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CASE SERIES

# Cerebral Aneurysms Repair Using Direct Carotid Artery Cutdown: A Case Series

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## ABSTRACT

**Background:** Cerebral Aneurysms (CA) including dissecting pseudoaneurysms are treated endovascularly through a trans-radial or trans-femoral approach. When these options are not available, a trans-carotid approach via Direct Carotid Artery Cutdown (DCAC) may be used as the last option. However, the safety and feasibility of DCAC is not well studied or defined in these contexts. Our objective is to present our four unique patients who were treated by the DCAC approach for their cerebral aneurysm and/or internal carotid artery dissecting pseudoaneurysm using flow diversion.

**Method:** This is a report of a case series and retrospective review.

**Results:** Patient 1; A 75-year-old woman with known left internal carotid artery (ICA) petrocavernous aneurysm that enlarged from 6 mm to 10 mm resulting in double vision and headaches. Trans-femoral approach failed due to the tortuosity in the common carotid artery (CCA). A multidisciplinary team was formed; A vascular surgeon began the surgery followed by FD by a neuroendovascular surgeon. A 6 French sheath was placed on the right common carotid artery via DCAC then brought to right ICA by vascular surgeon, and a neuroendovascular surgeon confirmed the placement with digital subtraction angiography (DSA). The DSA confirmed a large 10 x 8 x 5mm broad-based aneurysm. Flow diversion was performed with pipeline flex measuring 5 x 30mm. Patient was discharged home and achieved baseline modified Rankin Scale (mRS )1 which sustained in 5 years with aneurysm obliteration. Patient 2; A 65- year-old woman with multiple symptomatic left ICA-Para-ophthalmic artery aneurysm measuring 9 mm. Both femoral and radial arteries were occluded and underwent DCAC and flow diversion with pipeline flex of 4x30 mm using the similar technique described above. Patient discharged home in 48 hours with National Institute of Health Stroke Scale (NIHSS) of 0 and achieved her baseline mRS. However, this patient refused to have any further follow-up studies done. Patient 3; A 67-year-old man with aortic arch endograph with stent graft after previous aortic dissection and diagnosed with bilateral internal carotid artery dissecting pseudoaneurysm (ICADP) by computed topographic angiography (CTA). The right ICADP measured 19 x 15 x 20 mm, was multilevel, extending from skull base to the internal carotid artery (ICA) origin. The left ICADP was 16 x 9 x 22 mm with inflow-zone stenosis. The DSA was attempted but failed due to the aortic stent. The right ICADPA was repaired first using Surpass streamline (Stryker Neurovascular, Irving, CA) device measuring 4 x 50 mm x2 and 5 x 40 mm covering the entire dissecting artery. Patient was discharged home in 48 hours. Three months after the first procedure, using similar technique the left ICADPA was treated with a 5 x 50 mm Surpass evolve flow diverter. Patient achieved mRS 0. In 24-months follow up CTA demonstrated complete resolution of left ICDAP, but occlusion of the right ICA without impairing his mRS 0. Patient 4; a 76-year-old-woman with tinnitus, headaches and dizziness; DSA demonstrated RICA dissecting large 16 x 8 mm pseudoaneurysm. Trans-femoral approach failed and underwent DCAC, and flow diversion with a single surpass evolve flow diverter 4.5 x3 0 mm. Patient was discharged with NIHSS 0 and achieved her baseline mRs 0.

Abbreviations

CA: cerebral aneurysms

DCAC: direct carotid artery cutdown

DSA: digital subtraction angiogram

SSFD: surpass streamline flow diversion

SEFD: surpass evolve flow diversion

ICADPA: internal carotid artery dissecting pseudoaneurysm

NES: neuroendovascular surgeon

PDP: Percutaneous Direct Puncture

PFFD: pipeline flex flow diversion

## Introduction

The incidence of CA is up to 5-11%[1,2] in the general population, which increases with age and the presence of aneurysm risk factors. The annual rupture is greater than 1%, with greater CA size conferring more risk.[3,4] Internal carotid artery dissecting pseudoaneurysms, (ICADS) is a complication of craniocervical dissections, have a more benign natural history but rupture is equally devastating.[5] If CA rupture, mortality after subsequent subarachnoid hemorrhage can be as high as 25-60% after 3 months.[6] Even if the patient survives rupture, they likely will have some disability.[7] Therefore, a symptomatic aneurysm, especially enlarging aneurysm requires immediate evaluation and treatment to prevent a life-threatening rupture.

