

# Percutaneous direct carotid approach using the hyperflexible large-bore Navien distal intracranial catheter for treatment of anterior circulation aneurysms

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### Abstract

INTRODUCTION: Direct percutaneous carotid artery puncture (DPCAP) enables endovascular treatment of cerebral aneurysms that are otherwise untreatable in patients with non-navigable proximal vessel tortuosity. Traditionally, microcatheters were advanced directly through the carotid sheath to the intracranial target. This method is insufficient for complex modern neurointerventions necessitating robust, distal large-bore intracranial support.

METHODS: We retrospectively reviewed all neurointerventions performed by the senior author (ALC) to identify all aneurysms treated via DPCAP with utilisation of the 5F 0.058-inch inner diameter Navien distal intracranial catheter.

RESULTS: DPCAP was used in 6 neurointerventions for these reasons: bilateral iliofemoral occlusion (n=2) and failed transfemoral embolisation secondary to severe tortuosity of arch/supra-aortic vasculature (n=4). Mean patient age was 75.3 years (range 67-85). All treatments were for anterior circulation aneurysms (A2-3, n=2; ophthalmic, n=3; ACOM, n=1). Intra-procedural Navien position along the internal carotid artery were as follows: petrous (n=1), petrocavernous (n=1), cavernous (n=2), supraclinoid (n=1) and ICA terminus (n=1). All neurointerventions (coil embolisation, n=3; stent-assisted coiling, n=2; Pipeline embolisation, n=1) were successful. No complications occurred during carotid puncture, Navien positioning and aneurysm embolisation. Two cervical haematomas were observed without significant adverse sequelae. All patients were discharged home at their pre-procedure neurological baseline.

CONCLUSION: For neurointerventions of anterior circulation cerebral aneurysms in patients with complex proximal vasculature tortuosity or occlusion, DPCAP remains an effective technique. Use of the Navien catheter greatly enhances this approach by providing large-bore distal intracranial support necessary for modern neurointerventions. Cervical haematomas remain a known potential complication of DPCAP, particularly in patients on dual antiplatelet therapy.

Keywords: aneurysm, endovascular, flow diversion, pipeline embolisation device, transcarotid

Geoffrey P Colby, MD PhD – Department of Neurosurgery, Johns Hopkins University School of Medicine, The Johns Hopkins Hospital, 1800 Orleans Street, Zayed 6115C, Baltimore, MD 21287

Bowen Jiang, MD – Department of Neurosurgery, Johns Hopkins University School of Medicine, The Johns Hopkins Hospital, 1800 Orleans Street, Zayed 6115C, Baltimore, MD 21287

Neelesh Nundkumar, MD – Department of Neurosurgery, Johns Hopkins University School of Medicine, The Johns Hopkins Hospital, 1800 Orleans Street, Zayed 6115C, Baltimore, MD 21287

Judy Huang, MD – Department of Neurosurgery, Johns Hopkins University School of Medicine, The Johns Hopkins Hospital, 1800 Orleans Street, Zayed 6115C, Baltimore, MD 21287

Rafael J Tamargo, MD – Department of Neurosurgery, Johns Hopkins University School of Medicine, The Johns Hopkins Hospital, 1800 Orleans Street, Zayed 6115C, Baltimore, MD 21287

Alexander L Coon, MD (Corresponding Author) – Department of Neurosurgery, Johns Hopkins University School of Medicine, The Johns Hopkins Hospital, 1800 Orleans Street, Zayed 6115C, Baltimore, MD 21287 *Tel*: 410-955-2438 *Email*: acoon2@jhmi.edu

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Li-Mei Lin, MD — Department of Neurosurgery, Johns Hopkins University School of Medicine, The Johns Hopkins Hospital, 1800 Orleans Street, Zayed 6115E, Baltimore, MD 21287



### **Abbreviation Key**

CCA	common carotid artery
DPCAP	direct percutaneous carotid artery puncture
DSA	digital subtraction angiography
ICA	internal carotid artery
ID	inner diameter
OD	outer diameter
PED	pipeline embolisation device

# Introduction

The most common access route for neurointerventions is a percutaneous approach through the common femoral artery. However, in certain patients the transfemoral approach to the intracranial circulation access route is sometimes impossible using current technology. Such patients often have severe systemic atherosclerosis with the presence of bilateral iliofemoral artery occlusions, thoracic aortic dissection or tortuous upstream angioarchitecture of the aortic arch and supra-aortic vessels that may prevent stable guide catheter positioning and coaxial microcatheterisation in the intracranial vasculature [1, 2]. Approximately 1 %-6 % of neurointerventions fail secondary to access challenges [3, 4].

