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Original Article

Aneurysm treatment practice patterns for newly appointed dual-trained cerebrovascular/endovascular neurosurgeons: Comparison of open surgical to neuroendovascular procedures in the first 2 years of academic practice

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Abstract

Background: The practice patterns of a hybrid open cerebrovascular/neuroendovascular (CVNV) neurosurgeon in early academic practice is unknown.

Methods: We performed a multi-institutional retrospective cohort study of patients with cerebral aneurysms that were treated within the first 24 months of the neurosurgeon's practice.

Results: A total of 533 aneurysms were treated by the three senior authors within the first 24 months of their academic practice. Of these aneurysms, 172 were treated with microsurgical clipping, 191 with coiling, and 170 with flow diversion. Treatment in the setting of acute subarachnoid hemorrhage (SAH) occurred in 23% (122/533) of the aneurysms. Majority of the clipped aneurysms (70%, 121/172) were anterior cerebral artery (ACA), anterior communicating artery (ACOM), or middle cerebral artery (MCA) in location. In comparison, only 23% (82/361) of aneurysms treated with coiling or flow diversion therapy were ACA, ACOM, or MCA in location ($P < 0.05$). Additionally, majority of the flow diverted aneurysm (65%, 111/170) were cavernous or ophthalmic/paraophthalmic in location. During the second year of practice, there appeared to be a trend towards more aneurysms treated with neuroendovascular techniques (22% increase), particularly in flow diversion.

Conclusion: Although the CVNV neurosurgeon treats cerebral aneurysms more commonly with neuroendovascular techniques, a third of the cerebral aneurysms

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are still selected for microsurgical clipping. Aneurysms located along the ACA/ACOM or MCA are the most frequent aneurysms reserved for microsurgical clipping. The CVNV neurosurgeon must be prepared to manage a high percentage of ACA/ACOM or MCA aneurysms microsurgically.

Key Words: Aneurysm, clipping, coiling, endovascular, hybrid, flow diversion

INTRODUCTION

Intracranial aneurysms are managed by microsurgical clipping and/or endovascular techniques, with the selection of treatment modality dependent on several patients and aneurysm characteristics. Key studies have established the relative safety and efficacy of the two techniques in terms of clinical and radiographic outcomes.[4,9,11,13] Traditionally, neurosurgeons in the United States were trained only in open microsurgical techniques for the treatment of cerebral aneurysms while the endovascular interventions were performed by radiologists.

Since the invention of the Guglielmi detachable coil in the 1990s, the field of neurointervention has blossomed, with now a vast array of coils, stents, balloons, flow diverters, and endovascular devices being utilized routinely in the treatment of intracranial aneurysms.[8] These advancements in neuroendovascular techniques have transformed the field of cerebrovascular neurosurgery whereby increasing number of neurosurgeons are pursuing neuroendovascular training in order to offer a complete spectrum of treatment options for their cerebrovascular patients. In addition, neuroendovascular skills are becoming integrated into required neurosurgical training, with a growing trend for residents interested in cerebrovascular to become dual trained or hybrid cerebrovascular/neuroendovascular (CVNV) neurosurgeons, equipped with technical expertise to perform both neurointervention and open microsurgical treatments.[2] Skepticism around whether one physician specialist is capable of performing both open surgical and neuroendovascular techniques safely has largely been unfounded; several cohort and institutional studies from the United States and Europe have demonstrated no significant difference in clinical outcomes and procedural complications between hybrid CVNV neurosurgeons and interventional neuroradiologists.[2,3,5]

To our knowledge, there are no clinical studies that quantitatively reviewed the practice patterns of a CVNV neurosurgeon during early independent practice. In this report, we present multi-institutional data from three dual-trained CVNV neurosurgeons during the first 2 years of practice postresidency. We review the case volume and aneurysm characteristics for both open and endovascular therapy.

MATERIALS AND METHODS

This study is an institutional-based, non-randomized, retrospective cohort study from prospectively collected databases. The study was conducted at two major academic institutions in the United States, one on the east coast and the other on the west coast. The cerebrovascular cases performed during the first 24 months of practice for the three senior authors, who are all CVNV neurosurgeons, were selected for review. All three CVNV neurosurgeons received 2 years of in-folded, dedicated endovascular neurosurgery fellowship training at the Johns Hopkins Hospital.

