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Direct carotid exposure approach in the treatment of anterior circulation unruptured intracranial aneurysms for elderly patients

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Abstract

Background and purpose: The direct carotid exposure approach (DCEA) is a technical option for elderly patients with severe vessel tortuosity due to arteriosclerosis. We evaluated complications related to antiplatelet/anticoagulant management and compared the DCEA to standard transfemoral/transbrachial approaches (TFBA) in the treatment of unruptured intracranial aneurysms for elderly patients.

Methods: From August 2017 to August 2020, 52 patients (53 procedures) aged over 75 years with unruptured aneurysms in the anterior circulation were treated at our institution. All patients received dual antiplatelet drugs before the procedure. Eleven patients (21.2%) (12 procedures) were treated with the DCEA. The rest were treated with TFBA. The main indication of the DCEA was an unfavorable aortic arch or vessel tortuosity. Complications and the duration of the procedure were compared between the two groups.

Results: There were no significant differences between the two groups in age, aneurysm location, preoperative antiplatelet use, heparin use, or maximum activated clotting time (ACT) values. All endovascular treatments were successfully performed by DCEA. Among all parameters, the DCEA group had only bigger average aneurysm diameter (14 mm) and higher number of pipeline embolic device (PED) placement (58%). Time to the guiding-catheter placement was not significantly different between the groups (DCEA vs TFBA = 31.0 min vs 24.7 min, $p = 0.178$). No significant complications of DCEA, such as subcutaneous hematomas, were observed.

Conclusion: Even with the use of antiplatelet and anticoagulation therapy, the DCEA can be performed safely for unruptured aneurysms in elderly patients.

Keywords

Direct carotid exposure approach, unruptured aneurysm, coil embolization, pipeline embolic device, flow diverter, elderly, vessel tortuosity

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Introduction

Endovascular treatment (EVT) for intracranial aneurysms has reached advanced stages as a general technique due to its rapid technological innovation. The most significant advantage of EVT is its minimal invasiveness. The procedure is usually performed through a transfemoral approach, but it may be difficult due to arteriosclerosis or tortuosity of vessels. In such cases, EVT can be performed via the transbrachial approach. However, compared with the femoral artery approach, there are often limitations for the treatment devices that can be applied. We have actively employed the direct carotid exposure approach in cases with excessive vessel tortuosity. The advantage of DCEA in an unruptured aneurysm (UA) is that the treatment can be performed easily and quickly because the distance to the target aneurysm is short and is not substantially affected by vessel tortuosity. Even if the guiding catheter is inserted with the standard approach into the ICA, it is often unstable and creates a higher risk of thromboembolic complications. In DCEA, once the guiding system is inserted, the guiding catheter is stable and enables the excellent operability of the microcatheter.

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Few such cases have been reported so far;[1–5] however, most of them are based on the direct carotid puncture approach, which is slightly different from DCEA. Here, we present the detailed method, efficacy, and complications of performing EVT by DCEA while continuing to administer antiplatelet and anticoagulant therapy during the perioperative period. We reviewed the technical aspects and present cases illustrating the indications, benefits, and limitations of this approach.

Materials and methods

This study was approved by the Ethics Committee of our hospital and was carried out using the opt-out method described on our hospital website. As the data obtained were from routine examinations, for which the patients had provided written informed consent on admission and were used for retrospective analysis, the requirement for specific informed consent for the present study from the patients was waived. Regarding the approval of cervical incision, it was performed with the consent of each patient within the scope of the operative agreement. We retrospectively reviewed our database for all endovascular procedures. Clinical details and outcome data were extracted from our database and medical records. Indications for DCEA, procedure details, procedure-related complications, and patient outcomes were assessed. The technique of DCEA has been previously described in detail[6] and was applied with minor modifications. We routinely performed diagnostic cerebral angiography in all patients to evaluate the access route and morphology of the aneurysm before the endovascular procedure. According to the analysis of the angiographic images, patients in whom it was difficult to navigate the diagnostic catheter to the target vessel during diagnostic angiography were selected for EVT by DCEA (Figure 1).

