Distal Aneurysms of Intracranial Arteries: Application of Numerical Nomenclature, Predilection for Cerebellar Arteries, and Results of Surgical Management

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Key words
- Bypass
- Cerebellar arteries
- Distal aneurysms
- Nomenclature
- Surgical clipping

Abbreviations and Acronyms
ACA: Anterior cerebral artery
AICA: Anterior inferior cerebellar artery
AVM: Arteriovenous malformation
BTO: Balloon test occlusion
MCA: Middle cerebral artery
mRS: Modified Rankin Score
PCA: Posterior cerebral artery
PICA: Posterior inferior cerebellar artery
SCA: Superior cerebellar artery
STA: Superficial temporal artery

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BACKGROUND: **Distal intracranial aneurysms are rare, have unclear origins, and are frequently nonsaccular. Published clinical experience with these aneurysms is limited.**

OBJECTIVE: **To examine differences between distal aneurysms of cerebral and cerebellar arteries and to examine results associated with surgical therapy in 140 patients.**

METHODS: **Distal aneurysms in the cerebral arteries were defined as outside the circle of Willis, on or beyond the A2 anterior cerebral artery, M2 middle cerebral artery, or P2 posterior cerebral segments. Distal aneurysms in the cerebellar arteries were on or beyond the s2 superior cerebellar artery, a2 anterior inferior cerebellar artery, or p2 posterior inferior cerebellar artery segments. Clinical data, microsurgical technique, and patient outcomes were reviewed.**

RESULTS: **The incidence of distal cerebellar artery aneurysms was 4.3 times greater than distal cerebral artery aneurysms (6.5% vs. 28.6%; *P*< 0.01). The A3 anterior cerebral artery segment and the p2 and p3 posterior inferior cerebellar artery segments were the most common sites. Presentation with aneurysm rupture was more frequent with cerebellar aneurysms (65% vs. 40%; *P*< 0.05). Distal cerebellar artery aneurysms were less likely than distal cerebral artery aneurysms to be clipable (40% vs. 72%; *P*< 0.01), with 42% treated with trapping alone. Overall, 14% required a bypass.**

CONCLUSIONS: **Distal intracranial aneurysms have a predilection for cerebellar arteries and are not as rare as the literature suggests. Application of standardized nomenclature for segmental anatomy to these lesions will increase the precision of anatomic description and clarity of clinical discourse. Although technically difficult, good clinical results can be expected with surgical management.**

INTRODUCTION

Intracranial aneurysms typically arise at branch sites on parent arteries, which may be side branches or bifurcations. Aneurysms may also arise at turns or curves in the outer wall of a parent artery where hemodynamic stress is greatest. Rarely, aneurysms arise distally on a branch artery, remote from its origin from the parent artery (9, 11, 14). With the exception of pericallosal aneurysms (6-8, 10, 16, 33, 35), distal aneurysms are so rare that published experiences are limited to case reports and small patient series (3-5, 12, 15, 19, 20, 22, 24, 26-29, 31, 34, 36). The description of distal aneurysms in many of these reports is imprecise (30, 39, 40). A numerical nomenclature for segmental anatomy of cerebral arteries enables precise descriptions of distal aneurysms of the cerebral arteries, but no such nomenclature was established for segmental anatomy of cerebellar arteries. We recently proposed a numerical nomenclature for cerebellar arteries to address this deficiency and imprecision (23), and in this report will demonstrate its application to distal cerebellar artery aneurysms.

Distal aneurysms are intriguing lesions not only because of their rarity, but also because of their anatomic distribution, nonsaccular morphology, and mysterious pathogenesis (2). In the anterior circulation, they arise near dural leaflets like the free edge of falx on the distal anterior cerebral artery (ACA) or the tentorial incisura on the posterior cerebral artery (PCA) (10, 31). This association suggests a mechanical or traumatic pathogenesis with shearing of the artery against fixed dural structures. In the posterior circulation, distal aneurysms occur frequently on the posterior inferior cerebellar artery (PICA) (11, 17, 21, 32), suggesting unique hemodynamic stresses related to tortuosity. Their fusiform or dolichoectatic morphologies implicate infectious and dissecting etiologies. They are often located on feeding arteries to arteriovenous malformations (AVM) or dural arteriovenous fistulas (18), again suggesting a hemodynamic pathogenesis.