When patients become symptomatic from CA, they often have symptoms including headache, dizziness, visual changes, cranial neuropathies, or chronic symptoms due to mass effect of adjacent structures.[8] A symptomatic presentation is often the cause of diagnosis. Symptomatic aneurysms, traumatic aneurysms, larger-sized aneurysms, and aneurysms that are increasing in size quickly are often surgically treated.[9] Endovascular treatment is done via the use of intrasaccular coiling and intraluminal stenting, including flow diverter (FD) stents.[10] Coiling and stenting are currently more popular than use of FD for CA, including ICADP, but there is a growing body of literature that supports the use of FD in more contexts. [10-13] CA can be treated endovascularly via a trans-femoral or trans-radial approach. If these access points are not an option, there are no other clearly defined ways to access the CA or ICADP using an endovascular approach. The novel DCAC is a potential innovative option that has been considered in acute stroke thrombectomy and treatment of CA.[14,15] The risk of the procedure with DCAC must be weighed against the natural history of the case-specific CA and patient symptoms.

In regards to the treatment of the dissecting ICA pseudoaneurysm, trans-radial or transfemoral approaches are utilized for the endovascular repair. The patients outlined here had difficult anatomies that precluded them from the conventional trans-femoral and trans-radial approaches. Additionally, open surgical technique was not an option for our patients because of multiple factors including age, multiple active cerebrovascular risk factors, location of aneurysms, type of aneurysms, and most importantly, their antiplatelets couldn't be stopped due to the significant risks of cardiovascular ischemic event. Therefore, we have introduced an innovative DCAC approach that would allow for the patient to have an endovascular therapy without holding the necessary antiplatelets. The DCAC and endovascular treatment was done in a team-based collaborative fashion between vascular surgeon and neuroendovascular surgeon (NES). Each case had the same technical approach, with a vascular surgeon starting the procedure

with DCAC and a Neuroendovascular surgeon (NES) finishing the procedure. Most importantly, we have exclusively utilized flow diverters for the treatment of the dissection pseudoaneurysm, which is unique in our series compared to the others. This is the first case series of dissecting internal carotid artery pseudoaneurysms and cerebral aneurysms where a DCAC approach was utilized for the flow diversion in the endovascular treatment.

## Method:

This is a case series and retrospective chart review. Consecutive four patients underwent multidisciplinary DCAC from 2017 to 2022 were collected. Patient demographics including the technique aspect of DCAC and endovascular FD procedures were collected. Patient clinical outcomes were measured using modified Rankin Scale (mRS) score and National Institution of Health Stroke Scale (NIHSS). Aneurysm obliteration status was evaluated using CTA or magnetic resonance angiography (MRA).

Antiplatelets and anticoagulation strategies: Prior to the procedure, patients stopped smoking and blood pressure was optimized. On the day of procedure, all patients were given 300 mg of clopidogrel, 4 chewable 81 mg aspirin (324 mg). After the DCAC and sheath placement in the carotid artery by vascular surgeon, patient received intravenous heparin and activated coagulation time was maintained at two times of baseline during the procedure. Patient continued aspirin 325 mg and clopidogrel 75 mg daily for 3 months followed by two aspirin 81 mg chewable aspirin and clopidogrel 75 mg daily for additional 9 months. After 12-months, patients continued on either 325 mg or two 81 mg chewable aspirin daily. Antiplatelets regimen subject to modification based on platelets mapping results and none of our patients required any modification of the defined antiplatelet regimen in our series.

