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Comparison of Transfemoral Cerebral Angiography and Transradial Cerebral Angiography Following a Shift in Practice During Four Years at a Single Center in China

Authors' Contribution:
Study Design A
Data Collection B
Statistical Analysis C
Data Interpretation D
Manuscript Preparation E
Literature Search F
Funds Collection G

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Background: Cerebral angiography, or intra-arterial digital subtraction angiography (DSA), is a fluoroscopic imaging technique. In China, until recently, transfemoral access (TFA) has been used, rather than transradial access (TRA). This retrospective study aimed to compare transfemoral cerebral angiography (TFCA) with transradial cerebral angiography (TRCA) consecutively performed by the same operator, at a single center in China, to determine whether there were benefits from the shift from TFA to TRA in terms of efficiency, safety, and feasibility.

Material/Methods: A review of 1,048 cerebral angiograms in 980 patients was performed by a single operator from June 2014 to May 2018, including the TFA group (n=513) and the transradial access (TRA) group (n=535), and 39 patients underwent both TFA and TRA. The total procedure time, duration of fluoroscopy, catheterization success rate, image quality, length of stay in hospital, complications of the procedure, and patient preference were compared between the groups.

Results: Compared with TFCA, TRCA resulted in significantly shorter total procedure time, a higher catheterization success rate, better image quality, and shorter duration of hospital stay ($P<0.05$). There was no significant difference between the TFA and TRA groups for cardiovascular, cerebral, and access site complications. Patients in the TRA group showed a significantly reduced fluoroscopy time at the early stages of operator training ($P<0.05$). Patient preference included TRA (76.74%), TFA (16.28%), and no preference (6.89%).

Conclusions: During four years at a single center, and with a single operator, TRCA was safe, feasible, and more rapid when compared with TFCA.

MeSH Keywords: **Cerebral Angiography • Retrospective Studies • Technology, Radiologic**

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Background

Currently, digital subtraction angiography (DSA) remains the gold standard fluoroscopic imaging procedure for the diagnosis of cerebrovascular disease [1]. Cerebral angiography is mainly performed using transfemoral access (TFA), rather than by transradial access (TRA), in most centers in central and northern China [2]. However, transfemoral cerebral angiography (TFCA) has several limitations [3,4]. TFCA is more likely to result in access site complications when compared with transradial access (TRA). In some patients who have severe atherosclerosis or other occlusive lesions of the iliac artery and abdominal aorta, TFCA is contraindicated. Also, to avoid bleeding and prevent access site complications, TFCA requires prolonged femoral artery compression and limb immobilization, but a long period of postoperative bed rest may cause back pain, urinary retention, and predisposes to deep vein thrombosis [3,4].

The use of transradial cerebral angiography (TRCA) using TRA is a practical and safe interventional procedure [5,6]. Currently, TRA has been adopted completely in Europe [7]. Although DSA is widely accepted for use in the diagnosis of cerebrovascular disease in China, TRA is not widely used. The routine use of TFCA in China is important for the familiarity and expertise of the operator, or interventional radiologist [4]. The superiority of TRCA has been previously reported [8,9], but there have been few studies to compare the safety and effectiveness of changing from the use of TFA to TRA in cerebral angiography from the experience of a single operator at a single center.

In our center, TFA was previously the only access used. Recently, TRA has become increasingly used for cerebral angiography with a transition period of a few years. Therefore, this retrospective study aimed to compare TFCA with TRCA consecutively performed by the same operator, at a single center in China, to determine whether there were benefits from the shift from TFA to TRA in terms of efficiency, safety, and feasibility.

Material and Methods

Study design

This retrospective study was conducted in 2018. Data were obtained from patients who underwent consecutive fluoroscopic intra-arterial digital subtraction angiography (DSA) performed by a single operator at our center from June 2014 to May 2018. This radiologist started to learn cerebral angiography in June 2014. This study, and all procedures, were approved by the local Institutional Review Board. Informed consent was obtained from all patients.