Patient population

From August 2017 to August 202,052 patients (53 procedures) aged over 75 years with UAs in the anterior circulation were treated at our institution (Table 1). During this period, a total of 11 patients (12 procedures) with 15 UAs were treated with DCEA (Table 2). All the reasons for the treatment of these patients were aneurysm growth on follow-up investigations, symptomatic aneurysms or strong desire for treatment by the patient and family. Forty patients were treated using the transfemoral approach, and one patient was treated using the transbrachial approach. One patient received bilateral DCEA with two sessions for the treatment of multiple aneurysms. The average age of the patients was 80.9 years (75–91 years), and 10 patients were women. Table 2 shows a patient list of all procedures in DCEA. There were seven patients (8 procedures) on eleven unruptured internal carotid artery (ICA) aneurysms, one on an anterior communicating artery (Acom) UA, and three anterior cerebral artery (ACA) aneurysms. The aneurysm size ranged from 3 to 21 mm, with a mean of 13.5 mm. Seven out of the twelve procedures were treated with a pipeline embolic device (PED) (Medtronic, Irvine, CA, USA) placement through DCEA. The five procedures were saccular coil embolizations. In all the DCEA selected cases, the aortic arch or major vessel tortuosity was severe and preoperative angiography could not guide the diagnostic catheter. One patient had a history of dissection of the descending aorta, resulting in a high risk for the femoral approach (Procedure No. 5).

Details of the DCEA technique

All procedures were performed under general anesthesia in a hybrid operating room (Artis Q, Siemens Healthcare GmbH, Forchheim, Germany).[7] The head was placed in the head support cup of the angiography table, and the neck was slightly extended with a 30° rotation to the opposite side. Before surgery, a carotid duplex echo was performed to determine the exact site of the skin incision. The intended target puncture site was approximately 2 cm above (distal) to the site of the skin incision, avoiding a puncture too low and close to the clavicle that resulted in an almost perpendicular entry angle into the common carotid artery. Such a low puncture makes the access difficult and leads to the kinking of the dilators and sheath. A 3 cm transverse skin incision was made under ultrasonic guidance over the common carotid artery (Figure 2(a)). The superficial fascia was opened medial to the sternocleidomastoid muscle, which was retracted laterally, and the carotid sheath was exposed in the carotid triangle. The sheath was lifted and stabilized with a "stay" suture to facilitate the arterial puncture and secured for flow control with vessel loops. On the intended puncture site, an X-shaped wall stitch using CV-7 (GORE-TEX® Suture, Gore Medical, Flagstaff, AZ, USA) was placed for postprocedural complete closure of the puncture site. The puncture was performed using a 4-Fr pediatric micropuncture kit (Cook Medical, Bloomington, IN, USA) through an area 2 cm from the site of the skin incision (Figure 2(b)). The microwire attached to this standard kit is appropriate for the task as it is thin and has a soft tip; thus, it is unlikely to cause blood vessel damage. After confirming the guidewire insertion into the ICA under fluoroscopy (Figure 3(a)), the 4-Fr sheath of a micropuncture kit was inserted. A 0.035-in wire (Terumo Corporation, Tokyo, Japan) was placed in the ICA under roadmap guidance (Figure 3(b)), and a 4-Fr sheath was exchanged for a guiding sheath (Figures 2(c) and 3(c)). The following guiding sheaths