Cerebrovascular cases that were specific to aneurysm treatment were identified for analysis. Data were collected with respect to treatment modality (flow diversion versus coiling with and without use of adjunctive versus craniotomy), aneurysm location, and rupture status at presentation. Cases performed for treatment of other cerebrovascular pathologies (e.g., dural arteriovenous fistulas, arteriovenous malformations, etc.) and diagnostic cerebral angiography were not included in the analysis. The same aneurysm treated with multistage stent-assisted coiling was counted as one case. Data were presented as counts. Statistical analysis was performed on proportions of counts and a Fisher exact test was used to determine statistical significance between open microsurgical clipping and endovascular therapy (inclusive of both flow diversion and coil/stenting). A probability value of <0.05 was considered to be statistically significant.

RESULTS

A total of 533 aneurysms were treated by the three senior authors [(Geoffrey Colby (GPC), Alexander Coon (ALC), Li-Mei Lin (LML)] during their first 2 years of practice at their respective academic institutions (GPC July 2013 to June 2015, ALC July 2010 to June 2012, LML August 2014 to July 2016). Microsurgical clipping was performed for the treatment of 172 (32%) aneurysms while a neuroendovascular approach was undertaken for 361 (68%) aneurysms [Figure 1]. Of the neuroendovascular approaches, coiling with or without an adjunctive device was used to treat 191 aneurysms and flow diversion (including Pipeline, FRED, and/or Surpass) was used to treat 170 aneurysms [Figure 1]. A comparison of the first year of practice to the second year of practice demonstrates a trend towards more

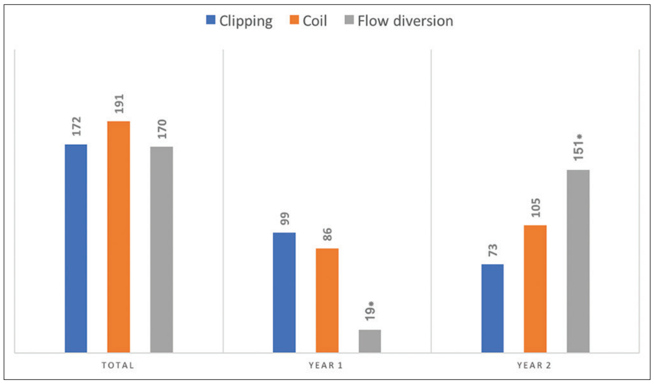

Figure 1: Distribution of all aneurysms by treatment modality and by year of practice

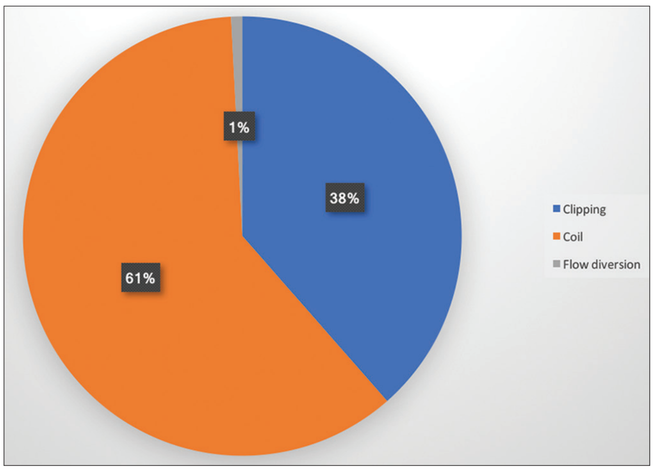

Figure 2: Distribution of ruptured aneurysms by treatment modality

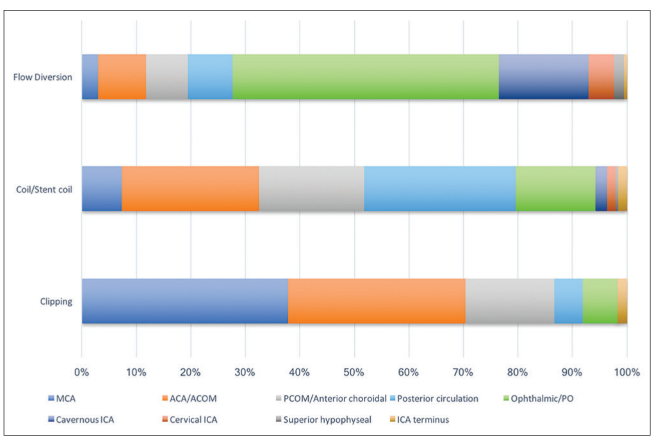

Figure 3: Graphic representation of aneurysm location distribution

aneurysms treated with neuroendovascular techniques (22% increase) and an increase in flow diversion treatments ($P < 0.05$) [Figure 1], which correlated with the FDA approval of the pipeline embolization device (PED). The number of aneurysms treated by open microsurgery decreased from 99 to 73 [Figure 1].