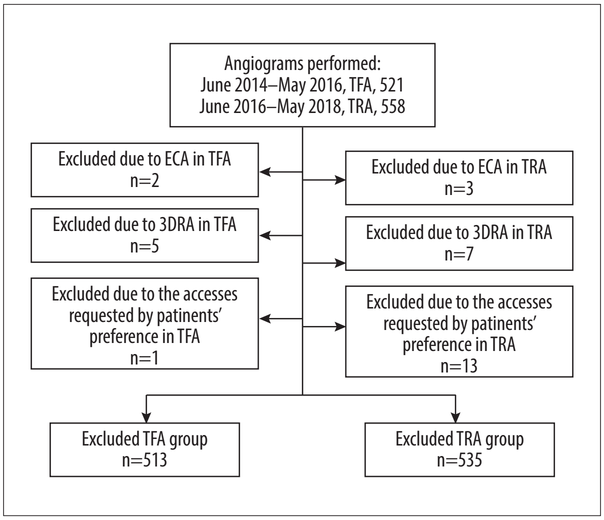

Figure 1. The process of patient selection. TFA – transfemoral access; TRA – transradial access; ECA – external carotid angiography; 3DRA – 3-dimensional rotational angiography.

Patient selection

The patient selection procedure is shown in Figure 1. All angiographic procedures were performed using either transfemoral access (TFA) between June 2014 and May 2016), or a shift to transradial access (TRA) between June 2016 and May 2018. A review of 1,048 cerebral angiograms in 980 patients performed by a single operator from June 2014 to May 2018 included the TFA group (n=513) and the TRA group (n=535). There were 39 patients who underwent both TFA and TRA. To compare the total procedure time between the TFA group and the TRA group, patients who required external carotid angiography (ECA) and 3-dimensional rotational angiography (3DRA) were excluded from the study. Patients who requested a preferred access site were also excluded from the study.

One angiogram was excluded because the patient underwent TRCA at another center and preferred TRA. In the TRA group, three and seven angiograms were excluded as they were performed by ECA and 3DRA, respectively, and 13 angiograms were excluded due to patient preference no matter which access was finally performed. Patients who underwent successful bilateral radial puncture and brachial artery puncture were included in the study because the same angiography techniques were used.

Clinical and demographic characteristics

The clinical characteristics of each patient were reviewed and included the body mass index (BMI) and waist circumference (WC). Details of past medical history included smoking, dyslipidemia, coronary heart disease (CHD), diabetes, kidney

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disease, stroke, atrial fibrillation, peripheral artery disease, use of antiplatelet agents, and previous cerebral angiography. Procedural-associated data obtained included the number of arterial punctures, puncture time, successful catheterization of the supra-aortic and branch vessels, total procedure time, total fluoroscopy time, contrast volume, and duration of hospital stay. The cardiovascular, cerebral, and access site complications were recorded by trained staff. The aortic arch morphology was divided into type I, type II, type III, and bovine-type, with the last two types representing complex aortic arch variations [10].

Selective arterial catheterization for transfemoral cerebral angiography (TFCA) and transradial cerebral angiography (TRCA)

The puncture time was the time from the initial puncture to the successful placement of the introducer sheath. Cerebral arteries for selective catheterization included the supra-aortic vessels, the right common carotid (RCC) artery, the left common carotid (LCC) artery, the right subclavian (RS) artery, and the left subclavian (LS) artery.

Branch vessels included the right internal carotid (RIC) artery, the left internal carotid (LIC) artery, the right vertebral (RV) artery, and the left vertebral (LV) artery. Selective catheterization of the branch vessels was directly performed when there were occlusive lesions, not including significant proximal lesions, which were identified by magnetic resonance angiography (MRA) or computed tomography angiography (CTA).

In some cases, at the end of the supra-aortic vessel angiography, the corresponding branch vessel had to be further catheterized. In these cases, the cerebral artery of selective catheterization was the branch vessel rather than the supra-aortic vessel. Catheterization success was defined as the catheter tip successfully catheterizing the target artery. Total procedure time was the time from puncture of the artery to closure. Total fluoroscopy time was recorded as a surrogate for procedural radiation exposure. Access site complications included hematoma or ecchymosis, artery spasm, vascular occlusion, pseudoaneurysm, arteriovenous fistula, retroperitoneal hemorrhage, and neurological injury.

Evaluation of the cardiovascular, cerebral, and access site complications

Cardiovascular, cerebral, and access site complications were recorded at 30-day follow-up and evaluated independently by a board-certified neurologist. The image quality of each artery was divided into excellent, good, poor, and very poor grades during the arterial, capillary, venous, and venous sinus period. If the angiography of the target artery was performed unsuccessfully, the grade was very poor. Three senior neuroradiologists independently evaluated the image quality of all cerebral angiograms.

The first 50 angiograms represented the early stages of training of the radiologist and were divided into five phases (P), with ten angiograms in each phase as follows: P1, 1–10; P2, 11–20; P3, 21–30; P4, 31–40; and P5, 41–50. The average fluoroscopy time of each phase was used to investigate the learning curve of the operator.

