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Original Article

Comparison of tertiary-center aneurysm location frequencies in 400 consecutive cases: Decreasing incidence of posterior communicating artery region aneurysms

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Abstract

Background: The growing number of community hospitals with neurointerventional services over the past decade has changed the type and complexity of cerebral aneurysms referred to tertiary centers. The authors hypothesized that this would be reflected in changes in the location frequencies of aneurysms treated now compared to before the widespread institution of endovascular coiling.

Methods: Using a prospectively collected aneurysm database, aneurysm location frequencies were retrospectively reviewed for the last 200 consecutively treated aneurysms (2009–2010) and 200 consecutive aneurysms treated starting from May 1999 to December 2000. International Subarachnoid Aneurysm Trial (ISAT) aneurysm location nomenclature was utilized. Two-tailed Student's t-tests were used to compare means and Fisher exact tests were used to compare proportions.

Results: The location frequencies of all aneurysms (ruptured and unruptured) treated in the 2000 epoch as compared to the modern epoch showed significant changes for middle cerebral aneurysms (12.0% vs. 21.0%, $P = 0.014$), posterior communicating (21.0% vs. 13.0%, $P = 0.0001$), and para-ophthalmic aneurysms (10.0% vs. 25.5%, $P = 0.0002$). For unruptured/elective aneurysms, the change in posterior communicating aneurysms was even more pronounced (27.8% vs 3.6%, $P = 0.0001$). The rate of aneurysm coiling at the center rose from 26% to 37% ($P = 0.02$).

Conclusions: The significant reduction in the referrals to our tertiary center of less technically complex aneurysms (posterior communicating segment) and increased referrals of aneurysms not as amenable to coil embolization (middle cerebral artery) is likely attributable to the growth of neurointerventional services at community hospitals over the past 10 years.

Key Words: Aneurysm, coiling, endovascular

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INTRODUCTION

Following the International Subarachnoid Aneurysm Trial (ISAT), the techniques employed to treat intracranial aneurysms have markedly changed. The use of endovascular coiling has steadily increased since Food and Drug Administration (FDA) approval in 1995, with concentrated growth in the eastern and western coastal states.[2-5,9,13] Andaluz and Zuccarello found a doubling of endovascular procedures in the context of a steady number of aneurysm clipping procedures from 1993 to 2003.[1] From 1996 to 2006, there has been an approximate 50% decrease in the number of craniotomies for clipping of cerebral aneurysms in Medicare patients with a concurrent sixfold increase in the number of endovascular cerebral embolization procedures.[11] The popularity of endovascular coiling, the rapid technological advances and the development of stroke centers at regional and community hospitals have led to increasing needs for the training and services of neurointerventionalists.[10,13] The widespread implementation of endovascular programs has the potential to greatly affect the type and complexity of cerebral aneurysms that are referred to tertiary cerebrovascular centers.

Posterior communicating artery (PCOM) aneurysms are commonly regarded as aneurysms that can be treated by traditional open microsurgery with relative ease. These aneurysms also are generally straightforward to treat through endovascular means as they are proximal on the internal carotid artery (ICA) and their typical posterior projection and oblong shape make them favorable for microcatheter access. Additionally, proximal sacrifice of the PCOM is often of little clinical significance (in non-fetal circulations),[6] which facilitates both treatment modalities.

Given the spread of endovascular coiling of aneurysms, we hypothesized that increasing numbers of more technically sophisticated aneurysms [e.g., middle cerebral artery (MCA) and ophthalmic aneurysms] are being referred to tertiary aneurysm centers, as the straightforward, less technically challenging aneurysms (e.g., PCOM aneurysms) are treated electively at community centers. We sought to test this hypothesis by retrospectively reviewing a single-center tertiary aneurysm referral aneurysm database that has been prospectively collected over the past 20 years. We compared the location frequencies in 200 consecutive aneurysms starting in May 1999 before the widespread adoption of endovascular aneurysm treatment at community care centers to 200 consecutive aneurysm cases starting in October 2009.

