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ORIGINAL ARTICLE

Transradial Diagnostic Cerebral Angiography: Local Experience, Technique, and Outcomes

HT Lau, YLE Chu, R Lee, WP Cheng, KW Ho

Department of Radiology, Queen Mary Hospital, Hong Kong SAR, China

ABSTRACT

Introduction: *Transradial approach (TRA) has become a popular alternative to traditional transfemoral approach for catheter cerebral angiography, as it offers advantages such as improved patient comfort, safety profile, and cost-effectiveness. This study aimed to evaluate the efficacy and safety of 'radial-first' approach in diagnostic neuroangiography in our locality.*

Methods: *We retrospectively analysed our database of consecutive catheter cerebral angiographies performed via TRA between September 2020 and July 2021. Patient demographics, procedural and radiographic metrics, radial access site–related complications, and total procedural time were recorded.*

Results: *A total of 52 TRA diagnostic cerebral angiographies were performed. Radial artery access was successfully obtained in all patients (n = 52). The rate of successful navigation through the brachial artery was 98.1% (n = 51), with an overall femoral crossover rate of 1.9% (n = 1). Satisfactory diagnostic images were obtained in all TRA cases (n = 51). Complications related to radial artery access were recorded in two cases (3.8%), including a case of transient radial arterial spasm and a case of transient radial artery occlusion. No access site–related permanent ischaemic symptoms were reported. Other severe access site complications such as pseudoaneurysm and arteriovenous fistula were not demonstrated.*

Conclusion: *TRA is a safe and feasible technique for diagnostic cerebral angiography in our locality, with a low complication rate.*

Key Words: *Angiography, digital subtraction; Cerebral angiography; Radial artery*

Correspondence: *Dr YLE Chu, Department of Radiology, Queen Mary Hospital, Hong Kong SAR, China*
Email: edchu.radiology@gmail.com

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中文摘要

經橈動脈診斷性腦血管造影：本地經驗、技術和結果

劉凱桃、朱賢麟、李雷釗、鄭永鵬、何家慧

引言：經橈動脈入路已成為傳統經股動脈導管腦血管造影術的流行替代方法，因其具有改善患者舒適度、安全性和成本效益等優勢。本研究旨在評估「優先採用經橈動脈入路」方法在我們本地診斷性神經血管造影術中的有效性和安全性。

方法：我們回顧性分析在2020年9月至2021年7月期間通過經橈動脈入路進行連續導管腦血管造影術的數據庫。我們記錄了患者的人口統計資料、手術和影像學指標、經橈動脈入路部位相關併發症和總手術時間。

結果：共進行了52次經橈動脈入路診斷性腦血管造影。所有患者（n = 52）經橈動脈入路插入均成功。通過肱動脈的成功導航率為98.1%（n = 51），一例後續採用了股動脈經路（1.9%）。所有經橈動脈入路病例（n = 51）都獲得了滿意的診斷圖像。兩例（3.8%）發生了與橈動脈通路相關的併發症，包括一例短暫性橈動脈痙攣和一例短暫性橈動脈閉塞。沒有與穿刺部位相關的永久性缺血症狀。未見其他通路部位嚴重併發症如假性動脈瘤和動靜脈等。

結論：經橈動脈入路是本地診斷性腦血管造影安全可行的技術，併發症發生率低。

INTRODUCTION

Catheter cerebral angiography is a common diagnostic method to examine cerebral vasculature. Traditionally, the procedures have been performed via the transfemoral route. However, the transfemoral approach (TFA) is not always feasible. For example, it will be problematic in patients with dissection of the thoracic aorta, iliofemoral occlusive disease, and inguinal infections. TFA angiography also requires patients to tolerate uncomfortable groin compression and bed rest after the procedures. Serious access site–related complications, including pseudoaneurysm, retroperitoneal haemorrhage, femoral artery dissection, and lower limb ischaemia are well recognised.[1-4]

There has been a notable trend of transition from TFA to the transradial approach (TRA) in cerebral angiography among the neuroangiography community. This transition was primarily fuelled by robust findings of TRA’s lower access-related complications, lower mortality rates, decreased length of hospital stay, and increased patient satisfaction in the cardiology literature.[5,6] Both neuroangiography and interventional cardiology require arterial catheterisation supplying the vital organs which have narrow margin of error. Also, both of them first started as TFA. Given these similarities between the two fields, it was believed that the significant safety advantages of TRA for interventional cardiology might be transferrable to neuroangiography. This has been supported by recent data from the neuroangiographic literature, which have demonstrated favourable safety profiles, patient experiences, and cost-effectiveness of TRA over TFA.[3,7-11]

