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Technical Notes

Direct carotid puncture for endovascular surgery of intracranial aneurysms: Technical note for avoiding complications

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ABSTRACT

Background: While the most intracranial aneurysms are approachable by femoral or brachial artery puncture during endovascular surgery, in some cases, the lesion is difficult to reach due to complications such as the presence of winding pathways. Direct carotid puncture (DCP) is an alternative access approach, despite the potential risk of fatal neck hematoma. Herein, we describe the DCP technique in a series of five patients with intracranial aneurysms, together with its technical considerations.

Methods: Patients with intracranial aneurysms who underwent endovascular surgery using DCP were reviewed retrospectively. We selected the 3F to 6F systems for DCP depending on the necessity of adjunctive techniques. To prevent DCP-associated complications, we (1) conducted a micropuncture before introducing the short sheaths, (2) selected the smallest possible size for the system, (3) reversed heparin postoperatively, and (4) performed perioperative intubation/sedation management.

Results: Five out of 535 patients underwent DCP in our hospital between 2015 and 2019; successful vascular access was achieved in all cases. Although a minor neck hematoma occurred in one case, the patient did not require additional treatment. According to a literature review, severe neck hematoma requiring rescue therapy occurs in 5 out of 95 cases (5.3%).

Conclusion: Although the potential risk of neck hematoma is not negligible, the DCP technique appears to be a safe and effective approach in treating intracranial aneurysms with challenging access routes in cases where perioperative counter measurements are appropriately performed.

Keywords: Direct carotid puncture, Intracranial aneurysm, Neuroendovascular treatment

INTRODUCTION

Endovascular surgery is a minimally invasive method for the treatment of intracranial aneurysms.[9,14] Although the most intracranial aneurysms can be approached through the femoral or brachial artery, in some cases, the lesion is difficult to reach due to complications, such as a steep common carotid artery (CCA) take-off angle and the presence of winding pathways. As the number of elderly patients undergoing endovascular surgery increases, the number of cases with such challenging access also increases. A direct carotid puncture (DCP) could be an alternative access route, although it carries a potential risk of neck hematoma with an incidence ranging from 9% to 14%, which may lead to fatal airway obstruction.[8,10,12] To date, studies on the prevention of DCP-associated complications are scarce. Herein, we describe a DCP approach performed in five patients with intracranial aneurysms, along with its technical considerations to help avoid complications.

MATERIALS AND METHODS

Study population

Subjects were identified through an electronic medical record search for all patients with intracranial aneurysms who underwent endovascular surgery between 2015 and 2019 at our hospital. Patients who needed the DCP approach were included in the study. Approval to conduct, this study was received from the Institutional Review Board of our hospital. All medical records and information were anonymized and identified just before analysis.

DCP procedures

All procedures were performed under general anesthesia with the patient's neck in an extended position. We first performed cerebral angiography through femoral approach in all cases and decided whether a guiding catheter could be placed through the femoral approach. If it seems difficult, we switched to DCP. The activated clotting time was maintained at 200–250 s during the procedure. For the DCP technique, the CCA was punctured percutaneously using a Metrik MAK™ Mini Access Kit (21-gauge needle and 0.018 guide wire) (Merit Medical, Utah, USA) for micropuncture followed by the insertion of a guidewire into the internal carotid artery (ICA) under radiographic guidance. We performed DCP by palpation-guided punctures. The following sheaths were then introduced into the ICA: (1) for coil embolization using a simple technique, we selected a 3F–4F system: SURFLO® IV Catheter 18-gauge (Terumo Corporation, Tokyo, Japan) (approximately 3F or 4F short sheath attached to an injector tube and a Y-connector). The inserted sheath was secured with sterile tape, which prevented it from coming out accidentally. (2) For coil embolization using an adjunctive technique, we chose a 5F system: a 5F short sheath attached to a two-way adapter (RS-VA284, Terumo Corporation, Tokyo, Japan) to secure the two-way route. (3) Finally, for flow diverter stenting, we selected a 6F system. While using the 3–4F system for coil embolization with the simple technique, we also performed common carotid angiograms with a 4F catheter placed at the origin of the CCA through the transfemoral approach. We reversed the effects of heparin with protamine sulfate immediately after surgery and proceeded with manual compression hemostasis. Protamine dosage was determined based on the heparin dosage received (10 mg/1000 units of heparin), not to exceed 50 mg. Finally, we provided perioperative intubation/sedation control to patients until the next day. The intubation tube was removed after confirming the complete hemostasis of the punctured CCA.