Imaging and procedure data were retrospectively collected. At hospital discharge, patients who had undergone both TFA and TRA were asked about access site preference for cerebral angiography as follows: preference for TFA; preference for TRA; or no preference (NP).

The cerebral angiography procedure for the TFA group

After the skin of the operative area was cleaned with disinfectant, topical anesthesia was used with a subcutaneous injection of lidocaine. The femoral artery was punctured using the Seldinger technique. A 5F introducer sheath (Terumo Corp., Tokyo, Japan) was inserted, and the side-port was flushed with sterile saline. The patient was heparinized using an intravenous dose of 70 units/kg. Under the guidance of a 0.035” wire (Terumo Corp., Tokyo, Japan), a 5F pigtail catheter (Cordis, Warren, NJ, USA) was used for aortic arch angiography, and a 5F diagnostic catheter (Cordis, Warren, NJ, USA) was used to perform cerebral angiography. If the vessel of interest could not be catheterized, a 5F Simmons 2 or a 5F Head Hunter catheter were also used. After angiography was completed, the sheath was removed, and manual compression was applied for about ten minutes until hemostasis was achieved. Layers of gauze were applied using an elastic bandage. After eight hours of immobilization of the lower limb, the gauze bandage was removed, and the patient was allowed to mobilize

The cerebral angiography procedure for the TRA group

Study participants in the TRA group had a normal collateral palmar circulation confirmed with the use of a modified Allen test [11]. After the skin of the surgical site was cleaned and disinfected, the right forearm was abducted at about 30°, supinated, and slightly extended using a wrist pillow on a modified arm board. A 5F introducer sheath (Terumo Corp., Tokyo, Japan) was inserted in the radial artery using the Seldinger technique. A solution consisting of 200 mg of nitroglycerin and 5 mg of verapamil was injected through the introducer side-port to prevent arterial spasm. The patient was heparinized with an intravenous dose of 70 units/kg of heparin. Using a 0.035’ guidewire (Terumo Corp., Tokyo, Japan), a 5F pigtail catheter (Cordis, Warren, NJ, USA) was used for aortic

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Table 1. Clinical characteristics of the patients undergoing cerebral angiography.

Variables	TFA (n=513)	TRA (n=535)	P-value*
Male, n (%)	266 (51.9)	284 (53.1)	0.690
Age, n (%)			
<65 years	161 (31.4)	142 (26.5)	0.084
≥65 years	352 (68.6)	393 (73.5)	
BMI, mean±SD, kg/m^2	25.8±3.6	27.2±4.0	0.394
WC, mean±SD, cm	88.9±12.5	88.8±12.9	0.826
Past medical history, n (%)			
Smoking	209 (40.7)	216 (40.4)	0.904
Hypertension	325 (63.4)	353 (66.0)	0.373
Dyslipidemia	192 (37.4)	184 (34.4)	0.306
Diabetes	127 (24.8)	118 (22.1)	0.302
Stroke	434 (84.6)	447 (83.6)	0.643
Kidney disease	55 (10.7)	64 (12.0)	0.527
CHD	90 (17.5)	86 (16.1)	0.523
Atrial fibrillation	25 (4.9)	27 (5.0)	0.897
Peripheral artery disease	1 (0.2)	2 (0.4)	0.588
Antiplatelet agents used	206 (40.2)	235 (43.9)	0.217
Previous cerebral angiography	25 (4.9)	43** (8.0)	0.038

* The chi-squared test or Fisher's exact test for categorical variables, and the Student's t-test for continuous variables. ** Four angiograms performed by TFA and 39 angiograms performed by previous TRA. TFA – transfemoral access; TRA – transradial access; BMI – body mass index; SD – standard deviation; WC – waist circumference; CHD – coronary heart disease.

arch angiography. A 5F Simmons 2 catheter (Cordis, Warren, NJ, USA) was used to perform the angiography.

A 5F Simmons 1 catheter was also used to perform selective catheterization of the branch vessels. The curve of the descending aorta was reformed, sometimes from the aortic valve [12]. If the vessel of interest, especially the branch vessel, could not be catheterized, the contrast dose was added, and/or the upper arm secured with a blood pressure cuff. At the termination of angiography, hemostasis at the puncture site was achieved using a radial armband (Terumo, Somerset, NJ, USA) [8]. Following angiography, the wrist joint was immobilized for about six hours, but without requiring bed rest.