In light of the body of evidence demonstrating the clinical benefits of TRA, our centre has adopted a ‘radial-first’ approach in neuroangiography since September 2020. Here we present our initial experience in the transition from the traditional TFA to a ‘radial-first’ approach for diagnostic cerebral angiography, including the technical feasibility, safety, and complications of the TRA technique.

METHODS

Study Design

We retrospectively analysed our institutional database of consecutive catheter cerebral angiographies performed via TRA between September 2020 and July 2021. Patient demographics, procedural and radiographic metrics, radial access site–related complications, and total procedural time were recorded.

Patient Selection

All patients underwent preprocedural ultrasound assessment in order to measure the diameter of the right radial artery and its patency. Patients with a radial artery diameter of <1.6 mm were excluded and the TFA was used instead. Patients requiring intervention in addition to diagnostic angiography were also excluded.

Operators

Transradial cerebral angiographies were performed by three operators during this time, including a neuroradiology trainee who had no prior endovascular experience and performed the procedure under the direct supervision of one of the two other Hong Kong College of Radiologists fellowship–qualified radiologists, who had performed a minimum of 500 TFA cerebral angiographies each.

Transradial Access Techniques

All TRAs used the right arm as the initial access site. The radial artery was accessed at a point 1 to 2 cm proximal to the wrist crease (standard TRA). The more distal radial artery was accessed at the anatomical snuffbox site (distal TRA) according to operator's preference. The patient was prepared and draped with the right arm placed at the patient's right side and the puncture location exposed. For a standard TRA, the patient's right distal forearm and hand were placed in a slightly supinated position of around 60°. Full supination of the hand can often result in discomfort and is not necessary. For distal TRA, the patient's arm was allowed to rest in a neutral position and hand supination was not required. A total of 1 to 2 mL of 1% lidocaine was infiltrated into the skin around the puncture site. Under ultrasound guidance, the radial artery was punctured using a 20-gauge needle via Seldinger or modified Seldinger technique according to the operator's preference. A 5-F vascular radial sheath introducer (Glidesheath Slender; Terumo, Tokyo, Japan or Prelude Radial Sheath; Merit Medical Systems, Inc, South Jordan [UT], US) was then placed over an 0.025-inch hydrophilic guidewire (Glidewire Hydrophilic Coated Guidewire; Terumo, Somerset [NJ], US). A cocktail containing 3000 units of heparin and 2.0 mg of verapamil diluted with 20 mL of blood prior to the infusion in order to avoid patient discomfort during injection was infused over 1 minute through the side-port of the sheath for antithrombotic and antispasmodic purposes, respectively. Heparin was withheld in cases where brain haemorrhage was a concern.

Catheter Navigation and Selection of the Great Vessels

After TRA was obtained, a 5-F Simmons 2 catheter (S2) (Radifocus Optitorque; Terumo, Somerset [NJ], US) was navigated over a 0.035-inch guidewire into the ipsilateral subclavian artery. The navigation of the forearm and brachium was performed under a monoplane setup with radial roadmap guidance (Artis zee biplane; Siemens Healthineers, Erlangen, Germany) in all of our cases, with the bed at a 10-degree clockwise rotation along patient's coronal plane. The radial roadmap is obtained in order to elucidate any radial artery anomalies and to avoid lodging the guidewire into small arterial branches during access to the subclavian. Loops that were difficult to pass with a 0.035-inch wire were navigated with a microcatheter system (Progreat Micro Catheter System; Terumo, Somerset [NJ], US) which would often straighten out the loop. Once the Simmons catheter was brought into the subclavian artery, the table was returned to its neutral position and the lateral plane was brought into position at 90° to the anteroposterior plane (Artis zee biplane).