MATERIALS AND METHODS

An aneurysm database of a single tertiary care center maintained by the senior author (RJT) was retrospectively reviewed. The "past" epoch was defined as 200 consecutively treated aneurysms beginning 05/17/1999 through 12/27/2000. The "present" epoch was defined as 200 consecutive aneurysms treated from 10/13/2009 through 11/22/2010. Patient's age, gender, race, aneurysm location, size, rupture status at presentation and discharge Glasgow Outcome Scale (GOS) were analyzed. Two-tailed Student's *t*-tests were used to compare means and Fisher exact tests were used to compare proportions. A probability value of <0.05 was considered statistically significant.

RESULTS

Patient demographics are shown in Table 1. The mean age of all patients in the past epoch was 51.9 ± 13.4 years and the mean age of all patients in the present epoch was 55.7 ± 12.0 years ($P < 0.05$). Seventy-seven percent of patients in the past epoch were females compared to 71% of patients in the present epoch ($P = 0.14$). There were no significant differences in race between the two epochs evaluated.

When all treated aneurysm cases (both unruptured and ruptured) were considered, the past epoch consisted of 17.5% posterior circulation aneurysms and 82.5% anterior circulation aneurysms. There was no statistically significant difference between this breakdown and that observed in the present epoch, where 11.5% of aneurysms were in the posterior circulation and 88.5% were in the anterior circulation ($P = 0.12$). There were also no statistically significant differences in the frequency of vertebral, basilar, superior cerebellar artery (SCA), posterior cerebral artery (PCA), posterior inferior cerebellar artery (PICA), anterior inferior cerebellar artery (AICA), anterior communicating artery (ACOM), pericallosal, and ICA bifurcation aneurysms between the past and present epochs for all treated aneurysms. However, statistically significant differences were present for ophthalmic, PCOM, and MCA aneurysms [Figure 1]. In the past epoch, 10% of treated aneurysms were ophthalmic compared to 25% of the present epoch ($P < 0.05$). Twenty-one percent of the aneurysms treated in the past epoch were located at the PCOM compared to 13% of all aneurysms treated in the present epoch

Table 1: Baseline demographics

	Past (%)	Present (%)	*P*-value
Age, mean years (SD)	51.9 (13.4)	55.7 (12.0)	0.003
Females	77.10	70.50	0.14
Race			
White	67.20	63.00	0.46
Black	27.40	30.70	0.51
Other	5.50	6.00	0.84

(P < 0.05). Finally, 12% of aneurysms treated in the past epoch were MCA aneurysms compared to 21% of treated aneurysms in the present epoch (P < 0.05). Of all the aneurysms treated, there was a statistically significant higher percentage of ruptured aneurysms treated in the past epoch (55%) as compared to the present epoch (32%, P < 0.05) [Table 2].

The past and present treatment groups were also analyzed for the proportion of aneurysms clipped, aneurysm size, and mean discharge GOS [Table 2]. Of all treated aneurysms, there was a statistically significant drop in percentage of aneurysms clipped from the past epoch (74%) to the present epoch (63%, P = 0.02). There was no significant difference in the size of the aneurysms treated, with the mean size in the past epoch of 9.1 ± 11.6 mm and the mean size in the present epoch of 7.8 ± 6.5 mm (P = 0.24). When discharge GOS was reviewed, there was a statistically significant improvement in discharge GOS from the past epoch (3.9 ± 1.4) to the present epoch (4.2 ± 1.1, P = 0.03).

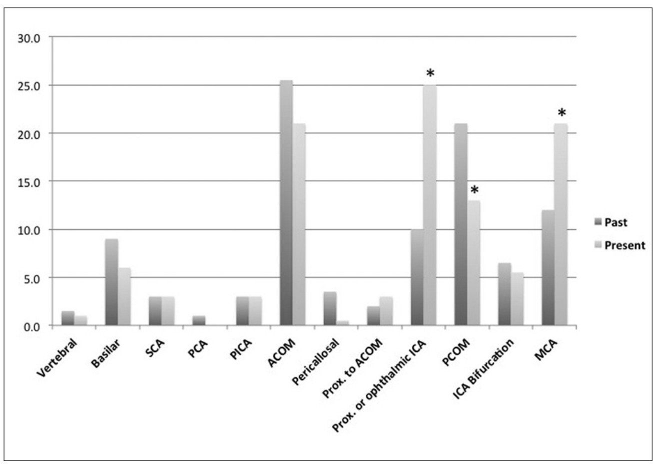

Figure 1: Location frequencies of all aneurysms analyzed in the two study periods