Direct percutaneous carotid artery puncture (DPCAP) has classically been used for diagnostic angiography and has also been described during neurointerventions as an alternative site of access to circumvent the proximal angioarchitecture tortuosity [5-10]. Classically, microcatheters were advanced directly through the carotid arterial sheath to the intracranial target [6, 7, 9]. Small-bore guide catheters have also been positioned at the skull base for more support [5, 8, 10]. However, for modern neurointerventions such as flow diversion that require larger microcatheters (0.027" inner diameter) and large-bore distal intracranial catheter support, these methods are insufficient. We present our institutional experience in DPCAP for modern intracranial neurointerventions utilising the 5Fr Navien distal intracranial support catheter (Covidien Vascular Therapies, Mansfield, Massachusetts, USA) to achieve large-bore intracranial access for treatment of anterior circulation aneurysms in patients with unfavourable proximal anatomy.

# Methods

#### Patient Selection/Research Design

We retrospectively reviewed all neurointerventions performed by the senior author identifying all aneurysm treatments accessed using DPCAP and a 5F 0.058" 115 cm length Navien catheter serving as the primary guide catheter.

#### Material Used/Intervention Technique

The common carotid artery (CCA) was accessed with the head positioned midline and slightly extended using a 21-gauge micropuncture needle and a 0.018" microwire under ultrasound guidance in all the cases (Figure 1). After introduction of the microintroducer, a 5F sheath (Terumo Medical Corporation, Somerset, New Jersey, USA) was inserted over a 0.035" glidewire (Terumo Medical Corporation, Somerset,



New Jersey, USA) under roadmap guidance. Once in position, the sheath was connected to a heparinised flush system and IV systemic heparin bolus was administered. The 5F 0.058" Navien served as the primary guide catheter and was tracked into position using a 0.027" 150 cm Marksman microcatheter (Covidien Vascular Therapies, Mansfield, Massachusetts, USA) and Synchro 2 standard 0.014" microwire (Stryker, Kalamazoo, Michigan, USA) under roadmap guidance.

### **Data Collection**

Data were collected with respect to patient demographics, reason for direct carotid access and pathology treated. Procedural data analysed include equipment used, amount of systemic anticoagulation, intraprocedural catheter position, fluoroscopy time, peri-procedural complications and immediate angiographic results. Data were presented as counts. The Johns Hopkins Hospital Institutional Review Board (IRB) granted permission for this study.

# Results

#### Demographics

Six cases were identified where DPCAP was necessary. Details from these procedures are presented in Table 1. Mean patient age was 75.3 years (range 67-85). There were 4 women and 2 men in this series. Marked tortuosity of the aortic arch and supra-aortic vessels was encountered in all but 2 cases that had bilateral iliofemoral artery occlusions.

# Aneurysm Treatment Characteristics

All treatments were for anterior circulation aneurysms in the following distributions: A2-3 (n=2), ophthalmic (n=3) and anterior communicating artery (n=1). Both A2-3 aneurysms and the anterior communicating artery aneurysm were treated with primary coil embolisation. Stent-assisted coil embolisation was performed for 2 of the ophthalmic aneurysms while the Pipeline embolisation device (PED; Covidien Vascular Therapies, Mansfield, Massachusetts, USA) was implanted for the third ophthalmic aneurysm. The final intra-procedural positions of the Navien along the internal carotid artery (ICA) were as follows: petrous (n=1), petrocavernous (n=1), cavernous (n=2), supraclinoid (n=1), and ICA terminus (n=1).

