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Impact of aneurysm location on hemorrhage risk

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ABSTRACT

Introduction: Recent studies have reinforced anterior communicating (AComm) artery location as a significant risk factor for aneurysm rupture in addition to posterior circulation/posterior communicating (PComm) artery location. However, studies stratifying aneurysm location in greater detail are sparse.
Methods: We reviewed the records of 747 consecutive patients with 1013 aneurysms seen at our institution over a 7 year period, noting aneurysm location and rupture status at the time of presentation.
Results: High proportions of ruptured aneurysms were seen among frontopolar/pericallosal (59%, OR 3.07, $p = 0.011$), vertebral/posteroinferior cerebellar (PICA; 53%, OR 2.49, $p = 0.0037$), AComm (50%, OR 2.46, $p < 0.0001$), and PComm aneurysms (44%, OR 1.77, $p = 0.0016$). Low proportions of ruptured aneurysms were seen among superior hypophyseal artery (SHA; 6%, OR 0.12, $p = 0.0001$), internal carotid artery (ICA) bifurcation (12%, OR 0.27, $p = 0.0012$), and ophthalmic artery aneurysms (15%, OR 0.33, $p = 0.0002$). The proportion of ruptured PComm aneurysms demonstrated a trend toward being greater than anterior choroidal artery aneurysms (OR 2.14, $p = 0.09$); however the proportion was significantly greater among anterior choroidal artery aneurysms as compared to nonPComm intradural ICA aneurysms (OR 2.78, $p = 0.03$). Notably, the lower rupture rate of SHA aneurysms as compared to ophthalmic artery aneurysms neared statistical significance (OR 0.38, $p = 0.10$).
Conclusion: Aneurysm location has a significant impact on risk of rupture and should be stratified in greater detail in future studies of aneurysm natural history.

1. Introduction

Notwithstanding symptomatic aneurysms, the primary characteristics that can be used to predict the risk of aneurysm rupture are size, location and morphology [1–7]. There is little controversy that increasing aneurysm size correlates with increasing rupture risk [1–10]. Although not well evaluated in the International Study of Unruptured Intracranial Aneurysms (ISUIA) [10], the Unruptured Cerebral Aneurysm Study (UCAS) of Japan clearly demonstrated a greater risk of rupture among aneurysms with daughter domes [1]. The impact of aneurysm location on rupture risk is not as well lineated as prominent prior studies have grouped many heterogeneous locations, leaving questions unanswered [9,10]. Specifically, what is the rupture risk of distal anterior cerebral artery (ACA)/pericallosal artery aneurysms? How does one effectively stratify nonPComm ICA aneurysms? Are anterior choroidal artery aneurysms more like PComm or other ICA aneurysms? Do SHA aneurysms have a similar rupture rate as ophthalmic artery aneurysms? In this study, we address these questions and more by evaluating aneurysm rupture rates across a more stratified system of locations.

2. Methods

With approval from our local institutional review board, we performed a retrospective review of a consecutive series of patients seen by the neurosurgical service over a 7 year period with at least one cerebral aneurysm. Baseline demographic information (age and sex), pertinent medical conditions (hypertension, smoking, family history of aneurysms), aneurysm location and aneurysm rupture status were noted. Aneurysm location was stratified as follows: cavernous, clinoidal, SHA, ophthalmic artery, PComm, anterior choroidal artery, ICA terminus, A1, AComm, frontopolar, pericallosal, anterior temporal artery, middle cerebral artery (MCA) bifurcation, distal MCA, vertebral/PICA, basilar trunk, basilar-superior cerebellar artery (basilar-SCA), basilar terminus and posterior cerebral artery (PCA). To evaluate the impact of aneurysm location on rupture, we calculated odds ratios for each

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Table 1
Distribution of 1013 aneurysms in 747 patients overall, among 710 unruptured aneurysms, and among 303 ruptured aneurysms.

Location	Overall prevalence	Unruptured	Ruptured
Cavernous	47/1013 (5%)	47/710 (7%)	0/303 (0%)
Clinoidal	41/1013 (4%)	41/710 (6%)	0/303 (0%)
Ophthalmic artery	94/1013 (9%)	80/710 (11%)	14/303 (5%)
Superior hypophyseal artery	64/1013 (6%)	60/710 (8%)	4/303 (1%)
Posterior communicating artery	151/1013 (15%)	85/710 (12%)	66/303 (22%)
Anterior choroidal artery	30/1013 (3%)	22/710 (3%)	8/303 (3%)
ICA bifurcation	58/1013 (6%)	51/710 (7%)	7/303 (2%)
A1	9/1013 (1%)	8/710 (1%)	1/303 (1%)
Anterior communicating artery	175/1013 (17%)	88/710 (12%)	87/303 (29%)
Frontopolar/pericallosal	22/1013 (2%)	9/710 (1%)	13/303 (4%)
Anterior temporal artery	11/1013 (1%)	11/710 (2%)	0/303 (0%)
MCA bifurcation	165/1013 (16%)	117/710 (16%)	48/303 (16%)
Distal MCA	18/1013 (2%)	15/710 (2%)	3/303 (1%)
Vertebral/PICA	43/1013 (5%)	20/710 (3%)	23/303 (8%)
Basilar trunk	9/1013 (1%)	6/710 (1%)	3/303 (1%)
Basilar apex/basilar-SCA	75/1013 (7%)	50/710 (7%)	25/303 (8%)
PCA	5/1013 (1%)	4/710 (1%)	1/303 (1%)

location as compared to all other locations excluding extradural aneurysms (cavernous, clinoidal). Probability values were considered statistically significant if $p < 0.05$.