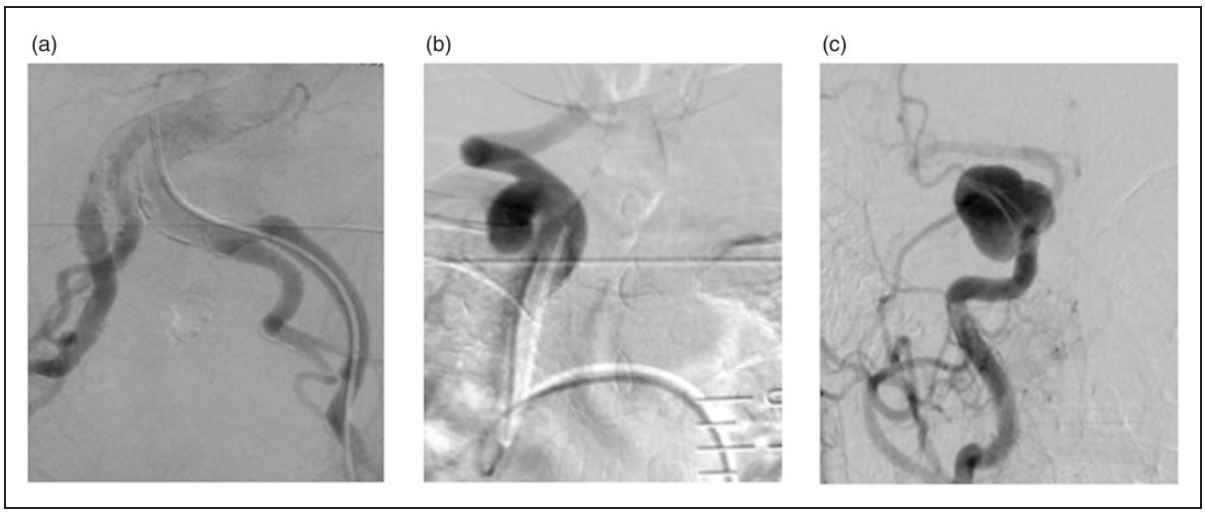

Figure 1. (a) The femoral artery has considerable tortuosity due to arteriosclerosis; (b) the brachiocephalic artery also has tortuosity and loops due to arteriosclerosis; (c) a 20 mm large aneurysm is located in the right cavernous sinus portion.

Table 1. Patient characteristics of 52 patients (53 procedures) with treatment of unruptured intracranial aneurysm over 75 years.

	DCEA		TFA/TBA		P value
	n	%	*n*	%	
No	12		41		
Age	81		78		0.026
Location of the aneurysm					
ICA	8	67%	26	63%	
ACA/Acom	4	33%	10	24%	
MCA	0	0%	5	12%	
Size (mm)	14		9		0.010
Guiding system					
8Fr	1	8%	32	78%	
6Fr	11	92%	7	17%	
5Fr	0	0%	2	5%	
Procedure					
CE	1	8%	20	49%	
SAC	4	33%	15	37%	
PED	7	58%	6	15%	
Procedure time (mean, min)	274		192		0.001
Approach time (mean, min)	31		25		0.178
ACT max (mean, s)	293		304		0.255
Heparin use (mean, unit)	5500		5049		0.351
Preoperative antiplatelet					
DAPT	10	83%	38	93%	
TAPT	2	17%	0	0%	
DAPT + DOAC	0	0%	1	2%	
Post procedure anticoagulation					
Heparin	1	8%	1	2%	
Argatoroban	11	92%	22	54%	
None	0	0%	18	44%	
Adverse event of puncture site	0		6 (15%)		
Morbidity	1 (8%)		2 (5%)		

were used: 6 Fr Destination (Terumo Corporation, Tokyo, Japan) (45 cm; $n = 10$, 90 cm; $n = 1$), and 8-Fr Shuttle sheath (Cook Medical, Bloomington, IN, USA) ($n = 1$). Subsequently, the extracranial carotid was visualized angiographically to confirm the absence of vascular injury. The guiding sheath was fixed with the isodine surgical drape (3M Corporation, MN, USA) so that it does not come

Table 2. Patients lists of direct carotid exposure approach for unruptured intracranial aneurysm.

No.	Age	Sex	Side	Site	Size (mm)	Palsy	Sheath	Procedures	Reasons for DCEA
1	83	F	R	ICA CS	15	III	6Fr Destination 90 cm	PED	Tortuosity
2	75	F	L	ICA paraclinoid	18	III VI	8Fr Shuttle	PED and coil	Tortuosity
3	89	F	R	ICA CS	21	III	6Fr Destination 45 cm	PED	Tortuosity
4	79	F	R	ICA CS	20	III	6Fr Destination 45 cm	PED	Tortuosity
5	75	F	R	ICA CS/paraclinoid	20/8	III	6Fr Destination 45 cm	PED and coil	Tortuosity, dissection of DA
6	76	F	R	ICA CS/paraclinoid	20/7	III	6Fr Destination 45 cm	PED	Tortuosity
7	91	F	L	ICA CS	21	III	6Fr Destination 45 cm	PED	Tortuosity
8	84	F	R	ACA	16		6Fr Destination 45 cm	SAC	Tortuosity
9	81	F	R	ACA	9		6Fr Destination 45 cm	SAC	Tortuosity
10	77	F	R	Acom	9		6Fr Destination 45 cm	CE	Tortuosity
11*	81	F	L	ICA paraclinoid	9/3		6Fr Destination 45 cm	SAC	Tortuosity
12	80	M	L	ACA	7		6Fr Destination 45 cm	SAC	Tortuosity