Literature review

To elucidate the potential risk of the DCP technique in patients with intracranial aneurysms, we performed a literature review, searching the publications on PubMed with the keywords "intracranial aneurysm" and "direct puncture" OR "DCP." After the cases of cerebral aneurysms accessed by DCP were selected, we assessed the perioperative management as well as the complications due to DCP.

RESULTS

A total of 535 patients underwent endovascular surgery for intracranial aneurysms in our hospital between 2015 and 2019. Among them, 5 cases (0.93%) were treated using the DCP technique. [Table 1] presents the characteristics of each case.

The patients' ages ranged from 71 to 88 years. All the patients were women. There were two cases of anterior communicating artery aneurysm and three cases of internal carotid-posterior communicating artery aneurysm. We treated two cases of unruptured and three cases of ruptured aneurysms. All the punctures were performed on the left CCA due to the challenging access routes, such as the winding course of the CCA or aorta and the steep left CCA take-off angle. For coil embolization with the simple technique, the 4F system was used in one case and the 3F system (SURFLO® 18-gauge IV catheter) was chosen in two cases.

We achieved successful vascular access in all cases, which resulted in successful embolization. Computed tomography immediately after the procedure revealed no hemorrhagic complication in all cases. Magnetic resonance imaging was performed in all patients on postoperative days 2–4, revealing an asymptomatic small infarct in one case. Postoperative neurological deterioration was not observed in all cases. A direct DCP-related complication was observed in one case as mild neck hematoma postoperatively, which did not require additional treatment.

Results of the literature review

There were reports of 95 patients with intracranial aneurysms accessed by DCP, including our cases, as shown in [Table 2].[2-6,10,12,13] While surgical cutdown was chosen to access the CCA in 12 cases (13%), the majority of cases with

Table 1: Characteristics of five patients with intracranial aneurysms accessed by direct carotid puncture.

Age/Sex	Location	Presentation	Procedures	Access route anatomy	Approach side	System	Vascular access	Complications
71/F	AcomA	Unruptured	Simple technique	Winding of the left CCA/aorta	Left CCA	4F short sheath	Success	None
81/F	Left ICA	Unruptured	Flow diverter stenting	Winding of the left CCA	Left CCA	6F short sheath	Success	Mild neck hematoma
74/F	AcomA	Ruptured	Balloon-assisted technique	Steep left CCA take-off angle	Left CCA	5F short sheath	Success	None
80/F	Left ICPC	Ruptured	Simple technique	Steep left CCA take-off angle	Left CCA	SURFLO® IV Catheter 18G (3F system)	Success	None
88/F	Left ICPC	Ruptured	Simple technique	Winding of aorta	Left CCA	SURFLO® IV Catheter 18G (3F system)	Success	None

AcomA: Anterior communicating artery, ICA: Internal carotid artery, ICPC: Internal carotid-posterior communicating artery, CCA: Common carotid artery

DCP were accomplished by percutaneous puncture (83 cases, 87%). DCP-associated complications were observed in 10 cases (11%), including six cases of neck hematoma, two cases of vasospasm, one case of pseudoaneurysm formation, and one case of CCA dissection. The overall mean age of the patients was 70 years, with female predominance (78%). The selected system ranged from 3F to 8F, and micropunctures were used in most cases. Ultrasound-guided puncture was performed in one report.[4] While heparinization was performed in all reports, postoperative protamine use for heparin reversal was observed only in a few reports. Prolonged intubation management was performed in two reports, including our study.

[Table 3] shows the DCP-associated complications of neck hematoma (six cases, 6.3%).[2,4,10] The selected systems were relatively large (5F–8F), and heparin reversal was performed only in our cases. Manual compression was chosen for hemostasis except in one case. Five out of six patients needed rescue therapy (5.3%), including surgical evacuation and prolonged intubation.