Study endpoints

The primary endpoints included the perioperative parameters that were used to assess and compare the effectiveness and safety of TFA and TRA. The study endpoints included the number of puncture sites, the puncture time, successful catheterization of supra-aortic and branch vessels, including subgroup analysis based on type III and bovine-type aortic arch, the total procedure time, the total fluoroscopy time, the contrast volume, and the duration of hospital stay for patients in the TFA group and the TRA group. Cardiovascular, cerebral, and access site complications were evaluated and compared between the TFA group and the TRA group. The secondary endpoints included the grade of the image quality based on the complexity of aortic arch morphology, the learning curve of the operator, and the patient preference for access site.

Statistical analysis

Data were analyzed using SPSS version 22.0 software (IBM Inc., Armonk, NY, USA). Continuous variables were expressed as the mean±standard deviation (SD) and tested for normality using the Kolmogorov-Smirnov test. Categorical variables were expressed as the count number and percentage. A comparison of nominal categorical variables between TFA and TRA was assessed by the chi-squared (χ^2) test or Fisher's exact test. Comparison of continuous variables between TFA and TRA was performed with the Student's t-test or Wilcoxon's rank-sum test. Radit analysis was performed for ordinal categorical variables. Comparison of continuous variables among the first five different phases of TRA or TFA learning curve was performed with a two-way analysis of variance (ANOVA). A P-value <0.05 was considered to be statistically significant.

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Table 2. Procedure-related characteristics of patients undergoing cerebral angiography.

Variables	TFA (n=513)	TRA (n=535)	P-value*
Unfavorable arch anatomy, n (%)	269 (52.4)	266 (49.7)	0.379
Puncture number, mean±SD	1.3±0.5	1.5±0.6	0.031
Puncture time, mean±SD, min	2.8±1.3	3.1±1.4	0.055
Successful catheterization of supra-aortic vessels,% (n/n**)			
RCC	96.7 (350/362)	100.0 (337/337)	0.001
LCC	100.0 (357/357)	99.1 (339/342)	0.117
RS	95.7 (354/370)	100.0 (383/383)	<0.001
LS	98.9 (361/365)	97.5 (346/355)	0.170
Successful catheterization of branch vessels, % (n/n**)			
RIC	94.7 (143/151)	97.4 (193/198)	0.175
LIC	96.8 (151/156)	87.0 (168/193)	0.001
RV	92.3 (132/143)	96.1 (146/152)	0.168
LV	93.9 (139/148)	56.1 (101/180)	<0.001
Total procedure time, mean±SD, min	45.7±4.6	38.1±5.7	0.001
Total fluoroscopy time, mean±SD, min	16.4±3.4	14.9±2.8	0.541
Contrast volume, mean±SD, ml	85.0±10.3	80.1±9.6	0.521
Hospitalization time, mean±SD, h	168.7±18.4	123.8±22.2	0.010
Cardiovascular and cerebral complications, n (%)	2[#] (0.8)	3[##] (1.3)	0.520
Access site complications, n (%)			
Pain during or after procedure	17 (3.3)	19 (3.6)	0.833
Hematoma or ecchymosis	5 (1.0)	8 (1.5)	0.446
Artery spasm	2 (4.0)	6 (1.1)	0.288
Vascular occlusion	1 (0.2)	0 (0.0)	0.490
Pseudoaneurysm	1 (0.2)	2 (0.4)	0.617
Arteriovenous fistula	1 (0.2)	1 (0.2)	1.000
Retroperitoneal hemorrhage	0 (0.0)	0 (0.0)	1.000
Neurological injury	0 (0.0)	0 (0.0)	1.000

* The Chi-squared test or Fisher's exact test for categorical variables, and the Student's t-test for continuous variables. ** The required number of selective catheterizations to the corresponding vessels. [#] Two cases with minor stroke. [##] Two cases with minor stroke and one case with paroxysmal supraventricular tachycardia (SVT). TFA – transfemoral access; TRA – transradial access; SD – standard deviation; RCC – right common carotid artery; LCC – left common carotid artery; RS – right subclavian artery; LS – left subclavian artery; RIC – right internal carotid artery; LIC – left internal carotid artery; RV – right vertebral artery; LV – left vertebral artery.