M: male; F: female; L: left; R: right; DCEA: direct carotid exposure approach; ICA: internal carotid artery; MCA: middle cerebral artery; ACA: anterior cerebral artery; Acom: anterior communicating artery; PAO: parent artery occlusion; PED: pipeline embolization device; DA: descending aorta, MC: microcatheter; SAC: stent-assisted coil embolization; CE: coil embolization; CS: cavernous sinus; III: oculomotor; IV: trochlear; V: trigeminal, abducens, tortuosity; the difficulty of access to target vessels due to tortuosity of aortic arch and cervical portion of carotid artery on diagnostic angiography; VI: abducens.
*Same patient as Case 4.

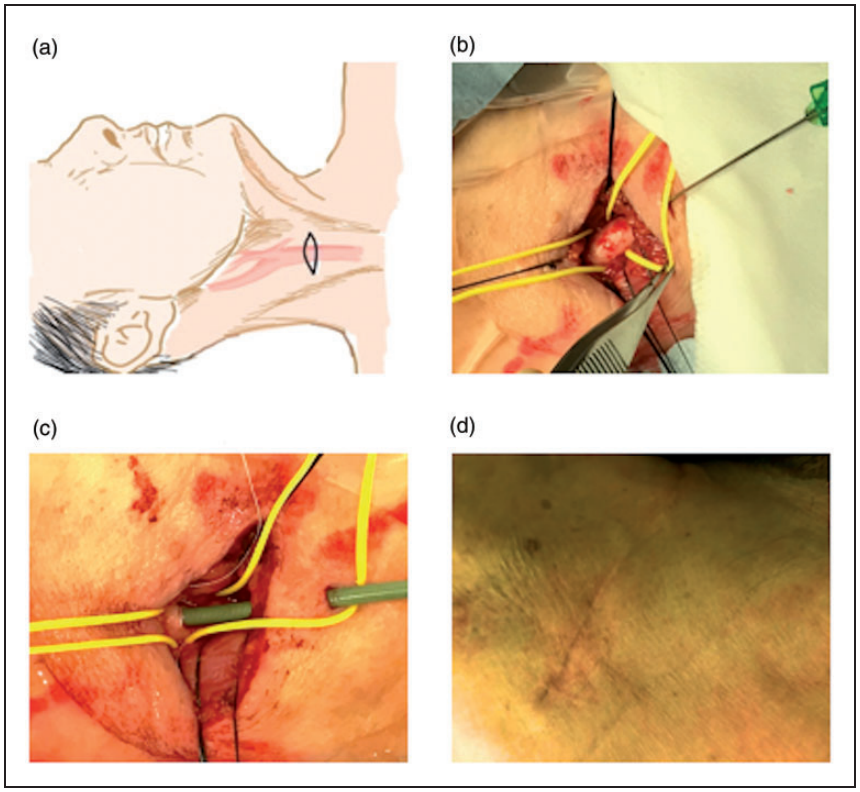

Figure 2. (a) A 3 cm transverse skin incision along the skin creases; (b) the target puncture site was approximately 2 cm distal to the site of the skin incision; (c) the 6 Fr Destination guiding sheath was adequately inserted; (d) the wound was barely noticeable after three months.

out of the puncture site even if the assistant does not hold it during the procedure. After sheath insertion, heparin was administered intravenously to maintain an activated clotting time (ACT) of over 250 seconds. In the case of PED (Figure 3(d)), after the 6 Fr Destination (45 cm) guiding sheath was sufficiently inserted, the 5 Fr Navien catheter (115 cm) (Medtronic Neurovascular, Irvine, CA, USA) was guided as an intermediate catheter proximal to the aneurysm. Furthermore, the Marksman microcatheter (150 cm) (Medtronic Neurovascular, Irvine, CA, USA) was guided to the middle cerebral artery (Figure 3(e)), and PED deployment was performed as usual (Figure 3(f)). After the operation, the guiding