Of the 533 aneurysm cases treated, 122 (23%) presented in the ruptured setting with acute subarachnoid hemorrhage (SAH). For these SAH cases, 75/122 (61%) were treated endovascularly with coiling in all, but one case where the aneurysm was treated with a flow diverter in a delayed fashion within 1 month of the SAH [Figure 2]. The remainder of the ruptured aneurysm cases 47/122 (38%) were treated with microsurgical clipping [Figure 2]. Of these ruptured aneurysms treated with microsurgical clipping, 68% (32/47) were ACA, ACOM or MCA, 21% (10/47) posterior communicating (PCOM), 8% (4/47) posterior circulation, and only 2% (1/47) paraophthalmic/ophthalmic ($P < 0.05$).

Table 1: Distribution of aneurysm locations by treatment modality

Aneurysm Location	Clipping	Coil/Stent coil	Flow Diversion	*P* value
MCA	65	14	5	<0.05
ACA/ACOM	56	48	15	<0.05
PCOM/Anterior choroidal	28	37	13	0.512
BA/VA/SCA/PICA/PCA	9	53	14	<0.05
Ophthalmic/PO/ Supraclinoidal	11	28	83	<0.05
Cavernous ICA	0	4	28	<0.05
Cervical/petrous ICA	0	3	8	<0.05
Superior hypophyseal	0	1	3	0.310
ICA terminus	3	3	1	0.688
Total	172	191	170	

When all microsurgically treated aneurysm cases (both ruptured and unruptured) were considered, 70% (121/172) were located along the ACA, ACOM, or MCA [Table 1] and only 6% (11/172) were located along the internal carotid artery (ICA), proximal to the PCOM ($P < 0.05$). In contrast, of the endovascularly treated aneurysms, only 23% (82/361) were located along the ACA, ACOM, or MCA, whereas 43% (158/361) were located along the ICA, proximal to the PCOM ($P < 0.05$). Flow diversion was the primary endovascular approach (77%, 122/158) for these ICA aneurysms ($P < 0.05$), despite the technology's relative infancy. The majority of posterior circulation aneurysms, 53/76 or 70% (basilar artery, vertebral artery, superior cerebellar artery, posterior inferior cerebellar artery, anterior inferior cerebellar artery, and posterior cerebral artery), were treated with coiling with or without an adjunctive device as compared to open clipping ($P < 0.05$) [Table 1]. The most common aneurysm location for each treatment modality were as follows: ACA/ACOM and MCA for microsurgical clipping 70% (121/172), ACA/ACOM and posterior circulation for coiling with or without adjunctive device 53% (101/191), and ophthalmic/paraophthalmic and cavernous for flow diversion 65% (111/170) [Figure 3].

DISCUSSION

Recent advancements in neuroendovascular techniques, including the introduction of flow diversion, have created increasing demand for the dual trained CVNV neurosurgeon. Initially, this training approach was met with skepticism, as many questioned whether a dual trained neurosurgeon would have the technical capacity and experience to safely perform both open and endovascular techniques. This skepticism is garnered from literature that suggest higher case volume (>20 cases/year) is associated with improved clinical outcomes, particularly in the setting of aneurysmal SAH.[15] However, several studies on the CVNV neurosurgeon have largely debunked this skepticism. Bekelis *et al.* performed a cohort study of 3247 Medicare patients with unruptured aneurysms who underwent microsurgical clipping by hybrid neurosurgeons versus neurosurgeons who only performed open craniotomies. Multivariate analysis did not find significant differences in mortality at 1 year, length of hospital stay, 30 day readmission rates, or functional outcomes between the two groups.[2] The authors reached the same conclusion on a separate cohort of 11716 patients who were treated with endovascular coiling for their unruptured aneurysms, with no difference in clinical outcomes between CVNV neurosurgeons and proceduralists only specialized in endovascular therapy.[3] Similarly, de Vries *et al.* performed a single center, retrospective review of 356 patients with ruptured intracranial aneurysms treated by two dual trained neurosurgeons.[5] The authors cited persistent neurological morbidity and mortality after endovascular treatment and open surgical clipping at 2.1% and 1.4%, respectively, which is consistent with known literature for traditionally trained neurosurgeons and proceduralists.[5,7,11,12,18] These data are further corroborated by several reports supporting the beneficial addition of endovascular training to residency programs in the United States and in Europe.[1,6,10,14,17]