Results

Patient demographics and clinical characteristics

The clinical characteristics of the patients undergoing cerebral angiography in the transfemoral access (TFA) group and the transradial access (TRA) group are shown in Table 1. This study included a review of 1,048 cerebral angiograms in 980 patients performed by a single operator from June 2014 to May 2018. The patient groups included the TFA group (n=513) and the transradial access (TRA) group (n=535) who underwent transfemoral cerebral angiography (TFCA) and transradial cerebral angiography (TRCA), respectively (Figure 1). The 5F Simmons 2 catheter was successfully used for re-catheterization in 36 of 53 angiograms, and the 5F Head Hunter catheter was successfully used for re-catheterization in 6 of 53 angiograms in the TFA group. The 5F Simmons 1 catheter was successfully used for re-catheterization in 40 of 61 angiograms in the TRA

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Table 3. Successful catheterization in type III aortic arch and bovine aortic arch.

Variables	TFA (n=269)		TRA (n=266)		P-value*
Supra-aortic vessels, % (n/n**)					
RCC	93.7	(119/127)	100.0	(146/146)	0.002
LCC	100.0	(171/171)	98.9	(162/164)	0.239
RS	91.4	(148/162)	100.0	(171/171)	<0.001
LS	98.3	(178/181)	97.4	(150/154)	0.707
Branch vessels, % (n/n**)					
RIC	91.9	(79/86)	96.7	(116/120)	0.207
LIC	96.9	(95/98)	90.2	(92/102)	0.083
RV	89.7	(87/97)	95.8	(91/95)	0.164
LV	92.0	(81/88)	58.9	(66/112)	<0.001

* The Chi-squared test or Fisher's exact test for categorical variables, and the Student's t-test for continuous variables. ** The required number of selective catheterizations to the corresponding vessels. TFA – transfemoral access; TRA – transradial access; RCC – right common carotid artery; LCC – left common carotid artery; RS – right subclavian artery; LS – left subclavian artery; RIC – right internal carotid artery; LIC – left internal carotid artery; RV – right vertebral artery; LV – left vertebral artery.

group when catheterization of the vessel of interest failed. There were 266 and 284 male patients in the TFA group and the TRA group, respectively.

In both groups, most patients were ≥65 years of age. The mean body mass index (BMI) was 25.8±3.6 kg/m^2 in the TFA group, and 27.2±4.0 kg/m^2 in the TRA group. The mean waist circumference (WC) in the TFA and TRA groups was 88.9±12.5 cm and 88.8±12.9 cm, respectively. There were no significant differences in the past medical history between the two groups (P>0.05), except for previous cerebral angiography, which was significantly less in the TFA group (4.9% *vs.* 8.0%; P<0.05). In the TRA group, 43 patients had previously undergone cerebral angiography, and 39 of them had previously undergone TFCA. Therefore, there were no significant differences in the clinical characteristics between the two study groups, except for previous cerebral angiography. The procedural-related characteristics of patients undergoing cerebral angiography are shown in Table 2.

Primary endpoints

The total procedure time in the TRA group was significantly less than that of the TFA group, but the number of arterial punctures in the TRA group was significantly greater than in the TFA group (38.1±5.7 *vs.* 45.7±4.6 min, P=0.001; and 1.5±0.6 *vs.* 1.3±0.5, P=0.031, respectively). There were no significant differences in puncture time between the two groups (P>0.05). The successful catheterization rate of the TRA group was significantly greater than that of the TFA group for the right common carotid (RCC) artery and the right subclavian (RS) artery (RCC, 100% *vs.* 96.7%, P=0.001; RS, 100% *vs.* 95.7%, P<0.001, respectively) and was lower than that of TFA for the left internal carotid (LIC) artery and the left vertebral (LV) artery (LIC, 87.0% *vs.* 96.8%, P=0.001; LV, 56.1% *vs.* 93.9%, P<0.001, respectively). The duration of hospital stay in the TRA group was significantly less than that of the TFA group (123.8±22.2 *vs.* 168.7±18.4 h, P=0.010). There were no significant differences between the study groups for total fluoroscopy time and contrast volume (P>0.05) (Table 2).

Cardiovascular, cerebral, and access site complications

Complications associated with the procedures included two patients with minor strokes within three days after TFA, two patients had minor strokes within three days after TRA, and one patient experienced paroxysmal supraventricular tachycardia during the process of reforming the Simmons curve in the ascending aorta. These five incidences of complications associated with the angiography procedure had no sequelae at the one-month follow-up. There were no significant differences in cardiovascular, cerebral, and access site complications between the two groups (P>0.05) (Table 2).