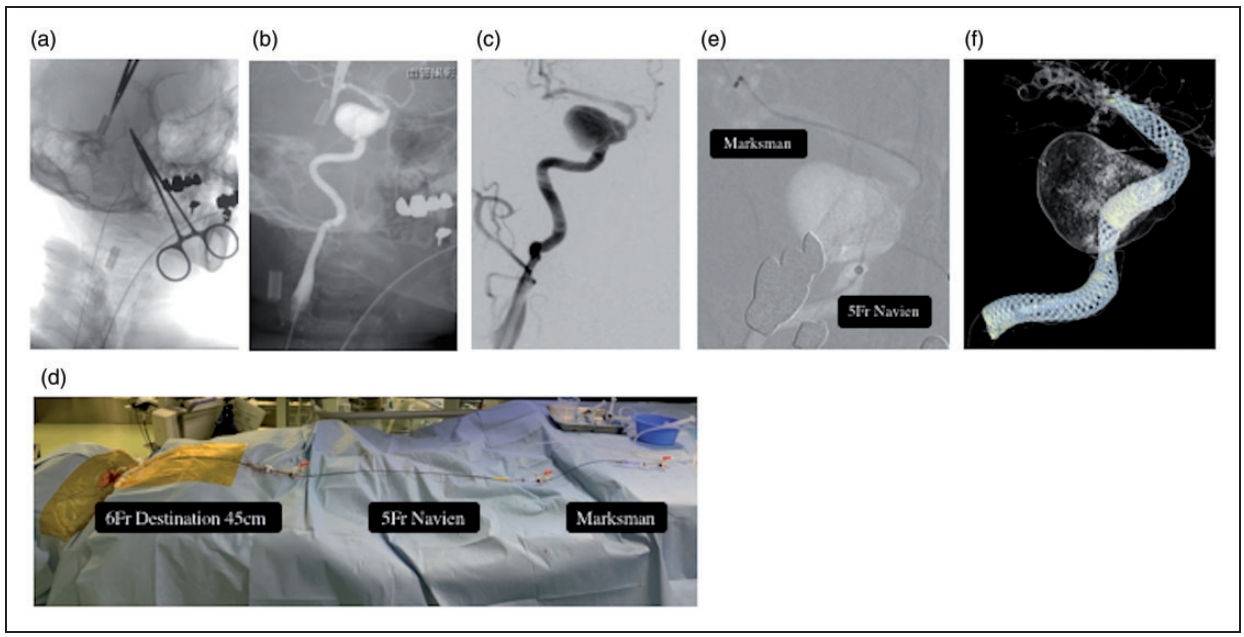

Figure 3. (a) Insertion of the microwire attached to the 4-Fr micropuncture kit; (b) guidance of the 0.035-inch wire to the internal carotid artery under the roadmap; (c) insertion of the guiding sheath through the wire; (d) a set up for pipeline deployment for the direct carotid exposure approach. A 6 Fr Destination (45 cm) is used as a guiding sheath and 5 Fr Navien (115 cm) is used as an intermediate catheter. Furthermore, a triple coaxial system using Marksman (150 cm) as a microcatheter for the pipeline embolic device deployment; (e) the 5 Fr Navien is guided proximal to the aneurysm, and Marksman is guided distal to the right middle cerebral artery; (f) two pipeline stents (5 mm × 35 mm, 5 mm × 20 mm) could be placed in the same way as a standard procedure.

catheter was slowly removed, and hemostasis was achieved using the CV-7 suture that had been applied before puncture. Manual compression was applied for approximately 10 min at the puncture site to achieve hemostasis. A Penrose drain was inserted into the wound until the next day in all cases. The subcutaneous tissue was sutured with 3–0 PDS® (Ethicon, USA), and the skin was closed with DERMABOND® (Ethicon, USA). Cefazolin sodium 1 g (once during surgery and once after surgery) was administered as prophylaxis. After the surgery, the patient was admitted to the intensive care unit for observation until the next day. Anticoagulation therapy was terminated on the day after surgery. Three months later, the wound was barely noticeable (Figure 2(d)).