### Technique:

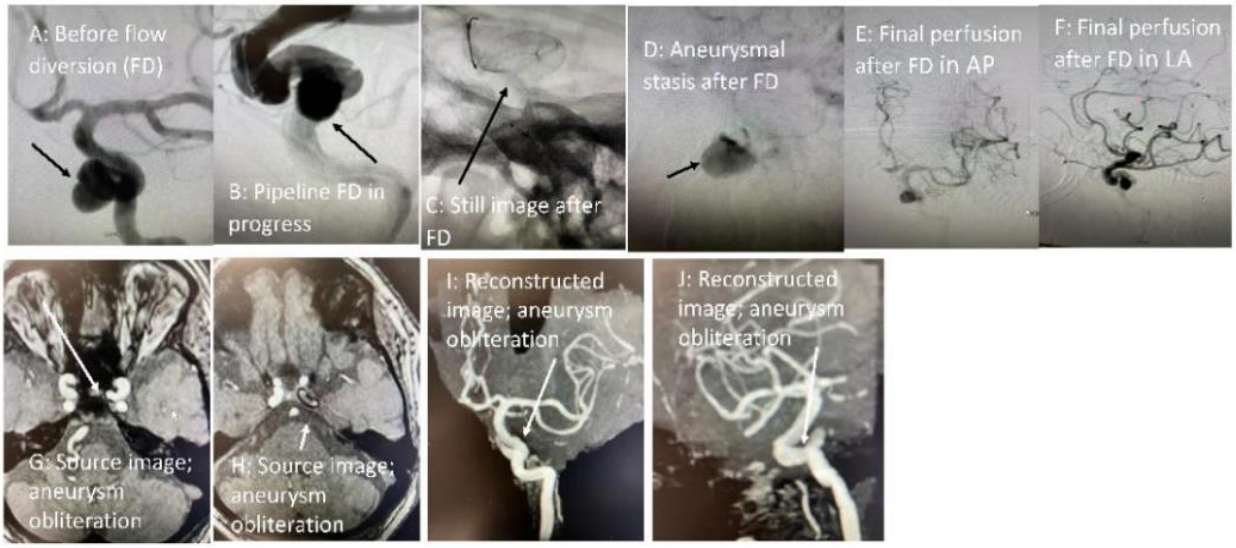
A vascular surgeon placed a 6 French sheath in the common carotid artery (CCA) via ultrasound-guided access and advanced to right or left ICA. Digital subtraction angiography (DSA) was used by NES to confirm the accurate placement. Purse-string suture was used to stabilize the sheath. An intermediate catheter and microcatheter were navigated through the sheath. Flow diversion of the ICA aneurysm was performed using either a Surpass flow diverter device or a Pipeline Flow diverter device. Catheters were removed and the DCAC site was sutured by the vascular surgeon at the end of the procedure. There was no reversal of anticoagulation performed for the removal of DCAC sheath.

### Patient 1

A 75-year-old woman with baseline mRS1 and past medical history of hypertension, hyperlipidemia and smoking with a known left ICA petrocavernous junction asymptomatic aneurysm for the last 5 years. Patient developed intermittent headaches and double vision and ptosis in the left eye. A repeat magnetic resonance imaging demonstrated that the aneurysm has enlarged from 6mm to 10 mm at 6 months. Patient underwent an initial trans-femoral and transradial trial approaches that failed due to the presence of significant left common carotid artery tortuosity that prevented navigation of the guiding catheter. However, DSA confirmed a

large 10 x 8 x 5 mm broad-based left ICA petro-cavernous junction angiogram (Figure1A). Based on the worsening symptoms and enlargement of her aneurysm, an endovascular approach with DCAC was planned in a team-based approach, in which DCAC was done by a vascular surgeon and FD by a NES. After the patient underwent full anesthesia, a vascular surgeon gained ICA access and a 6-french sheath was placed from CCA to ICA. The placement was confirmed by DSA (Figure1). Aneurysm flow diversion was performed with a single Pipeline Flex device measuring 5 x 30 mm, using a phenom plus and phenom microcatheter (Figure1B-F). There were no complications during the procedure. The patient was discharged home after 48 hours at baseline mRS and NIHSS 0. Patient symptoms resolved and follow-up MRA demonstrated aneurysm obliteration (Figure 1G-I).