The mechanism of distal aneurysm formation will not be deciphered without an experimental model in animals, but some of these clinical associations deserve examination. We acquired a surgical experience with 140 distal intracranial aneurysms, which is one of the largest in the literature that combines the anterior and posterior circulations. In this report, we examined our clinical data for differences between distal aneurysms of cerebral and cerebellar arteries, as well as results associated with surgical therapy. Many of the characteristics of distal aneurysms are familiar to neurovascular clinicians who encounter them. The purpose of this report is not to describe these characteristics as novel insights, but to define them quantitatively to better understand these unusual lesions.

METHODS

Definitions

Distal aneurysms were located on a branch artery distal to its origin from the parent artery. Among the cerebral arteries, distal aneurysms were defined as beyond the circle of Willis, on the ACA distal to the anterior communicating artery complex (A2—A5 segments), on the middle cerebral artery (MCA) distal to the limen insulae (M2—M4 segments), or on the PCA distal to the posterior communicating artery (P2—P4 segments). Aneurysms on the internal carotid artery (petrous, cavernous, clinoidal, and supraclinoidal segments) were considered proximal and excluded, as were aneurysms on the M1 and A1 segments and the basilar artery bifurcation. Basilar artery bifurcation aneurysms were considered proximal aneurysms of the PCA. Among the cerebellar arteries, distal aneurysms were defined as distal to the vertebral or basilar arteries, on the superior cerebellar artery (SCA; s2—s4 segments), on the anterior inferior cerebellar artery (AICA; a2—a4 segments), or on the PICA (p2—p4 segments). Vertebral artery aneurysms and basilar trunk aneurysms were considered proximal and excluded.

Table 1. Summary of Proximal and Distal Aneurysms

	Total	Proximal		Distal	
	Number	Number	%	Number	%
Cerebral artery aneurysms					
MCA	649	626	96.5	23	3.5
ACA	547	486	88.8	61	11.2
PCA	333	317	95.2	16	4.8
Total	1529	1429	93.5	100	6.5
Cerebellar artery aneurysms					
SCA	46	44	95.7	2	4.3
AICA	11	2	18.2	9	81.8
PICA	83	54	65.1	29	34.9
Total	140	100	71.4	40	28.6

MCA, middle cerebral artery; ACA, anterior cerebral artery; PCA, posterior cerebral artery; SCA, superior cerebellar artery; AICA, anterior inferior cerebellar artery; PICA, posterior inferior cerebellar artery.

Patients

The study was approved by the Institutional Review Board and conducted in compliance with Health Insurance Portability and Accountability Act regulations. The prospectively maintained database for the Vascular Neurosurgery Service was searched for patients with distal intracranial aneurysms. Medical records, radiographic studies, operative reports, intraoperative photographs, neurologic course, and clinical follow-up evaluations were reviewed.

RESULTS

Predilection of Distal Aneurysms for Cerebellar Arteries

During a 13-year period, 2789 aneurysms were treated microsurgically by the senior author (M.T.L.). Of these aneurysms, 1529 were associated with MCA, ACA, or PCA vessels, of which 1429 (93.5%) were proximal and 100 (6.5%) were distal (Table 1). The ACA had the highest percentage of distal aneurysms (11.2%; $P < 0.01$), and distal ACA/pericallosal aneurysms were the most common distal aneurysms on cerebral arteries ($n = 61$).

Table 2. Segmental Anatomy of Distal Intracranial Aneurysms

Cerebral Arteries			Cerebellar Arteries		
	Distal Aneurysms			Distal Aneurysms	
	Number	%		Number	%
Middle cerebral artery			Superior cerebellar artery		
M1	0	0	s1	0	0
M2	14	61	s2	1	50
M3	6	26	s3	1	50
M4	3	13	s4	0	0
Anterior cerebral artery			Anterior inferior cerebellar artery		
A1	0	0	a1	0	0
A2	12	20	a2	5	56
A3	40	66	a3	2	22
A4	7	11	a4	2	22
A5	2	3			
Posterior cerebral artery			Posterior inferior cerebellar artery		
P1	0	0	p1	0	0
P2	13	81	p2	11	38
P3	3	19	p3	10	34
P4	0	0	p4	7	24
			p5	1	3
Total	100		Total	40	