In cases where imaging of the posterior fossa was of interest, we preferred to first catheterise the right vertebral artery, as this is often the great vessel encountered coming in from the right subclavian artery, and its catheterisation does not usually require reforming the S2 catheter. The catheter was then navigated to the arch to access the other great vessels. We preferred to reform the reverse curve of the Simmons catheter in the descending aorta first whenever possible. In cases where the aorta was too unfolded or too capacious to allow access to the descending aorta with the guidewire, we reformed it off the aortic valve.

Catheterisation and angiograms of the rest of the great vessels was then performed with a formed S2 catheter. In cases where it was difficult to select the left vertebral artery, depending on the operator's preference, catheterisation of the vessel with a S3 catheter was attempted. Alternatively, subclavian injection with a blood pressure cuff around the left arm was performed.

Haemostasis Technique

All arteriotomy closures were achieved with haemostatic compression bands. In standard TRA, a radial wristband (TR Band; Terumo, Somerset [NJ], US) was secured to the arteriotomy site and inflated. The sheath was then removed with the band inflated. The band was then slowly deflated until a small amount of bleeding occurred, after which we injected another 1 to 2 cc of air. By using the minimum amount of compression needed for haemostasis, we maximise the chances of preserved

Table 1. Departmental haemostasis protocol.

Release time of compression band (TR Band or PreludeSYNC DISTAL haemostasis device)	
Basic (5F vascular sheath, no risk factor): 1 hour	Risk factors (+30 min each): • 6F vascular sheath or above • Use of antiplatelet • Use of anticoagulant • Intraoperative heparin • Intraoperative integrilin • Platelet count <100 • Other bleeding tendency
Release 3-4 mL of air every 15 min: inflate 1-2 mL of air back if bleeding encountered and retry after 15 min	

radial artery patency. A similar approach is used in the closure of the distal TRA with a haemostasis device (PreludeSYNC DISTAL; Merit Medical Systems, Inc, South Jordan [UT], US).

We followed a departmental protocol for releasing the compression band in the postoperative unit (Table 1).

RESULTS

A total of 83 patients underwent diagnostic cerebral angiography in our institution from September 2020 to July 2021. TRA was used as the primary access technique in 52 patients (19 women and 33 men) with a median age of 53 years, ranging from 20 to 81 years. The results are summarised in Figure 1.

Radial artery access (including standard and distal TRA) was successfully obtained in all 52 patients. Radial artery anomalies, including a radial loop (Figure 2) and severe radial artery tortuosity (Figure 3) were demonstrated in two cases (3.8%). The rate of successful navigation through the radial and subsequent brachial artery via TRA was 98.1% (n = 51). A microcatheter-microwire system (Progreat Micro Catheter System) was used in one of the successful cases with severe radial tortuosity. In another case, a tight loop was encountered in the proximal radial artery (Figure 2) and the operator decided to crossover to a TFA.

Satisfactory diagnostic images were obtained in cases where catheters were successfully advanced past the brachial artery (n = 51). None of these cases required conversion to a TFA. The overall TFA crossover rate was 1.9% (n = 1) in our cohort.

The mean diameter of the radial artery and distal radial artery were 2.2 mm (range, 1.6-3.4) and 1.9 mm (range, 1-3), respectively. Distal TRA was attempted in 20 out of 52 cases. Access to the distal radial artery was unsuccessful in two cases requiring crossover to a standard TRA. Overall, standard TRA was performed in 34 cases (65.4%) and distal TRA were performed in 18 cases (34.6%). The mean diameter of the distal