3. Results

3.1. Background/demographics

We reviewed the records of 747 patients with 1013 aneurysms. Mean patient age was 53.9 years-old (SD = 13.7). There was a significant female sex predilection (83% female), 39% of patients had a history of hypertension, 32% were smokers and 16% had a family history of cerebral aneurysms. The overall distribution of the 1013 aneurysms is detailed in Table 1. Overall, AComm aneurysms were most common (17%), followed by MCA bifurcation (16%), PComm (15%), ophthalmic artery (9%) and basilar apex/SCA aneurysms (7%). Of the 929 intradural aneurysms, 303 had ruptured (33%). Among ruptured aneurysms, the most common location was AComm (29%), followed by PComm (22%), MCA bifurcation (16%), and basilar apex/SCA (8%). Rupture rates are summarized in Table 2 and illustrated in Fig. 1. Individualized analysis for A1, anterior temporal artery, distal MCA and PCA aneurysms was not performed owing to the small number of aneurysms at each of these respective locations.

3.2. High rupture rate locations (OR > 1.0)

The group of frontopolar/pericallosal aneurysms had the highest percentage of ruptured aneurysms (59%, OR 3.07 95% CI 1.30–7.27, $p = 0.011$ as compared to all other locations). Frontopolar aneurysms were grouped with pericallosal aneurysms as there were only two and both bled. In descending order, this location was followed by vertebral/PICA aneurysms (53% rupture rate, OR 2.49 95% CI 1.34–4.61, $p = 0.0037$), anterior communicating artery aneurysms (50%, OR 2.46 95% CI 1.76–3.45, $p < 0.0001$), posterior communicating artery aneurysms (44%, OR 1.77 95% CI 1.24–2.53, $p = 0.0016$), and basilar aneurysms (33%, OR 1.03 95% CI 0.64–1.67, $p = 0.88$). The basilar aneurysm group incorporates basilar trunk, basilar-SCA and basilar apex aneurysms as each individual group had the same hemorrhage rate.

Considering comparisons of interest among these higher rupture rate locations, the greater rate of rupture among pericallosal/frontopolar aneurysms as compared to AComm aneurysms did not meet statistical significance (OR 1.46, 95% CI 0.59–3.59, $p = 0.83$). The higher rate of rupture of AComm aneurysms as compared to PComm aneurysms also did not meet statistical significance (OR 1.27, 95% CI 0.82–1.97, $p = 0.28$); however the higher rate of rupture of AComm aneurysms as compared to basilar aneurysms did meet statistical significance (OR 1.98, 95% CI 1.15–3.40, $p = 0.01$), while that of PComm aneurysms as compared to basilar aneurysms trended toward but did not meet statistical significance (OR 1.55, 95% CI 0.89–2.71, $p = 0.12$). Interestingly, the higher rupture rate of PComm aneurysms as compared to anterior choroidal artery aneurysms also neared statistical significance (OR 2.14, 95% CI 0.89–5.10, $p = 0.09$). Among posterior circulation aneurysms, the higher rupture rate of vertebral/PICA aneurysms as compared to basilar aneurysms met statistical significance (OR 2.30, 95% CI 1.08–4.88, $p = 0.03$).

3.3. Low rupture rate locations (OR < 1.0)

Superior hypophyseal artery aneurysms had the lowest rate of rupture (6%, OR 0.12, 95% CI 0.05–0.35, $p = 0.0001$ as compared to all other aneurysm locations). In ascending order, ICA bifurcation aneurysms had a 12% rupture rate (OR 0.27, 95% CI 0.12–0.59,

Table 2
Proportion of ruptured aneurysms, stratified by location. Odds ratios compare the proportion of ruptured aneurysms at the respective location to that of all other intradural locations.

Location	Number	Ruptured	OR (95% CI)	*p*
Ophthalmic artery	94	14/94 (15%)	0.33 (0.18–0.59)	0.0002
Superior hypophyseal artery	64	4/64 (6%)	0.12 (0.05–0.35)	0.0001
Posterior communicating artery	151	66/151 (44%)	1.77 (1.24–2.53)	0.0016
Anterior choroidal artery	30	8/30 (27%)	0.74 (0.33–1.69)	0.48
ICA bifurcation	58	7/58 (12%)	0.27 (0.12–0.59)	0.0012
Anterior communicating artery	175	87/175 (50%)	2.46 (1.76–3.45)	<0.0001
Frontopolar/pericallosal	22	13/22 (59%)	3.07 (1.30–7.27)	0.011
MCA bifurcation	165	48/165 (29%)	0.81 (0.57–1.18)	0.29
Vertebral/PICA	43	23/43 (53%)	2.49 (1.34–4.61)	0.0037
Basilar artery	84	28/84 (33%)	1.03 (0.64–1.67)	0.88