**Figure 1A-J: 75-year-old women with known left ICA petro-cavernous aneurysm that enlarged from 6 mm to 9 mm on repeat MRA resulting in double vision and headaches, underwent DCAC and pipeline flow diversion. A-B; dark arrow showing aneurysm, C; dark arrow pointing device, D; aneurysm stasis, E-F; final angiographies, G-H; aneurysm obliteration MRA source images, I-J; aneurysm obliteration MRA reconstructed images.**




## Patient 2:

A 65-year-old woman presented with CA in the left ICA, measuring .9mm. The patient was symptomatic and had smoking as a risk factor for progression. The patient had DCAC because of bilateral occlusions of both femoral and radial arteries, due to the atherosclerosis and active smoking history. Patient underwent flow diversion with Pipeline Flex of 4 x 30 mm. Patient had no clinical events, was discharged home after 48 hours with NIHSS 0 and baseline mRS. This patient refused to have any further imaging and long-term follow up.

## Patient 3:

A 67-year-old man with a history of hyperlipidemia, hypertension, smoking, and an aortic arch endograph with stent after previous aortic dissection presented with worsening neck pain, dizziness, and headaches. CT angiogram (CTA) revealed bilateral ICADPA; right ICADPA measured 19 x15 x 20 mm, was multilevel, and extended from the skull base to the ICA origin (Figure 2A) and measured 16 x 9 x 22 mm and had an inflow-zone stenosis on a long segment (Figure 2A). Digital subtraction angiography (DSA) was not feasible because of the aortic

arch stent (Figure 2B-C). An open surgical approach was not possible due to the anatomical location of the right ICADPA. Considering the severity and extent of lesions with worsening symptoms, a multidisciplinary DCAC was planned for the bilateral FD to repair the ICADP. Since the patient had bilateral extensive diseases, it was planned to perform FD in a staged manner in which right ICADP was treated first followed by left ICADP. DCAC and 6F sheath was placed in the right ICA. The position was confirmed by DSA by NES (Figure). A CAT 5 intermediate catheter (Stryker Neurovascular, Irving, CA) was placed in ICA beyond the lesions. Surpass Streamline FD was performed to repair the ICADPA. These are; two 4 x 50 mm x2 and one 5 x 50 mm to cover the entire right ICADP and diseased ICA (Figure 3A-F)). The DCAC site was sutured by the vascular surgeon and the patient was extubated. Patient was discharged home in 48 hours with mRS of 1 and NIHSS of 0. The left ICDAP approached similar techniques and was repaired with two 5x 50 mm Surpass Streamline FD (Figure 3G-L). Angioplasties were performed for the better apposition of FD. Patient was discharged home after 24 hours and returned to his baseline activities of daily living and mRS improved to 0 at 6 months follow up, which sustained into the 24 months follow up visit but refused CTA, which finally performed in 24 months (Figure 2DG), demonstrates complete obligations of the left ICADSA but occlusion of right ICA with robust collaterals from left ICA. Patient admits premature discontinuation of dual antiplatelets after 3 months and being on an 81 mg aspirin when he learned about the CTA results. Patient was restarted on dual antiplatelets for 30 days and currently on 325 mg aspirin daily. Patient CT head did not reveal any stroke as he cannot have an MRA due to the presence of an aortic arch stent. This case was published in Medical Research Archive, European Society of Medicine (ESMED).[16]

**Figure 2A-G: 69 Y/O man developed headaches and neck pain. CTA of the head and neck demonstrated bilateral ICADP at multilevel up to skull-base (A). Aortic arch stent graph (B) and stent (C) in anterior posterior (AP) and lateral (LA) views prevented performing digital subtraction angiography (DSA). Two year CTA head and neck (D-G); demonstrates right ICA occlusion with good collateral from the left.**