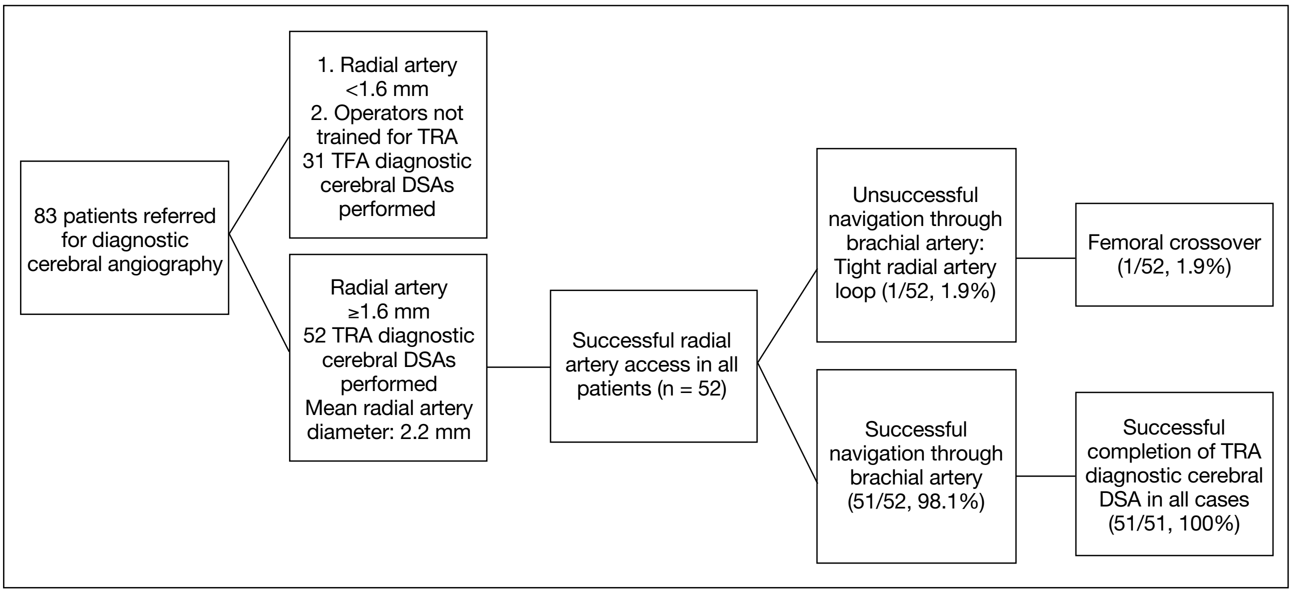

Figure 1. Flowchart showing subject recruitment and outcome.
Abbreviations: DSA = digital subtraction angiography; TFA = transfemoral approach; TRA = transradial approach.

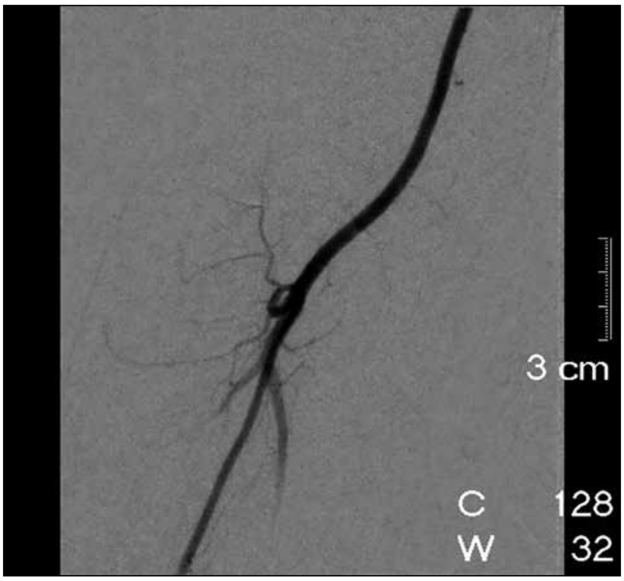

Figure 2. Proximal radial loop required femoral crossover.

Figure 3. Radial artery tortuosity required microcatheter-microwire system.

radial artery of successful distal TRAs was 2.2 mm, as compared to 1.7 mm in the two unsuccessful cases. The mean diameter of the radial artery in successful standard TRAs was 2.2 mm.

The mean total procedural time was 45 minutes (range, 7-98), while the mean number of supra-aortic vessel angiograms performed was 4.7. Choices of diagnostic catheters for successful angiograms of different vessels in our series are described in Table 2.