When ruptured aneurysms were analyzed separately, there was no significant difference in the frequency for any of the aneurysm locations studied [Figure 2]. Seventy-seven percent of ruptured aneurysms in the past epoch were clipped compared to 63% of ruptured aneurysms in the present epoch, representing a statistically significant difference (P = 0.05) [Table 2]. The mean size of ruptured aneurysms in the past epoch was 7.6 ± 5.9 mm and the mean size of ruptured aneurysms in the present epoch was 6.0 ± 2.8 mm (P = 0.06). Finally, the mean discharge GOS in the past epoch was 3.3 ± 1.6 compared to the mean discharge GOS of 3.3 ± 1.3 in the present group (P = 0.98) [Table 2].

When unruptured aneurysms were analyzed separately [Figure 3], there was no significant difference in the frequency of vertebral, basilar, SCA, PCA, PICA, AICA, ACOM, pericallosal, ICA bifurcation or MCA aneurysms. However, there were statistically significant differences for ophthalmic and PCOM aneurysms [Figure 3].

Table 2 : Location frequencies of ruptured aneurysms during the two study periods

	Past (%)	Present (%)	*P*-value
All aneurysms			
Ruptured	55.00	32.00	0.0001
Clipped	74.00	63.00	0.02
Size, mean mm (SD)	9.1 (11.6)	7.8 (6.5)	0.24
Discharge GOS, mean (SD)	3.9 (1.4)	4.2 (1.1)	0.03
Ruptured aneurysms			
Clipped	77	63	0.05
Size, mean mm (SD)	7.6 (5.9)	6.0 (2.8)	0.06
Discharge GOS, mean (SD)	3.3 (1.6)	3.3 (1.3)	0.98
Unruptured aneurysms			
Clipped	68.90	62	0.32
Size, mean mm (SD)	6.6 (6.6)	8.6 (7.5)	0.79
Discharge GOS, mean (SD)	4.6 (0.8)	4.6 (0.7)	0.76

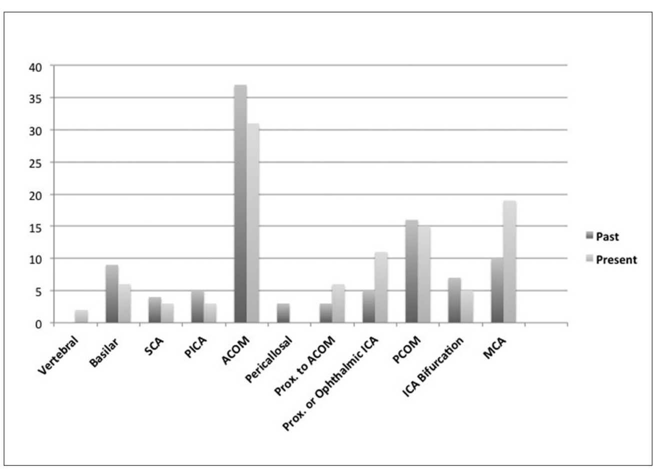

Figure 2: Location frequencies of ruptured aneurysms during the two study periods