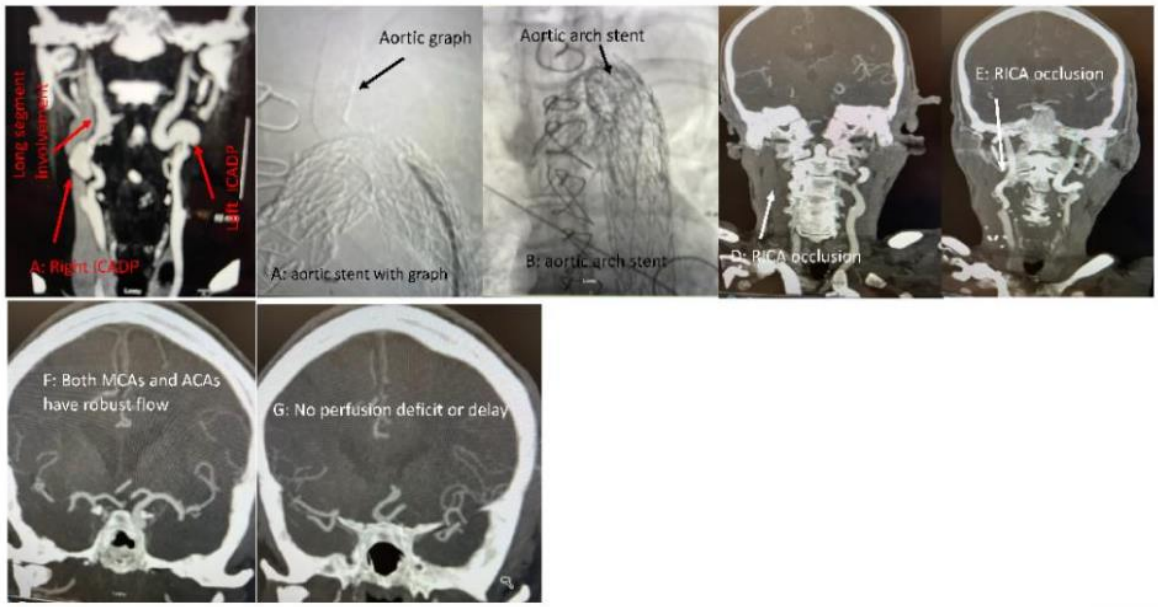
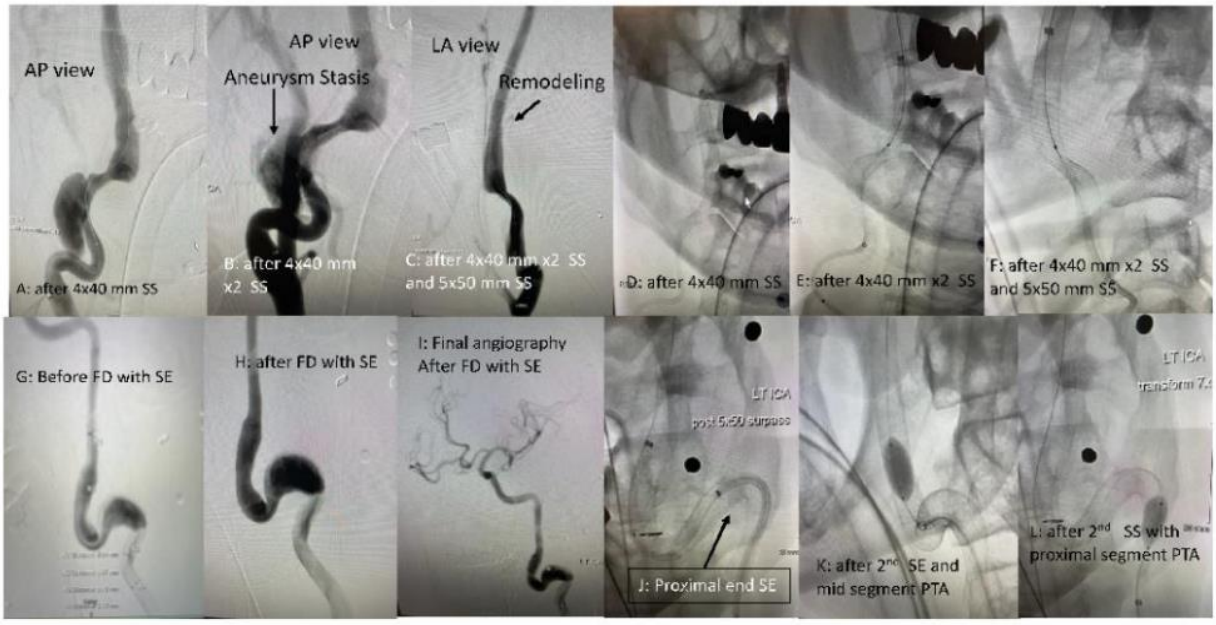