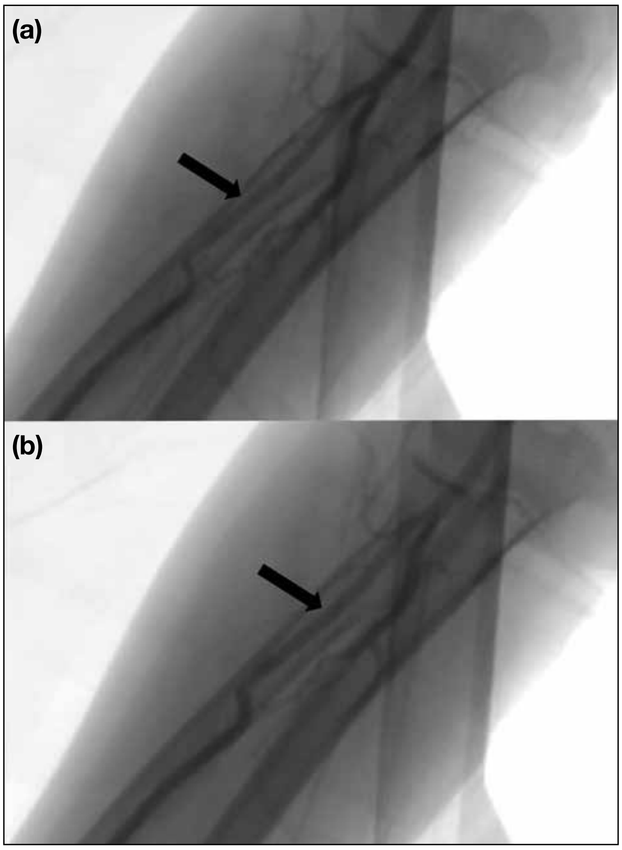

Figure 4. Transient radial artery spasm (arrow in [a]), resolved after administration of 2-mg intra-arterial verapamil (arrow in [b]).

Complications related to radial artery access were recorded in two cases (3.8%). This included a case of transient radial arterial spasm (Figure 4) which was managed with administration of 2-mg intra-arterial verapamil. The angiogram was successfully completed after the radial artery spasm was resolved. No complications were encountered and the patient was discharged on the day of the procedure. In the second case (distal TRA), the patient complained of reduced muscle strength of his right hand and fingers, which recovered spontaneously over a 2-week period. Sonographic assessment at initial presentation showed partial radial artery occlusion at the puncture site (Figure 5). This was spontaneously resolved together with the symptoms 2 weeks after the procedure. No access site–related permanent ischaemic symptoms were reported.

Other severe procedure-related vascular complications such as pseudoaneurysm, arteriovenous fistula, or functional disability of the hand described in the literature[4,7,8] were not demonstrated in our series.

Table 2. Choice of diagnostic catheter used in successful angiograms.*

Patient No.	Vessels catheterised with S2/Glidecath (in S2 tip)	Vessels catheterised with catheters other than S2/ Glidecath (in S2 tip)	Diagnostic catheter(s) used
1	Left CCA, Left VA	Nil	Nil
2	Left and right CCA, left and right ECA, left and right VA, left and right SCA	Nil	Nil
3	Left and right CCA, left and right ICA, right VA	Nil	Nil
4	Left and right CCA, left and right ICA	Nil	Nil
5	Left CCA, left ICA	Nil	Nil
6	Femoral crossover due to radial loop		
7	Left and right CCA	Right VA	Vert
8	Left and right CCA, left and right ICA, left and right ECA, left and left VA	Nil	Nil
9	Right VA	Nil	Nil
10	Right CCA, right ICA, right VA	Nil	Nil
11	Left CCA, left ICA	Nil	Nil
12	Left and right CCA, left ICA, left and right ECA, left and right VA	Nil	Nil
13	Left and right CCA, left and right ICA, left and right ECA, left and right VA	Nil	Nil
14	Left and right CCA, left and right ICA, left and right ECA, right VA	Left VA	S3
15	Left and right CCA, right ICA, right ECA, left and right VA	Nil	Nil
16	Right CCA, right ICA	Nil	Nil
17	Left and right CCA, left and right ICA, left and right ECA	Nil	Nil
18	Left and right CCA, left and right ICA, left and right ECA, left and right VA	Nil	Nil
19	Left and right CCA, left ICA, left and right ECA	Nil	Nil
20	Left and right CCA, right ICA, right VA	Nil	Nil
21	Left and right CCA, left ICA, left ECA, left and right VA	Nil	Nil
22	Left and right CCA, right VA	Nil	Nil
23	Right CCA, right ICA, right ECA	Left CCA, left and right VA	S1
24	Left and right CCA, left ICA, left ECA, right VA	Nil	Nil
25	Left CCA, left ICA, left ECA, left internal maxillary artery	Left facial artery	XT27
26	Right CCA, right ICA, right ECA	Left CCA, right VA	S3
27	Left CCA, left ICA	Nil	Nil
28	Left and right CCA, left and right VA	Nil	Nil
29	Left and right CCA, left and right ICA, left and right ECA, left and right VA	Nil	Nil
30	Left and right CCA, left and right ICA, left and right ECA, left VA	Nil	Nil
31	Left and right CCA, left ICA, left and right ECA, left VA	Nil	Nil
32	Left and right CCA, right VA	Nil	Nil
33	Left and right CCA, left and right ICA, right ECA, left VA	Left ECA	S3 and Renegade 27 microcatheter
34	Left and right CCA, left and right VA	Nil	Nil
35	Left and right CCA, left and right ICA, right VA	Nil	Nil
36	Right CCA, right ICA	Nil	Nil
37	Left and right CCA, left VA	Nil	Nil
38	Left and right CCA, left and right ICA, left and right ECA, left and right VA	Nil	Nil
39	Left and right CCA, left ICA, left ECA, right VA	Nil	Nil
40	Left and right CCA, left ICA, left ECA, right VA	Nil	Nil
41	Left and right CCA, left and right ICA	Nil	Nil
42	Left and right CCA, left and right ICA, left and right VA	Nil	Nil
43	Left CCA	Nil	Nil
44	Left and right CCA, left and right ICA, left and right VA	Nil	Nil
45	Left and right CCA, right ICA	Nil	Nil
46	Left and right CCA, left ICA, left ECA, left and right VA	Nil	Nil
47	Left and right CCA, left ICA, left ECA, right VA	Nil	Nil
48	Right VA	Nil	Nil
49	Left and right CCA, left and right ICA, left and right ECA, left and right VA	Nil	Nil
50	Right CCA, right ICA, right ECA	Nil	Nil
51	Left and right CCA, left VA, left and right SCA	Nil	Nil
52	Left CCA, left ICA	Nil	Nil