Subgroup analysis

Subgroup analysis showed the successful catheterization rate of TRA was still higher than that of TFA in the RCC artery and the RS artery (RCC, 100% *vs.* 93.7%, P=0.002; RS, 100% *vs.* 91.4%, P<0.001, respectively). The successful catheterization rate of TRA was lower than that of TFA only in the LV artery (58.9% *vs.* 92.0%, P<0.001) in type III and bovine-type aortic arch (Table 3).

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Table 4. Image quality* based on the complexity of the aortic arch morphology.

Variables	TFA (n=513)				TRA (n=535)				t	P-value**
	Excellent	Good	Poor	Very Poor	Excellent	Good	Poor	Very Poor		
Supra-aortic type I and II aortic arch, n										
RCC	137	93	0	5	123	67	1	0	–1.18	0.237
LCC	130	54	2	0	122	55	0	1	0.20	0.844
RS	139	67	0	2	144	68	0	0	–0.25	0.803
LS	138	45	1	0	140	57	0	4	0.97	0.334
Supra-aortic type III and bovine aortic arch, n										
RCC	79	41	0	7	113	32	1	0	–2.31	0.021
LCC	121	48	2	0	99	63	0	2	1.63	0.103
RS	112	36	3	11	143	28	0	0	–2.51	0.012
LS	126	51	4	0	90	61	0	3	1.72	0.085
Branch type I and II aortic arch, n										
RIC	45	20	0	0	58	17	2	1	–0.41	0.684
LIC	49	8	1	0	68	10	4	9	1.21	0.227
RV	33	12	0	1	43	12	1	1	–0.29	0.774
LV	43	15	1	1	37	25	2	4	1.79	0.074
Branch type III and bovine aortic arch, n										
RIC	47	32	3	4	69	48	2	1	–0.64	0.522
LIC	71	23	1	3	71	22	8	1	0.47	0.642
RV	77	16	2	2	78	14	1	2	–0.33	0.738
LV	38	48	2	0	34	69	4	5	1.93	0.053

* The image quality of each artery was divided into excellent, good, poor, and very poor grades according to the arterial, capillary, venous, and venous sinus period. ** Radit analysis for ordinal categorical variables. TFA – transfemoral access; TRA – transradial access; RCC – right common carotid artery; LCC – left common carotid artery; RS – right subclavian artery; LS – left subclavian artery; RIC – right internal carotid artery; LIC – left internal carotid artery; RV – right vertebral artery; LV – left vertebral artery.

Secondary endpoints

The image quality in the TRA group was better than that of the TFA group for the RCC artery and the RS artery in type III and bovine aortic arch (RCC, t=–2.31, P=0.021; RS, t=–2.51, P=0.012, respectively). The image quality of each artery is shown in Table 4. For the operator learning curve, the TRA group curve was not steeper than the curve for the TFA group (Figure 2). The results of the intragroup analysis showed a significant reduction in the average fluoroscopy time at P4 in both the TFA and TRA groups (P<0.05) (Figure 3), The results of the intergroup analysis showed the average fluoroscopy time were not different between the two groups in each phase (P>0.05) (Figure 3). There were 39 patients who underwent both TFA and TRA. Patient preference included TRA (76.74%) and TFA (16.28%), and 6.89% of patients expressed no preference (Figure 4).

Discussion

This retrospective study was undertaken at a single center in China to compare transfemoral cerebral angiography (TFCA) with transradial cerebral angiography (TRCA) consecutively performed by the same operator for four years. The findings showed that patients who underwent the shift to transradial access (TRA) from transfemoral access (TFA) showed significant benefits in terms of efficiency, safety, and feasibility. The use of TRA was associated with a shorter total procedure

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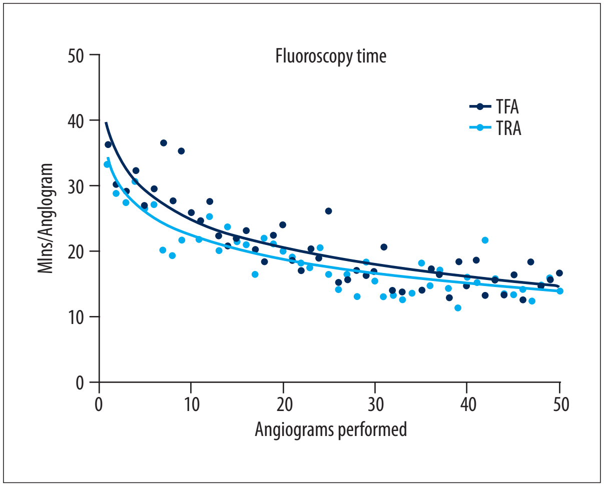

Figure 2. The learning curve for transfemoral access (TFA) and transradial access (TRA).