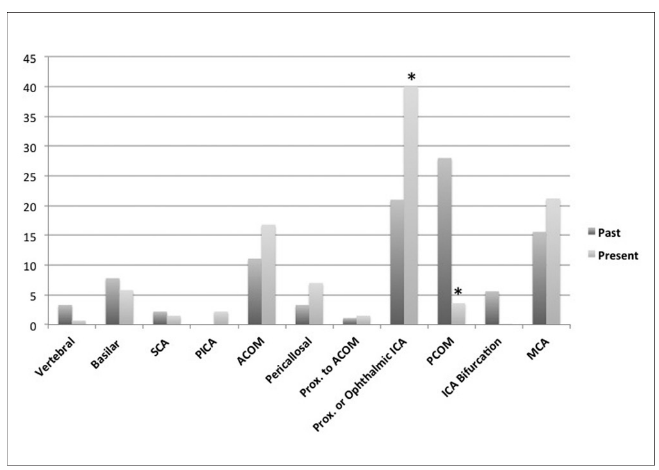

Figure 3: Location frequencies of unruptured aneurysms in the two study periods

Twenty-one percent of unruptured aneurysms in the past epoch were ophthalmic as compared to 40% of unruptured aneurysms in the present epoch ($P < 0.05$). Twenty-eight percent of unruptured aneurysms in the past epoch were PCOM compared to 3.6% of unruptured aneurysms in the present epoch ($P < 0.05$). There was no significant difference in the percentage of unruptured aneurysms clipped in the past or present epochs (69% vs. 62%, $P = 0.32$). There was also no significant difference in the mean size of unruptured aneurysms in the past or present epoch (6.6 ± 6.6 mm vs. 8.6 ± 7.5 mm, $P = 0.79$). Finally, the mean discharge GOS of patients in the past epoch with unruptured aneurysms was 4.6 ± 0.8 compared to a mean discharge GOS of 4.6 ± 0.7 for patients in the present epoch ($P = 0.76$) [Table 2].

DISCUSSION

In this study, we sought to analyze potential changes in aneurysm location frequency at our tertiary care center over the past decade. When all aneurysms treated were taken into account, there was a significant decrease in the number PCOM aneurysms treated at our institution between the past and present epochs (from 21% to 13%, $P = 0.0001$). However, there was an increase in the number of ophthalmic aneurysms (from 10% to 25%, $P = 0.002$) and MCA aneurysms (from 12% to 21%, $P = 0.01$). There also was a trend toward decreasing frequency of posterior circulation aneurysms, but this did not reach statistical significance (17.5% vs. 11.5%, $P = 0.12$). When only unruptured aneurysms were considered, there was pronounced decrease in PCOM aneurysms (from 27.8% to 3.6%, $P = 0.0001$) and a significant increase in ophthalmic aneurysms treated (from 21.1% to 40.1%, $P = 0.04$). There were no significant differences in aneurysm location of ruptured aneurysms treated at our institution during the two epochs.

ACOM aneurysms are the most frequently seen (30%) followed by PCOM (25%) and MCA (20%) aneurysms. Posterior circulation aneurysms are seen 5–15% of the time.[7] This distribution is consistent with the frequencies of aneurysms that we treated in the past epoch with the exception of fewer MCA aneurysms (12%). The distribution of the present epoch was significantly different, with fewer PCOM aneurysms (13%) and more MCA aneurysms (21%) treated at our institution.

In an analysis of 1069 sporadic ruptured saccular aneurysms, Huttunen *et al.* found 29% ACOM aneurysms, 32% MCA aneurysms, and 12% PCOM aneurysms.[8] Our institution treated a larger number of ruptured ACOM aneurysms in both the past and present epochs (37% and 31%, respectively) and a smaller number of MCA aneurysms in both epochs (10% and 19%, respectively). A similar percentage of ruptured PCOM aneurysms were treated in the Huttunen *et al.*'s study and both the past and present epochs of our study (16% and 15%, respectively).[8]

The results of this study support the hypothesis that relatively simple, elective aneurysms, such as unruptured PCOM aneurysms, are increasingly being treated outside of major academic centers. It is our impression that this trend is secondary to the widespread expansion and adoption of endovascular techniques and services in community hospitals. The converse of this finding is that the more complex and technically difficult aneurysms, including MCA and paraophthalmic aneurysms, are more frequently being referred to and treated at tertiary care centers.

Ruptured cerebral aneurysms are classically more challanging to manage both open and with endovascular techniques. The location of ruptured aneurysms did not significantly change from the past epoch to the present epoch in our study, but there was a significant decrease in the percentage of ruptured aneurysm treated during this time period from 55% to 32%. This finding is likely secondary to the trend of increased vigilance in the health care community leading to increased frequency brain imaging for headache and other, sometimes, vague neurological symptoms. With more patients undergoing MRI/MRA or CT/CTA brain imaging, cerebral aneurysms are likely being identified and treated prior to a rupture event.

Patients with subarachnoid hemorrhage secondary to a ruptured aneurysm generally have long, complicated hospital courses that are best managed in a tertiary care setting. These patients often have permanent sequelae as a result of the hemorrhage. The significant increase in discharge GOS from the past epoch (3.9) versus the present epoch (4.2), corresponding to improved outcomes, is likely secondary to the lower percentage of ruptured aneurysms in the latter group.