Abbreviations: CCA = common carotid artery; ECA = external carotid artery; ICA = internal carotid artery; SCA = superior cerebellar artery; VA = vertebral artery.

* Catheters: Glidecath = 5Fr Glidecath Hydrophilic Coated Catheter (Terumo, Somerset [NJ], US); Renegade 27 microcatheter = Renegade HI-FLO Microcatheter (Boston Scientific, Marlborough [MA], US); S1 = Simmons 1 catheter (Radifocus Optitorque; Terumo, Somerset [NJ], US); S2 = 5F Simmons 2 catheter (S2) (Radifocus Optitorque, Terumo, Somerset, [NJ], US); S3 = SIM3 (Torcon NB Advantage Catheter; Cook Medical, Bloomington [IN], US); Vert = Vertebral (Radifocus Optitorque; Terumo, Somerset [NJ], US); XT27 = Excelsior XT-27 Microcatheter (Stryker, Fermont [CA], US).

Figure 5. Colour Doppler ultrasound showed partial radial artery occlusion (arrow) at the puncture site.

In all, 38 patients underwent elective TRA diagnostic cerebral angiography and 13 cases were performed on an emergency basis. For elective cases, most of the patients were discharged on the same day as the procedure (n = 32, 84.2%), while five were discharged the following day according to different departmental practice. One patient, who underwent elective superficial temporal artery to middle cerebral artery bypass surgery for moyamoya disease on the same admission, was discharged 3 days after the TRA procedure.

Overall, a success rate of 98.1% (n = 51) for transradial cerebral angiography was achieved. In the case where the TRA was unsuccessful, the procedure was completed via TFA, for an overall crossover rate to femoral approach of 1.9%. Cerebral angiograms were successfully obtained in all cases when catheters were able to be advanced beyond the brachial artery. The radial access site–related complication rate was 3.8%.

DISCUSSION

Transradial Approach Benefits

All patients who underwent TRA cerebral angiography in an outpatient setting were ambulatory immediately after the procedure and most of them could be discharged on the same day.

It is well-established that observation time after TRA cerebral angiography is significantly shortened as compared to TFA; this in turn reduces nursing workload and hospital costs.[9] TRA is also associated with significantly fewer access site complications.[11] Uncomfortable groin compression and prolonged bed rest can be avoided for TRA procedures.