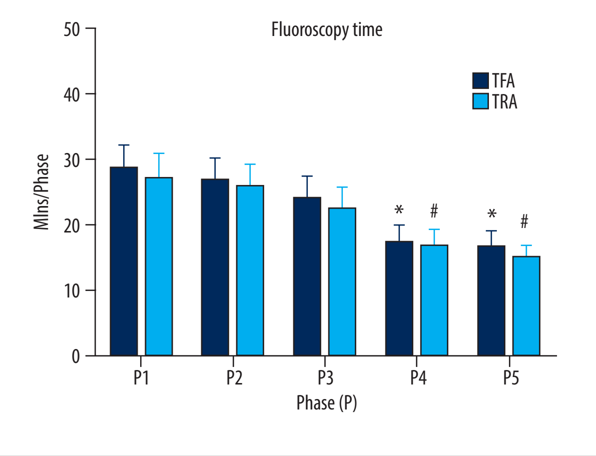

Figure 3. The average fluoroscopy time of the first five phases for transfemoral access (TFA) and transradial access (TRA). Bars with a symbol are significantly different. * P<0.05 *vs.* P1, P2, and P3 in TFA; $^{\#}$ P<0.05 *vs.* P1, P2, and P3 in TRA.

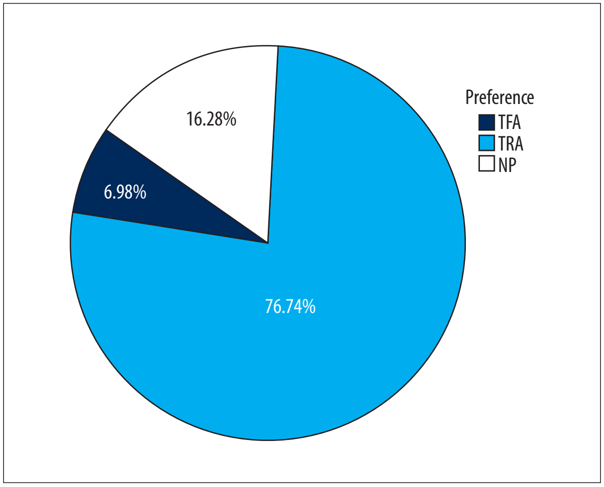

Figure 4. The preference of patients who underwent both transfemoral access (TFA) and transradial access (TRA). No preference (NP).

time, higher successful catheterization rate in the right common carotid (RCC) artery and the right subclavian (RS) artery in type III and bovine aortic arch. Also, the use of TRA was associated with a shorter duration of hospital stay than TFA with no significant differences for cardiovascular, cerebral, and access site complications. TRA resulted in better image quality for the RCC artery and the RS artery and type III and bovine aortic arch than TFA. A significant reduction in the average fluoroscopy time appeared at P4 in both the TFA and TRA study groups. Patients who underwent both TFA and TRA preferred the use of the TRA access.

Although a previous study showed that TRA puncture was easier than TFA puncture [13], the present study had the opposite findings. The differing results might be due to the lack of pre-puncture ultrasound examination and a relatively smaller radial artery caliber in the present study [14,15]. However, in the present study, all patients in both the TFA and TRA study groups had successful access, and the total procedure time of TRA was significantly less than that for TFA. This study also showed that successful catheterization rates of the right common carotid (RCC) artery and the right subclavian (RS) artery in the TRA group were higher than in the TFA group. The successful catheterization rates of the left internal carotid (LIC) artery and the left vertebral (LV) artery in the TRA group were lower than in the TFA group. The reason that some vessels in the TFA group or the TRA group were more difficult to catheterize may have been due to shape mismatching between the catheter and the aortic arch [4].

In our center, limb immobilization in the TFA group was the main reason that patients who underwent TRA had a shorter duration of hospital stay compared with patients undergoing TFA, which supported a benefit from the shift from TFA to TRA. The radial artery access area was superficial, with good collateral circulation and no adjacent blood vessels and nerves, so the incidence of access site complications was low [16]. In this study, cardiovascular, cerebral, and access site complications were lower in both groups compared with other studies [4,9]. Given that the shift from TFA to TRA can promote the effectiveness of the procedure without reducing safety, support its widespread adoption. However, when compared with the findings from a previous study [17], in this study, the image quality grade was firstly used to evaluate the feasibility of TRA after the shift from TFA to TRA based on the complexity of aortic arch morphology. Also, previous studies showed the advantages of TRA in type III or bovine aortic arch in interventional procedures [5,18]. TFA can be associated with

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arterial tortuosity and may be more challenging for arterial catheter access [19].