Perioperative antithrombotic management

All patients took double or triple antiplatelet drugs aspirin 100 mg, clopidogrel 75–150 mg, and cilostazol 100 mg one to three weeks before the procedure. Especially in the cases of PED, we usually administered aspirin 100 mg and clopidogrel 75 mg for three weeks before the surgery. We routinely investigated the platelet aggregation. The platelet aggregation test with light transmission aggregometry (LTA), using adenosine diphosphate, was performed preoperatively.[8] Of these patients, except for one, the LTA test before surgery showed decreased values, within the target value range of less than 60% using adenosine diphosphate (36–67%; median: 47.5%). All patients were administered heparin intraoperatively. Generally, a bolus of 3000–8000 U was intravenously administered after the sheath was inserted. The ACT throughout the procedure was evaluated with a target of 250–300 s. The average ACT was maintained at about twice the baseline value (246–314 s; median: 268.7 s). Argatroban (60 mg daily) ($n = 11$) or heparin (12,000 IU/day) ($n = 1$) were continuously infused intravenously for 24 h after the procedure.

Statistical analysis

Age, maximal aneurysm diameter, total treatment time, time from the start of procedure to the insertion of a guiding catheter system, average ACT, and total usage of heparin in each group was compared by one-way analysis of variance. They were compared by the unpaired t-test. Statistical significance was defined as a P-value of less than 0.05. All analyses were performed with statistical software (Statview version 5.0, SAS Institute Inc., Cary, NC, USA; Stata version 16.0, StataCorp LLC, College Station, TX, USA; or Excel of Mac 2016 Microsoft, Redmond, WA, USA).

Results

Procedure outcome

The average time from the skin incision to completing the insertion of the guiding system was 31.0 min. All procedures were successfully performed as planned

and provided adequate arterial access. Furthermore, we performed postoperative CTA and duplex ultrasonography follow-up examination of the carotid artery, and no apparent pseudoaneurysm or arterial stenosis occurred. There were no procedural complications related to DCEA. One patient had a decrease in the mRS at the time of discharge due to cerebral infarction, but not in relation to the carotid exposure procedure (Procedure No.7). Morbidity and mortality were 8.3% and 0%, respectively. All patients were followed up in the outpatient clinic, and there were no complications related to the wound or skin incision. Although antiplatelet and anticoagulation treatments were continued after the procedure, there were no notable hemorrhagic complications, as a subcutaneous hematoma, related to the DCEA.

DCEA vs. TFBA

We compared the puncture site complications, the time from the start of the procedure to the insertion of the guiding system, and the overall treatment time between DCEA and the transfemoral/brachial approach (TFBA) in elderly patients for the treatment of UAs in the anterior circulation during the same period (Table 1). No puncture complications were experienced with DCEA, whereas TFBA had puncture complications in six out of forty-one cases (14.6%). Of these, three were subcutaneous hematomas, two were pseudoaneurysm formations, and one was a subcutaneous abscess. A vascular closure device (Angio-seal, St. Jude Medical., Minnetonka, MN, USA) was used for hemostasis in all cases performed with the transfemoral approach. Manual compressions for hemostasis was performed in only one patient who underwent the transbrachial approach. We compared the time from the start of the procedure until the guiding system was inserted into the ICA. The DCEA group had an average of 31.0 min (time range: 20–42 min), while the TFBA group had an average of 24.7 min (time range: 8–66 min), showing no significant difference ($P = 0.178$). The overall treatment time was similarly examined. The mean was 273.5 min in the DCEA group and 192.0 min in the TFBA group, showing a significant difference ($P = 0.001$).