Preprocedural Collateral Circulation Assessment

We do not routinely perform preprocedural collateral testing such as Barbeau or Allen tests in accordance with recommendations from the American Heart Association, as they have been proven to be unreliable in predicting the incidence of hand ischaemia.[12-14]

Radial Cocktail

Nitroglycerin is one of the most common vasodilators applied prophylactically to prevent radial artery vasospasm.[3,7,10,15] However, its use in patients with potential neurovascular disease such as carotid stenosis may lead to complications such as transient ischaemic attack or even haemodynamic stroke due to an abrupt fall in blood pressure.[16,17] In our centre, we only included 2 mg of verapamil and 3000 units of heparin as a standard radial cocktail to reduce the risk of vasospasm during TRA. Overall, the rate of vasospasm, radial access site complications, and femoral crossover were all comparable to recent large-scale trials involving TRA cerebral angiograms with prophylactic nitroglycerin.[3,7,10]

Radial Artery Anomaly and Technical Challenges

Anomalous radial artery anatomy, including a radial loop, high-bifurcating radial origin, arterial tortuosity, atherosclerosis, and accessory branches, is relatively common. A recent study of 1540 patients reported the overall incidence of radial artery anomalies was 13.8%, and procedural failure was far more common in patients with anomalous anatomy than in patients with normal anatomy.[18]

A radial roadmap was essential in identifying difficult radial anatomy and therefore performed in all of our cases. We encountered three cases of difficult radial artery anatomy, including two cases of radial artery anomalies (radial loop and severe radial tortuosity) and a case of radial artery spasm despite pretreatment with verapamil and heparin.

For the patient with severe radial tortuosity, a microcatheter-microwire system (Progreat Micro Catheter System) was used to overcome the tortuous vessel. An additional 2-mg intra-arterial verapamil dose was used in the case with radial artery spasm. Successful TRA cerebral angiography was subsequently performed in both cases.

One patient failed TRA due to the presence of a tight radial loop. In retrospect, it is possible that this could have been resolved with the use of a microcatheter or soft tip guidewire.

Choices of Diagnostic Catheter

The 5-F S2 catheter was our catheter of choice for diagnostic cerebral angiography, similar to many other centres worldwide.[7,8,19] First-pass success rate was 82.4% (n = 42) of the cases. With the aid of a 5-F Glidecath Hydrophilic Coated Catheter (Terumo, Somerset [NJ], US) in S2 tip shape, 88.2% (n = 45) of cases were completed. In our series, the right common carotid artery, both internal carotid arteries, the right external carotid artery, and both subclavian arteries were all successfully cannulated by either a S2 or Glidecath (in S2 tip shape) catheter.

The vertebral arteries are often different in diameter, with the left side more frequently being dominant.[20] The success rate of direct left vertebral artery catheterisation from a right radial approach is known to be lower compared to that of the rest of the great vessels.[19] Specifically, the passage of a diagnostic catheter from the aortic arch to the left vertebral artery through the left subclavian artery could be difficult, and the success rate depends on the angle of origin of the left vertebral artery.[21] Successful left vertebral artery catheterisation is less likely if the angle between the left vertebral artery and left subclavian artery is <90°.[21]

In our series, 91.3% (21 out of 23) of left vertebral artery angiograms were performed with a S2 or Glidecath (in S2 tip shape) catheter. The other two cases were performed with S1 (Radifocus Optitorque; Terumo, Somerset [NJ], US) and S3 (SIM3, Torcon NB Advantage Catheter; Cook Medical, Bloomington [IN], US) catheters, respectively. There was difficulty in forming the S2 curve in the descending arch in one patient, and the operator therefore switched to a S1 catheter to cannulate the left-sided supra-aortic vessels, including the left vertebral artery. In another case, a S3 catheter was used to perform a left vertebral artery angiogram as the S2 catheter failed to catheterise the vessel securely.

Haemostasis Protocol

All arteriotomy closures were achieved with a haemostatic compression band as mentioned (Table 1). None of our patients experienced severe bleeding complications at the radial artery access site, such as pseudoaneurysm or significant haematoma.

Limitations

Our study had some limitations, including its retrospective design and small sample size. Larger-scale studies are needed to validate our initial findings.

CONCLUSION

TRA is a safe and feasible way for diagnostic cerebral angiographies, with a low complication rate.

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