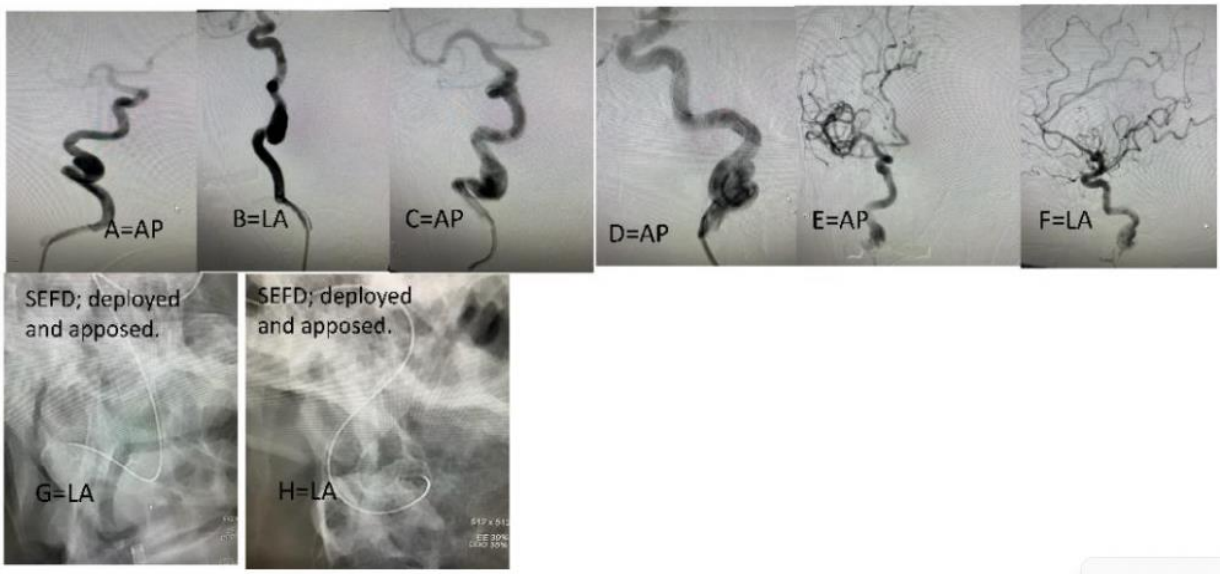
**Figure 3A-C: Digital subtraction angiography (DSA) of the right ICA after FD with Surpass Streamline (SS)demonstrated immediate stasis and remodeling of the ICADP; 3D-F: Still images after FD with SS; 3G-I: DSA of the left ICA after FD with Surpass Evolve (SE); 3J-L; still images after FD with SE.**




## Patient 4:

A 76-year-old woman with history hypertension, hyperlipidemia and bradycardia thought to be related to betablocker. She developed tinnitus, headaches and dizziness for which she was referred to neuroendovascular surgeon for suspected anterio-venous fistula. The DSA demonstrated right ICA dissecting large 16 x 8 mm pseudoaneurysm and there appeared to have significant tortuosity of the common carotid and internal carotid artery. Multiple attempts were failed to straighten the artery and advancement of the guiding catheter. The authors noticed bradycardia with multiple pauses in the electrocardiography and felt concerned that patient would be benefited with an urgent pacemaker placement prior to the DCACD procedure. However, cardiologist wanted to wait and monitor after stopping betablocker before the pacemaker placement. The DCACD was postponed and cardiac monitoring revealed persistent bradycardia with significant pauses in the heart rate. Patient underwent pacemaker placement before DCAC. Patient was scheduled again and underwent DCAC, and flow diversion was performed with a single surpass evolve flow diverter (SEFD) measuring 4.5 x 30 mm (Figure 4). Patient was discharged home with NIHSS 0 and achieved her baseline mRs 0.