DISCUSSION

We attempted the DCP technique in patients in whom vascular access through the femoral or brachial approach was difficult. In the cases presented here, aortic arch anomalies, including the winding course of the CCA or aorta and the steep left CCA take-off angle, hampered access to the ICA through the conventional approach. According to other reports, aortic dissection and iliac occlusive disease could be other indications for using DCP.[8,10] Access to the left ICA through the femoral approach is usually more complex than access to the right ICA because the bovine origin of the left CCA creates an angle that is problematic to cross with the catheter when navigating from the femoral artery.[11] In addition, elderly patients with vascular risk factors have a higher incidence of anatomical anomalies which increase the technical difficulty of performing endovascular surgery.[7] Indeed, all the patients who underwent the DCP technique in the present study were women over 70 years of age, and all the puncture sites were on the left CCA. In addition to our study findings, the average age of the patients who needed the DCP technique for the endovascular surgery of intracranial aneurysms was 70 years, according to the literature review [Table 2]. Therefore, we need to keep in mind that alternative access, such as the DCP, might be needed in elderly patients who will undergo endovascular surgery, especially through the left CCA.

The appropriate choice of the system for the DCP technique is necessary to avoid complications. Blanc *et al.* previously reported the effectiveness of DCP for anterior circulation aneurysms when performing coil embolization.[2] In that report, a sheath with a relatively large outer diameter (5F–8F sheath introducer) was placed in the ICA for all anterior circulation aneurysms followed by the insertion of a guiding catheter (Tracker-38, Target Therapeutics). In addition, the literature review revealed that the range of available systems for DCP access is relatively large; from 3F to 8F. The operators might tend to choose larger systems to ensure the good quality angiogram through the system during the procedure or to keep the pathway for adjunctive technique. We propose that selecting a sheath with the smallest outer diameter is essential to prevent perioperative complications associated with DCP. Using a smaller system will help secure the hemostasis of the punctured CCA and avoid iatrogenic carotid artery dissection. We selected the 3–4F, 5F, and 6F systems for coil embolization with the simple technique, coil embolization with the adjunctive technique, and flow diverter stenting, respectively. Although we used

Table 2: DCP cases in the endovascular surgery of intracranial aneurysms.

Authors	Approach	Number of cases*	Sex (M/F)	Mean age±SD	Punctured side (R/L)	Micropuncture	System	Anesthesia	Heparinization	Heparin reversal	Hemostasis	Prolonged intubation management
Ross *et al.*[12]	S	0/2	0/2	68.5±7.8	2/0	No	7F	General	Yes	Yes	Suture	NA
Dorfer *et al.*[3]	S	0/10	2/8	67.6±7.0	NA	No	3-8F	General	Yes	No	Suture	Yes
Dorfer *et al.*[3]	P	0/6	1/5	64.7±11.0	NA	Yes	3-5F	General	Yes	No	Manual compression	NA
Sedat *et al.*[13]	P	0/2	1/1	58±11.3	2/0	NA	5, 6F	NA	Yes	Yes	Manual compression	NA
Kai *et al.*[6]	P	0/5	0/5	71.2	NA	NA	6F	General	Yes	No	Manual compression	NA
Nii *et al.*[10]	P	1/27	9/18	79.9	NA	Yes	5F	General	Yes/No#	No	Manual compression	NA
Guzzardi *et al.*[4]	P	1/1	0/1	80	1/0	NA	6F	General	Yes	No	Surgical repair	No
Iosif *et al.*[5]	P	1/1	NA	72	1/0	NA	6F	NA	Yes	No	Angio-Seal device	NA
Blanc *et al.*[2]	P	6/36	NA	62	NA	Yes	5-8F	NA	Yes	No	Manual compression	NA
Present cases	P	1/5	0/5	78.8±6.6	0/5	Yes	3-6F	General	Yes	Yes	Manual compression	Yes

*Cases with a complication/total DCP cases. #Systemic heparinization was performed in the first 15 patients, but no systemic heparinization was performed in the latter 12 patients. DCP: Direct carotid puncture, S: Surgical cutdown, P: Percutaneous puncture, SD: Standard deviation

Table 3: Cases with DCP-associated neck hematoma in the endovascular surgery of intracranial aneurysms.