Neurointerventional surgery first became accredited in 2000, and there has been an increase in the past decade in the training of neurointerventionalists.[13] With this expansion has come a significant increase in the number of endovascular cases being performed for aneurysm treatment. Simon *et al.* demonstrated a sixfold increase in the number of endovascular cerebral embolization procedures performed on Medicare patients between 1996 and 2006.[11] Additionally, a recent analysis of the National Inpatient Sample by Smith *et al.* found an increase in the number of patients with ruptured aneurysms treated endovascularly (from 17.28% to 57.9%) from 2002 to 2008 as well as an increase in patients with unruptured aneurysms treated endovascularly (from 29.7% to 62.7%).[12] The percentage of aneurysms treated endovascularly at our institution is lower than the national average, but has increased steadily since 2000. In the modern epoch, 38% of unruptured aneurysms and 37% of ruptured aneurysms were treated endovascularly, an increase from 31% and 23%.

Looking toward the future, patients with ruptured cerebral aneurysms and unruptured complex aneurysms will likely continue to be primarily treated at tertiary care centers. As endovascular treatment of aneurysms becomes more widespread and ubiquitous in the United States, it will be important to closely follow these patients for aneurysm recurrence. The treatment of aneurysm recurrence after endovascular embolization is often technically complicated, requiring the use of adjunct devices. Patients treated by endovascular embolization at community hospitals that subsequently have a recurrence may represent a new sub-category of patients presenting to tertiary care centers for further management. Following the trends in location frequencies and recurrence status of aneurysms treated in tertiary care centers versus community hospitals is important to provide optimal care to the patients.

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Commentary

Coon *et al*. have performed an interesting study on aneurysm referral patterns to the Johns Hopkins Hospital utilizing the prospective neurovascular database which has been maintained by Dr. Rafael Tamargo and his team. Using this database, the authors have retrospectively analyzed and compared 200 consecutively treated intracranial aneurysms between the years of 1999-2000 to 200 consecutively treated intracranial aneurysms in 2009 and 2010 at their tertiary medical center. A key difference in practice patterns in these two eras has been the proliferation of neurointerventional surgery services at community hospitals. The authors hypothesized that this proliferation would have an impact on the types of aneurysms treated at their center. During the 10 year span of this review, the percentage of unruptured ophthalmic and middle cerebral artery aneurysms among aneurysms that were treated at their center increased from 10% to 25% ($P<$ 0.05) and 12% to 21% ($P<0.05$) respectively, while the percentage of unruptured PCOM aneurysms dropped from 21% to 13% ($P<0.05$). For ruptured aneurysms, however there were no such changes in the percentages. The authors postulate that the expansion of endovascular capabilities to community hospitals may be the main reason behind the observed decline in percentage of unruptured PCOM aneurysms treated microsurgically at their center. They theorize that the ease of coiling these aneurysms particularly when they are unruptured may explain this trend. On the other hand the relative complexity of MCA and ophthalmic segment aneurysms may explain the increase in the percentages of these aneurysms in the more recent time period.

Clearly the trends described in this paper have implications for resident and fellow training. Clipping of PCOM aneurysms remains a necessary and fundamental neurosurgical skill. Furthermore, a number of questions are raised by the data presented by the authors. Are patients being served well by the expansion in the number of hospitals capable of neuro-interventional surgery? Is the trend noted by the authors good or bad for patients? The answers to these questions must ultimately be tied to short and long term outcomes. Aneurysm patients should ideally receive the best possible care at hospitals with the critical mass of human talent and technological capabilities to handle complications and offer state of the art microsurgery, neurointerventional surgery and medical care. Fundamentally, there are not enough aneurysms that need treatment to allow every hospital to become a center of excellence for aneurysm management and future training may rely heavily on simulation as a means to achieve mastery. On the other hand outstanding care can be provided at any hospital willing to invest in the human and technological components of a center of excellence. This will require the availability of proficient and experienced microsurgical and interventional surgeons with the capability to handle elective cases as well as emergent life-threatening situations.

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