#### **Procedural Outcomes**

No complications (e.g. dissection) were encountered during carotid access or positioning of the Navien catheter. All interventions were completed successfully and technically uncomplicated. Upon completion of the neurointervention, the carotid sheath was immediately removed and haemostasis was achieved with 25 min of primary manual compression. In 1 case, reversal of systemic heparinisation was performed with 20 mg IV protamine. For the other 5 cases, haemostasis was first attempted with a 5F MynxGrip Vascular Closure Device (AccessClosure, Santa Clara, California, USA). Four of these cases required additional manual compression for complete haemostasis. Two cervical haematomas occurred after deployment of the MynxGrip and manual pressure, for which the patients remained intubated



preemptively for airway protection. After 24 h of observation, extubation for both patients proceeded without event or additional complications.

### **Case Illustration**

Ruptured A2-3 aneurysm with failed transfemoral approach coiling from an outside institution

A 67 year-old patient was transferred to our institution 6 days after subarachnoid hemorrhage from a ruptured left-sided A2-3 aneurysm and an aborted transfemoral coil embolisation attempt at the transferring center. Diagnostic cerebral angiography revealed a widened type 3 aortic arch, bovine configuration of the left CCA, significant tortuosity of the great vessel and a highly dysmorphic 6.7 mm left-sided A2-3 aneurysm (Figure 2). Coil embolisation was successfully achieved with the Navien providing robust support in the petrous ICA and the SL-10 45 degree microcatheter (Stryker, Kalamazoo, Michigan, USA) coaxially introduced. A combination of 4 Target 360 Ultra-Soft coils were deployed without event. After the aneurysm sac was secured, 2000 units of IV heparin bolus were administered. Final control angiography demonstrated complete angiographic occlusion of the aneurysm (Figure 2). The carotid sheath was removed and haemostasis achieved with 5F MynxGrip closure device. No complications occurred.

### Discussion

In this report, we describe our experience using DPCAP with the 5F 0.058" Navien catheter serving as the primary guide catheter support in 6 cases. Two patients had failed transfemoral approaches for attempted neurointervention at other institutions. The combination of direct carotid access with the hyperflexible 5F Navien allowed successful coiling of a ruptured A2-3 aneurysm in 1 patient and PED implantation for a dumbbell-shaped ophthalmic aneurysm in the other patient. This strategy also allowed successful stent-assisted coiling of a large ophthalmic aneurysm in a patient whose proximal tortuosity had hampered PED deployment and coiling of an A2-3 aneurysm in a patient with bilateral iliofemoral artery occlusions. No complications (e.g. dissection) were encountered during carotid access or positioning of the Navien catheter. Two cervical haematomas were encountered with the 5F MynxGrip closure device used to achieve haemostasis after carotid sheath removal. Supplemental manual compression was applied for additional haemostasis and the patients experienced no prolonged adverse effects from the cervical haematoma.

For patients with severe systemic atherosclerosis, thoracic aortic dissections, iliofemoral artery occlusions or severe tortuosity of the aortic arch and supra-aortic vessels that render transfemoral approaches infeasible, DPCAP has been well described in the literature as an effective and safe alternative [5-10]. Classically, microcatheters were advanced directly through the carotid arterial sheath to the intracranial target [6, 7, 9]. However, unconstrained microcatheters may exhibit instability and unpredictable behavior. Subsequently Nii et al. reported a series of 27 cases of anterior circulation aneurysm coilings via DPCAP using the Tracker-38 catheter (Boston Scientific, Fremont, California, USA) as a guide catheter positioned as distal as the petrous ICA [8]. Yuzawa et al. developed a 5F 0.051" 35 cm guide catheter, Avantguide (IR Co LTD, Tokyo, Japan) for use with their DPCAP cases in 21 anterior circulation aneurysm coilings [10]. However, for modern neurointerventions that require large-bore catheters to deliver devices such as flow diverters, intrasaccular neck bridging devices, stents or balloons intracranially, and



cases with severe vessel tortuosity necessitating robust distal intracranial support, these small-bore guide catheters are insufficient. For this reason, Dorfer et al. favored direct surgical carotid cutdown technique for the ability to use larger carotid sheaths (12-gauge to 14-gauge Cathlon sheath; Medex, Medical Ltd, Haslingden, Rossendale, UK) to accommodate larger-bore catheters [6].