Authors	System	Anesthesia	Antiplatelet therapy	Heparinization	Heparin reversal	Hemostasis	Additional treatment
Nii *et al.*[10]	5F	General	NA	Yes	No	Manual compression	Intubation Manual compression
Guzzardi *et al.*[4]	6F	General	DAPT	Yes	No	Surgical repair	Surgical evacuation
Blanc *et al.*[2]	8F	NA	NA	Yes	No	Manual compression	Surgical evacuation
	6F	NA	NA	Yes	No	Manual compression	Intubation
	8F	NA	NA	Yes	No	Manual compression	Intubation
Present case	6F	General	DAPT	Yes	Yes	Manual compression	None

DCP: Direct carotid puncture, DAPT: Double antiplatelet therapy

the 4F short sheath in the first case of coil embolization with the simple technique, we changed to the 3F system in the subsequent cases, which did not disturb the subsequent endovascular procedure. A representative DCP system is shown in [Figure 1]. We used a micropuncture kit for CCA puncture and a guidewire to navigate the ICA. After inserting the SURFLO® 18-gauge IV catheter along with the guidewire into the ICA, the SURFLO® IV catheter was connected to an injector tube attached to a Y-connector. A single microcatheter, such as an Excelsior SL-10 (Stryker Ltd., Michigan, USA), can be navigated through this DCP system. By inserting the injector tube between the SURFLO® IV catheter and the Y-connector, the operator can maintain a distance from the X-ray tube, leading to reduced radiation exposure. The disadvantage of choosing the smaller system is that adequate angiogram cannot be performed through the system during the procedure. This problem can be resolved by placing catheter at CCA origin through femoral approach for control angiogram.

The most severe direct complication associated with the DCP technique is hemostasis failure, which might result in airway obstruction. Five out of six neck hematoma cases in the literature review needed additional treatment [Table 3]. In these cases, a system with a large outer diameter (5F–8F) was chosen without heparin reversal postoperatively. In the present study, to counteract this potentially fatal complication, we used micropuncture kits to prevent hemorrhagic complications and ensured a minimally invasive puncture in all cases. We reversed the effects of heparin with protamine sulfate immediately after each procedure. In addition, we performed perioperative intubation/sedation control until the next day to avoid airway obstruction, even if hemostasis was complete. Indeed, we encountered a case of mild postoperative cervical hematoma; however, the patient did not need rescue therapy for the complication, possibly due to the perioperative management. Our suggested tips to prevent DCP-related complications might harbor

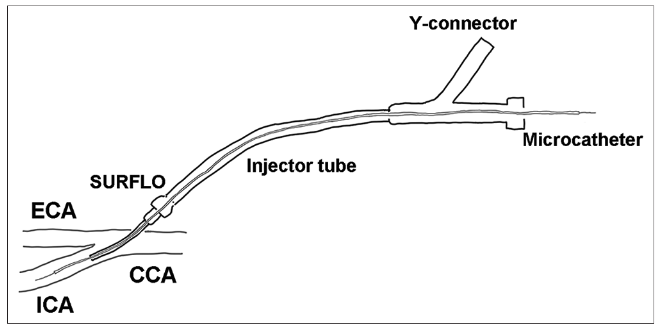

Figure 1: The illustration shows a representative 3F direct carotid puncture system for coil embolization with the simple technique. The SURFLO® 18-gauge IV catheter (approximately of the 3F system) is inserted into the common carotid artery and then connected to the Y-connector attached injector tube.

potential risks such as not being able to assess neurological examination after the procedure due to prolonged sedation, thromboembolic complication by heparin reversal. Further studies are warranted to clarify this important issue. Aside from our suggested technical tips, the value of ultrasound imaging during puncture has been reported.[8] In addition, ANGIO-SEAL (St. Jude Medical, MN, USA) was frequently used in DCP for mechanical thrombectomy, with acceptable complications.[1,8,15] The use of ultrasound imaging or the closure device would be other potential choices to avoid DCP-related complications.

CONCLUSION

Based on our experience and previous reports, we consider that if appropriate countermeasures are taken, the DCP technique would be a safe and effective approach to treat intracranial aneurysms that are anatomically difficult to access. In particular, it is important to select a small-diameter system, perform heparin reversal, and manage prolonged intubation/sedation control.

Declaration of patient consent

Institutional Review Board (IRB) permission obtained for the study.

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Conflicts of interest

There are no conflicts of interest.

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