Discussion

The direct carotid puncture has been reported and associated with relatively good therapeutic results for aneurysms, thrombectomy for acute cerebral infarction, and carotid artery stenting.[1–5,9–11] The main indications for DCEA were tortuous vessels due to atherosclerosis. We routinely perform diagnostic cerebral angiography for EVT planning. All patients in whom DCEA was chosen were cases with difficulties in guiding the catheter from the femoral artery during the diagnostic cerebral angiography performed by a neuro-endovascular board-certified physician, especially in elderly patients, whose vessels are tortuous due to atherosclerosis. The reason why we applied an age boundary 75 years of age is because the Japan Gerontological Society and the Japan Geriatrics Society have defined those 75 years of age and older as elderly. In fact, there were 15 EVTs with DCEA at our institution, 11 (73.3%) of whom were on 75 years or older patients. In past reports, age was not related to treatment results, but it has been reported that elderly patients typically have severe vessels tortuosity that creates difficulties for EVT.[12,13] Therefore, we focused on DCEA for the elderly by retrospectively analyzing our experience. It was found to be successful, with the goals of EVT achieved without adverse events due to the procedure. Compared with the transfemoral approach, there were no significant differences in the time from the start of the procedure to the insertion of the guiding system. DCEA is a practical approach to EVT in the elderly.

Transbrachial[14–16] and transradial approaches[17] are often chosen when it is difficult to reach the target lesion via the femoral artery. However, the alternative brachial artery approach can also be complicated due to altered anatomy and angulation of the subclavian or brachiocephalic arteries; therefore, the guiding catheter may not be inserted into the carotid artery, which is usually less tortuous. DCEA is the closest to the cerebral aneurysm compared to any other arterial entry point. Once the guiding catheter is inserted, the microcatheter is easily controlled and stabilized because of the much shorter distance to the tip. DCEA reduces the negative influence of tortuous vessels, and the torque of the catheter is readily transduced to its distal end.

PED placement is also a good adaptation of the DCEA. PED placement is often complicated in cases with tortuous vessels.[18,19] PED placement via the femoral or brachial approach can be difficult for navigation and deployment because the distance to the target aneurysm is too long in the case of tortuous vessels. We consider this method to be entirely suitable for PED placement, as deployment is easy, and planning is reliable. Once the guiding catheter is inserted by DCEA, the stability of the guiding catheter, which is an essential factor for the success of PED placement, can be obtained. Although the patients who underwent PED were elderly with tortuous vessels, the procedure was completed successfully in all cases.

Antiplatelet drugs and anticoagulation therapy did not influence the clinical outcome of DCEA cases. The risk of hemorrhagic complications at the puncture site remains a severe problem in EVT. Hemorrhagic complications in DCEA have a potential risk of severe morbidity due to tracheal compression by a hematoma.[4] The use of a vascular closure device (Angio-seal, St. Jude Medical., Minnetonka,

MN, USA) for hemostasis may be insufficient, and safety cannot be guaranteed. Closure devices themselves can also cause complications such as pseudoaneurysms and larger hematomas.[20,21] However, off-label use of a closure device after such procedures has been previously reported.[22,23] As already reported by Nii et al.[4] and Doffer et al.,[5] the percutaneous carotid approach is uncertain in hemostasis because the puncture site cannot be seen under direct vision as compared to DCEA. Our procedure of directly exposing the common carotid artery and suturing the puncture site with a 7–0 needle followed by manual compression using Surgicel (Ethicon, USA) under direct observation, performed in a similar way as in carotid endarterectomy, proved to be efficient and safe. The use of a CV-7 suture that has a thread thicker than the needle reduces the potential of bleeding from the needle puncture hole if the suturing is applied to the vessel wall in an X-shape before the puncture. Therefore, compared to the conventional percutaneous carotid direct puncture approach, direct exposure of the carotid artery enables more reliable puncture and hemostasis. A 3 cm skin incision in the neck may be a disadvantage, but it is not considered to be of a significant invasiveness.

Limitations

This approach has some limitations. Firstly, it requires special attention and care to manage re-treatment. In 5–10% of EVTs, re-treatment is needed within a few years of the first treatment. Secondly, elder patients often have cervical spondylosis and should be aware of excessive cervical extension during treatment. Thirdly, when inserting the guiding sheath after puncture, the assistant's hand is temporarily exposed to radiation for a short period of time to hold the sheath.

Conclusions

Even with the use of antiplatelet and anticoagulation therapy, DCEA can be performed safely for UAs in elderly patients.

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Ethical approval statement/IRB approval number

This study was approved by the Ethics Committee of our hospital (approval nos. 26-050 and 7555).

Declaration of conflicting interests

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