In this report, we achieved large-bore intracranial access with the DPCAP technique by using the 5F 0.058" Navien catheter. The Navien catheters are the newest type of distal access catheters designed in the era of flow diversion and have a larger ID compared to its predecessors to accommodate the 0.027"ID microcatheters needed for deployment of flow diverters.[12] Compared to catheters of similar class, 5.2F 0.057" Outreach Distal Access Catheter (DAC; Stryker, Kalamazoo, Michigan, USA) and 5F 0.053" Neuron (Penumbra, Alameda, California, USA), the 5F Navien has the largest ID at 0.058". Our experiences with these hyperflexible catheters have demonstrated their superior trackability with atraumatic navigation into intracranial positions as distal as the M1 and mid-basilar segments for a variety of neurointerventions [12, 13]. We attribute the success of our previously described pseudo-corking technique in PED procedures [14] to the performance profile of the Navien. Being a true 5F throughout its entire length, the 5F Navien allowed for the less invasive technique of DPCAP with a 5F sheath rather than surgical cutdown while providing large-bore 0.058" intracranial support for the variety of neurointerventions detailed in this report.

Comparing the direct carotid access methods of percutaneous puncture versus surgical cutdown for neurointerventions, Dorfer et al. recommended the cutdown approach for the additional ability of generating better roadmap images with improved visualisation of lesion morphology [6]. Using the Navien catheter, we were able to achieve adequate roadmaps and angiography with the DPCAP technique. The Navien's 0.058 ID enables adequate contrast injections to produce functional intra-procedure roadmaps and angiography while accommodating larger profile balloons or 0.027" microcatheters. This larger ID also provides adequate room for improved flush around the microcatheter. By using the Navien, we were able to perform the procedures in a standard bi-plane angiography suite, and did not require true operating room capability recommended for a cutdown approach.

A major complication observed with DPCAP is cervical haematomas with upper airway compression [5, 6, 9, 10]. The reported rate of this complication in the literature ranges from 3.7 % to 14.3 % [5, 8, 9]. In a series of 42 percutaneous carotid access neurointerventions, Blanc et al. reported cervical haematoma occurrences were associated with use of extensive anticoagulation or antiplatelet therapy, or use of a sheath larger than 6F [5]. They described 1 cervical haematoma (8F sheath used) requiring emergent surgical evacuation. To minimise the potential risk of cervical haematomas and to prevent significant flow reduction of downstream territory during manual cervical compression particularly with stent deployments, they advocated the use of haemostatic closure devices. The Angio-Seal Vascular Closure Device (St. Jude Medical, St. Paul, Minnesota, USA) was used in 4 of their cases to achieve haemostasis and no haematomas were encountered [4].

In this report, we used the 5F MynxGrip closure device in 5 of the 6 cases. Unlike the Angio-Seal, which uses at least a 6F introducer and achieves haemostasis via anchoring a footplate endoluminally against the arteriotomy, the MynxGrip is available in 5F and remains exoluminal, obviating the potential risk of device-engendered endoluminal thrombus formation and subsequent source for emboli to the intracranial vasculature. Of the 5 cases where the MynxGrip was used, cervical haematomas developed in 2



immediately after device deployment and haemostasis was achieved with supplemental manual compression. Although the Angio-Seal closure device used by Blanc et al. was not associated with any post-procedural cervical haematomas, the patients were not on dual antiplatelets plus heparinisation. In this series, in both these MynxGrip cases, the patients were on dual antiplatelet therapy and received intra-procedural heparinisation (3000 units and 6000 units) without protamine reversal after sheath removal. Appropriately, those patients on dual antiplatelet therapy are at higher risk for cervical haematoma and may require additional manual compression for haemostasis with unique post-procedural protocols. For these reasons, both patients remained intubated for preemptive airway protection after haemostasis was achieved and after 24 h of observation, both patients were extubated without event. These patients were maintained on mild to moderate sedation for comfort, but did not require additional general anesthesia for the prolonged intubation. Even though both patients had good outcomes, the additional compression and extra 24 h of intubation increases the overall procedural risk. Thus, in these patients with significant vasculopathy precluding transfemoral access, and particularly in those requiring dual antiplatelet therapy, the risk of post-procedural cervical haematoma should be taken into account for the overall risk/benefit analysis of the procedure.