Figure 4 A-H: 76 year-old woman with tinnitus, headaches and dizziness; DSA demonstrated RICA dissecting large 16x8 mm pseudoaneurysm. Trans-femoral approach failed and underwent DCAC, and flow diversion with surpass evolve flow diverter device (SEFD) 4.5x30 mm. A-B; demonstrated tortuous anatomy, B-C; flow diversion with SEFD in progress, E-F; final cerebral angiographies, G-H; deployed SEFD with fully apposed device including proximal and distal ends of SEFD. AP= anterior posterior view. LA=lateral view.




## Discussion

To our knowledge, this is the first case series describing DCAC for the endovascular repair of both intracranial aneurysms and an ICADP using flow diversion. This case series has significant scientific contributions for few reasons: it is first case series outlining the treatment of intracranial aneurysm and ICADP with DCAC and flow diversion; it describes an alternative, staged team-based approach for the management of nonemergent endovascular treatment using DCAC. It also highlights cases where DCAC can be used when patient anatomy precludes conventional trans-femoral and trans-radial approaches. Without a trans-cervical approach, these patients would not have the opportunities to repair their symptomatic aneurysms in endovascular approach. Our patients were treated with a consecutive, staged team-based approach, which differs from others, where DCAC has been done for posterior CA.[15] Our team-based approach, using a vascular surgeon who has more experience with DCAC, gives greater support to the use of multiple providers for DCAC for endovascular treatment. This study further supports for the use of DCAC to bypass trans-femoral and trans-radial approaches in the setting of an aortic stent, common carotid tortuosity, and when attempts at conventional access fail. Further examination of DCAC, in both an emergent setting and a nonemergent setting, will give important data on the safety and efficacy of this method for endovascular interventions.

The DCAC has been shown to be a relatively safe procedure in other endovascular surgeries.[14] A cervical hematoma occurs approximately in .8% of cases and carotid dissections in 1.9% of cases. Percutaneous direct puncture (PDP) approach could have been a potential alternative for a trans-carotid approach treatment for these patients, but this procedure has been less safe historically in the literature.[17] Anticoagulation is used in endovascular

treatments to decrease distal embolization events or proximal thrombus formation. A cervical hematoma forms more frequently with PDP (5-8.6%) than with DCAC.[17-19] This risk is further exacerbated by necessary anticoagulation usage in endovascular treatments. Other studies advocate for 5-french catheter usage for decreasing hemorrhagic complications, but our study had demonstrated feasibilities with 6-french sheaths.[18] Our study supports that 6-French catheters may be a safe alternative for DCAC, but further studies are needed.

The DCAC strategy has been utilized in a few other endovascular cases. It has been used in an emergent endovascular setting with thrombolysis for mechanical thrombectomy for patients with difficult anatomy.[14] The DCAC can significantly reduce time to intervention if there are failed attempts to access internal carotid artery via trans-femoral or trans-radial routes. An exploration of DCAC in the setting of traumatic CA or ICADP could be warranted. A study in Japan used DCAC to treat 6 patients with non-emergent CA with stenting and coiling by a single provider.[15] In contrast, our patients were treated in a staged, team-based manner and with FD. They had a higher complication rate with only a single provider (person accessing ICA via DCAC, also performing endovascular procedure) with cervical hematoma occurring 16% of the time.[15] Flow diversion is being increasingly supported for intracranial and ICADP.[20-22] Unlike the immediate effect of coil embolization, FD causes aneurysm occlusion more slowly, over weeks. Flow diversion can be associated with thromboembolic or hemorrhagic events in this time of aneurysm obligation.[21,23] Therefore, it is critical to have further information about its potential benefits. Our study supports the use of multiple FD, including Surpass and Pipeline flow diversion devices. In one case report, ICADP was treated with FD, using Surpass Streamline in 7 unilateral ICA loops dissecting pseudoaneurysms successfully without complication, similar to our patient 3 and 4.[20] Pipeline flow diversion demonstrated lower complication rates than in small ICA aneurysms in the <10 mm group in a multicenter study, which was further supported by our first and second patients.[24]