The findings from the present study also showed that access to the RCC artery and the RS artery with TRA could also achieve better image quality in type III and bovine aortic arch. Target arteries in cerebral angiography are usually visualized with a proximal injection of the target artery orifice [4]. However, this study showed that the image quality of all branch vessels showed no significant differences between the two study groups even though successful catheterization rates of the LV artery in the TRA group were lower than in the TFA group in patients with type III and bovine aortic arch. In some studies, the operators performed both approaches at the initial phases of training, and benefits could be achieved for TRCA [8,19,20]. The findings from the present study support the beneficial effects of the shift from TFA to TRA in cerebral angiography, which has occurred at our center in the past few years.

Previously published studies have shown that the threshold to overcome the initial learning curve was between 30 and 50 cerebral angiography procedures and that high-volume operators might not experience a significant learning curve [21,22]. In the present study, there was a significant reduction in the average fluoroscopy time that appeared at the P4 phase in both the TFA and TRA study groups. The average fluoroscopy time was not different between the two groups in each phase. The first 30 cases represented the threshold to overcome the initial learning curve, which was consistent with the findings from previous studies [21,23].

In the TRA procedure, the process of reforming the Simmons 2 curve to select the target artery is complex, as previously reported [19,24]. Therefore, the learning phase for TRA might be more prolonged, resulting in an increased radiation dose associated with fluoroscopy, with a requirement for a greater volume of contrast during the process of learning the procedure [23]. However, there were no significant differences between the two study groups in total fluoroscopy time and contrast volume. In this study, the TRA learning curve was overcome after performing 30 cases, which was the same as for TFA, because the operator was relatively experienced in TRA. Shen et al. also found that TFA might be time-consuming in patients with type III and bovine aortic arch [25]. In the present study, for both TFA and TRA, the operator became skilled after performing 30 angiograms. Therefore, the short duration of the learning curve for the radiology operator supported the benefit and feasibility of the shift from TFA to TRA.

Patient preference might affect the choice of access for cerebral angiography by the interventional radiologist [26]. This study showed that patients had a clear preference for TRA, which was consistent with the findings from a previous study [26]. Several previously published studies have identified the main factors that determine patient preference in angiography arterial access [4,8,12,19,26]. Firstly, TRA did not require strict limb immobilization and bed rest, which improved the quality of life for the patients. Secondly, patients did not require preoperative hair removal and exposure of the groin, which reduced stress and embarrassment. Also, the total procedure time for TRA was significantly less than for TFA, which reduced patient discomfort. The reasons for patient preference require further study. However, the shift from TFA to TRA is feasible for a single operator in terms of the imaging quality, the learning curve, and patient preference. Based on these findings, TRCA was found to be a better choice.

This study had several limitations. This retrospective observational clinical study was not controlled, the study was conducted at a single center, and all procedures were performed by a single operator, according to the workflow. Patients who underwent external carotid artery (ECA) angiography and three-dimensional rotational angiography (3DRA) were excluded from the study to control for potential bias. The data used in this study might have been biased due to the limitations of the retrospective design of this study. For example, pain may result from nerve injury associated with hematoma as a complication of the puncture point, which may not have been recorded in the clinical notes. Also, the use of the hemostasis technique in TRA reduced the total procedure time and was preferred by the patients. Large-scale, multicenter, prospective controlled studies are required to support the findings from this retrospective clinical study.

Conclusions

Cerebral angiography, or intra-arterial digital subtraction angiography (DSA), is a fluoroscopic imaging technique. In China, until recently, transfemoral access (TFA) has been used, rather than transradial access (TRA). This retrospective study aimed to compare transfemoral cerebral angiography (TFCA) with transradial cerebral angiography (TRCA) consecutively performed by the same operator, at a single center in China, to determine whether there were benefits from the shift from TFA to TRA in terms of efficiency, safety, and feasibility. During the four-year shift from TFA to TRA, TRCA was safe, feasible, and more rapid when compared with TFCA.

Acknowledgments

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Conflict of interest

None.

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