Blanc et al. reported additional complications observed with the direct percutaneous carotid punctures [5]. In 1 case, puncture-related vasospasm of the CCA led to thrombus formation at the ICA termination. This was treated with intra-arterial Abciximab and nimodipine. In another case, a small asymptomatic aneurysm at the cervical ICA puncture site was observed on angiography. Neither of these complications resulted in any neurological deficits. We did not observe any of these complications with the treatments detailed in this report.

# Conclusion

Direct access via percutaneous puncture of the cervical carotid artery remains an effective alternative for select intracranial procedures that would otherwise be impossible secondary to issues with proximal anatomy. The 5F Navien catheter augments the utility of this technique for complex modern neurointerventions by providing hyperflexible large-bore intracranial support with its 0.058" ID. Its larger ID enables adequate intra-procedural injections for improved visualisation and improved flush capability. The superior trackability allows robust, distal intracranial guide catheter positioning. Cervical haematomas remain a pertinent complication of DPCAP, particularly in patients on dual antiplatelet therapy, and additional care should be taken to prevent airway compromise in these patients.

# **Conflict of Interest**

ALC is a proctor for the Pipeline Embolisation Device (Covidien, Mansfield, Massachusetts, USA) and consults for Covidien, Stryker and MicroVention; he also receives research grants from Stryker Neurovascular and MicroVention. GPC consults for Covidien. No author received financial support in conjunction with the generation of this submission.



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# Figures

**Figure 1** - Direct percutaneous carotid artery puncture (DPCAP) technique. (A) Native AP fluoroscopic image of left CCA accessed with a 21-gauge micropuncture needle (white asterisk) and a 0.018" microwire (double black arrows). (B) Intra-procedure roadmap through the microintroducer used to introduce a 5F sheath over a 0.035" glidewire. (C) Left CCA unsubtracted angiography after sheath placement.





Figure 2 - Ruptured A2-3 aneurysm with failed transfemoral approach coiling from an outside institution. (A) Arch aortogram demonstrating widened type 3 arch with severe tortuosity of the supra-aortic vessels. (B) Pre-embolisation left common carotid DSA lateral view demonstrating left A2-3 aneurysm with secondary dilatation consistent with rupture site (white asterisk). (C) Post-coiling left ICA DSA lateral view demonstrating complete angiographic occlusion of the aneurysm. Black arrow marks the Navien catheter position in the petrous ICA.





# Tables

Table 1 - Summary of neurointerventions via direct percutaneous carotid artery puncture with the 5F0.058" Navien distal intracranial support catheter as the primary guide

Case	Age	Reason	Aneurysm	Treatment	Navien Position	Heparin	Pre-op	Fluoro	Method of	Adverse
No.	(Y)		Туре			(units)	Antiplatelet Therapy	Time (min)	Haemostasis	Events
1	67	Type 3 Arch & Iliofemoral tortuosity	6.7mm Left A2-3	Coil	Petrous	2000	None	45.3	Mynx	None
2	73	Type 3 Arch & Fibromuscular Dysplasia	10mm Bilobed Right Ophthalmic	PED	Cavernous	6000	ASA Plvx	71.3	Mynx + Manual	Haematoma
3	74	Wide Type 1 Arch & supra-aortic tortuosity	10mm Left Ophthalmic	Stent coil	Petro-cavernous	3000	ASA Plvx	47.4	Mynx + Manual	Haematoma
4	80	Bilateral iliofemoral occlusions	8mm Left A2-3	Coil	Supra-clinoid	5000	None	44.5	25min Manual (20mg protamine)	None
5	85	Supra-aortic tortuosity	18mm Bilobed Right Ophthalmic	Stent coil	Cavernous	5000	ASA Plvx	79.9	Mynx + Manual	None
6	73	Bilateral iliofemoral occlusions	6.2mm ACOM	Coil	ICA terminus	6000	None	44.8	Mynx + Manual	None

PED: Pipeline embolisation device; ACOM: Anterior Communicating Artery; ICA: internal carotid artery; ASA: Aspirin; Plvx: Plavix