If we discuss in depth about each of our patient which might shed more lights to the audiences to appreciate the importance of DCAC technique and repair of our patients' intracranial aneurysms and ICA dissecting pseudoaneurysms. Our first patient was a 75-year-old woman with multiple cerebrovascular risk factors. Therefore, open surgical repair would have significantly put the patient as risk of ischemic event as the open craniotomy would have required not to use antiplatelets and anticoagulation during the repair. More importantly, aneurysm location at the petro-cavernous junction would have posed remarkable difficulties to access the aneurysm and required many hours to cutdown the clinoid bone with no guarantee to successful repair. But, the novel technique of DCAC followed by pipeline flow diversion was performed successfully in a short period of time with an acceptable informed risk. Our second patient is a 67-year-old and had multiple cerebrovascular risk factors and aneurysm being located at the ophthalmic internal carotid artery, which would have exposed the patient to the similar difficulties like our first patient. Our third patient had bilateral long-segments internal carotid artery dissections which have extended to the skull base with multiple dissection pseudoaneurysms. There

is no safe surgical option defined or available for the repair of the dissecting long segments internal carotid artery pseudoaneurysm that has extended to the skull base. Therefore, DCAC followed by endovascular treatment with flow diversion probably was the only safe option available in our opinion other than just medical management and observation. The fourth patient had a large dissection pseudoaneurysm in the distal cervical internal carotid artery, who was not a surgical candidate. Additionally, the presence of an extreme tortuosity in the common carotid artery that has prevented navigating guiding catheter for the aneurysm repair. Straightening of the ICA using biaxial or triaxial approach was an option, which was not attempted as this patient already had a dissection pseudoaneurysm and straitening technique would have potentially further worsened the dissection leading to the potential occlusion of ICA and/or aneurysm rupture. Our strategies of DCAC followed by flow diversion using a single Surpass Evolve device resulting in successful repair and achievement of good outcomes.

## Conclusions

This is the first case series of intracranial aneurysm and/or internal carotid artery dissection pseudoaneurysms, where a direct carotid artery cutdown technique was used to place a 6 French sheath in the internal carotid artery followed by successful endovascular repair of the aneurysm using exclusive flow diverter device. In our series, the traditional trans-femoral and trans-arterial approaches were not an option including open surgical repair as described above. Without this novel DCAC technique, treatment of the symptomatic intracranial aneurysm and ICA dissecting pseudoaneurysm wouldn't have been achieved and may lead to a potential ischemic or hemorrhagic event. In our DCAC approach, we have not observed any perioperative thromboembolic event despite patients are being older with the presence of multiple cardiovascular and cerebrovascular risk factors. The absent of thromboembolic event in our series most likely due to the fact that our DCAC technique allowed us to utilize full anticoagulation during the procedure and continuation of the necessary antiplatelets during perioperative period. This is a case series and therefore, a definitive conclusion and generalized recommendation is not advised based on our series. However, a case by case evaluation and justification of the unique DCAC and endovascular flow diversion therapy may be a viable option for those who would be benefited of their symptomatic cerebral aneurysms and ICA dissection pseudoaneurysm, when a trans-femoral and trans-arterial approaches are not feasible. Further examination of the specific types of flow diver devices and the use of flow diversion for intracranial and internal carotid artery dissection pseudoaneurysms using the DCAC is needed.

## Conflict of Interest Statement:

None

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