

Author Contributions

Conception and design: Khandelwal, Majmudar, Patel, Dodson, Tomycz. Acquisition of data: Khandelwal, Majmudar, Dodson, Bach, Liu, Tomycz. Analysis and interpretation of data: Khandelwal, Majmudar, Patel, Bach. Drafting the article: Khandelwal, Majmudar, Patel, Dodson, Bach, Tomycz. Critically revising the article: Khandelwal, Majmudar, Patel, Dodson, Liu. Reviewed submitted version of manuscript: Khandelwal, Majmudar, Liu. Approved the final version of the manuscript on behalf of all authors: Khandelwal. Statistical analysis: Khandelwal, Tomycz. Study supervision: Khandelwal.

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