As endovascular techniques continue to evolve, fewer aneurysms are selected for microsurgical clipping.[10] Additionally, the characteristics of aneurysms treated by microsurgical clipping have grown increasingly complex. For instance, the clipping of PCOM aneurysms have historically been considered straightforward and common; however, small aneurysms with narrow necks are now favorably treated with endovascular coiling. Thus, the modern open neurosurgeon is exposed more to PCOM aneurysms with complex morphology, including larger side, wide necks, and/or with fetal configurations.[16] In the current study, we noted that despite advanced endovascular techniques, a high number of MCA and ACA aneurysms are still clipped with statistical significance compared to the number of MCA/ACA aneurysms being treated endovascularly. Aneurysms in these locations are less easily accessed via current distal intracranial catheters and not as amenable to flow diversion. As such, the CVNV neurosurgeon must be prepared to take a high percentage of ACOM and MCA aneurysms for microsurgical clipping. On the other hand, side wall aneurysms of the ICA proximal to the PCOM, such as cavernous or ophthalmic/paraophthalmic, are preferentially treated with endovascular techniques due to the ease of distal intracranial access ($P < 0.05$ in our study).

The findings from this study also suggest a trend towards more endovascular management of aneurysms in the second year of practice for a newly minted CVNV neurosurgeon, despite known potential influencers on junior attending practice preferences from institutional bias and senior faculty experience. In our study, all three CVNV neurosurgeons underwent endovascular training at the same institution, one that historically preferred open microsurgical clipping. The senior partners for all three practitioners only practiced open microsurgery and do not have endovascular training. Despite the dominant, open vascular influences, the trend towards endovascular management persisted, likely as a true reflection of current clinical trends. Particularly, this trend was statistically significant for the increased utilization flow diversion techniques. This trend could be confounded by the fact that flow diversion was still in its infancy during one of the senior author's first year in practice, during which time the PED was not widely available at the institution. The lower volume of flow diversion during year 1 of practice could also be attributed to proctoring requirements prior to off-label treatments.

In the current study, the majority of the cases treated by the senior authors were elective, unruptured aneurysms. As such, only about 20% of the patients treated were in the setting of ruptured aneurysmal SAH. Most junior CVNV neurosurgeons would be expected to have higher numbers of non-elective cases early in their practice. The current data reflect that of academic centers with high referral patterns, thus may skew the practice pattern towards higher elective volume.

CONCLUSION

Although there is an increasing trend towards endovascular treatment of majority of cerebral aneurysms by the hybrid cerebrovascular neurosurgeon, this study demonstrates that a significant number of MCA and ACA aneurysms are still selected for microsurgical clipping by the CVNV neurosurgeon. The hybrid CVNV neurosurgeon must be prepared to manage a high percentage of ACA/MCA aneurysms with open microsurgical techniques in both unruptured and ruptured settings.

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Nil.

Conflicts of interest

ALC is a proctor for the Woven Endobridge (WEB) device (Sequent Medical, Aliso Viejo, CA), a proctor for the Surpass device (Stryker Neurovascular, Fremont, CA) and a consultant for Stryker Neurovascular, a proctor for the Pipeline Embolization Device (Medtronic Neurovascular, Irvine, CA) and a consultant for Medtronic, and a proctor for the FRED device (MicroVention, Tustin, CA) and consultant for MicroVention. GPC is a consultant for Medtronic, MicroVention and participates in clinical trials for Medtronic and Stryker. LML is a proctor for the Pipeline Embolization Device (Medtronic Neurovascular, Irvine, CA), a consultant for MicroVention and participates in clinical trial for Stryker. The other authors have no conflict of interest. No author received financial support in conjunction with the generation of this submission.

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