# Surgical Resection of Cavernous Malformations of the Brainstem: Evolution of a Minimally Invasive Technique

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**Key words**
- Brainstem
- Cavernoma
- Cavernous malformation
- Skull base

**Abbreviations and Acronyms**
**CMB**: Cavernous malformation of the brainstem
**Gd**: Gadolinium
**mRS**: Modified Rankin scale
**MR**: Magnetic resonance

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*Citation: World Neurosurg. (2013) 79, 5/6:691-703. http://dx.doi.org/10.1016/j.wneu.2012.04.030*

*Supplementary digital content available online.*

*Journal homepage: **www.WORLDNEUROSURGERY.org***

*Available online: **www.sciencedirect.com***



OBJECTIVE: **The purpose of this study is to provide an institutional retrospective review of surgically treated brainstem cavernous malformations.**

METHODS: **Between 2005 and 2010, 22 consecutive patients with brainstem cavernous malformations (15 female and 7 male) with a mean age of 43 years underwent surgical treatment. Mean volume of the resected cavernous malformations was 0.65 $cm^3$. A minimally invasive resection technique was used for these cases, in conjunction with skull base approaches.**

RESULTS: **The mean follow-up period was 26.6 months (range, 4-68 months). Of the 22 patients, 9% did not have clear evidence of hemorrhage at the time of presentation. Of the remainder, 22% had two or more instances of hemorrhage documented by magnetic resonance imaging. After resection and during follow-up, 54% of patients had an improvement in their modified Rankin scale, whereas 14% were worse compared with their preoperative presentation; 32% were unchanged and 9% of patients were found to have residual cavernoma post-surgery.**

CONCLUSION: **Our longitudinal experience has guided us to emphasize minimally invasive approaches during resection of the brainstem cavernous malformations, occasionally at the expense of achieving a complete resection, to improve patient outcomes.**

## INTRODUCTION

Cavernous malformations (cavernomas) have an estimated prevalence of approximately 0.4% to 0.8% in the population (4, 25, 29, 37, 38, 40, 43), with approximately 40% discovered incidentally (28). Prospective observation has indicated an overall symptomatic rate of hemorrhage of 0.22% to 0.7% per year for these lesions (15, 26, 37). Nevertheless, data from cavernous malformations situated in the brainstem suggest a markedly greater propensity for bleeding. In retrospective analyses of patients with such lesions, a calculated annual average symptomatic hemorrhage rate of 2.7% to 5% and re-hemorrhage rate of 21% to 60% per year and per lesion was discovered (1, 14, 23, 25, 27, 33). In accordance with their location, hemorrhages of brainstem cavernous malformations carried with them a high level of morbidity and mortality (14, 23).

Given the significant risk of death and disability presented by expectant management of cavernous malformations of the brainstem (CMBs), surgical resection has been increasingly advocated for therapy (2, 13, 14, 16, 33, 39, 42). Over this timeframe, imaging technologies have significantly improved (5, 10-12, 43), and surgical techniques have been refined for approaching lesions of the brainstem (6, 13, 14, 24, 25, 32, 35, 39, 42). Here, we report our case series of 22 surgically treated brainstem cavernomas, their presentation, and outcomes, as well as describe the general principles guiding surgical resection.

## PATIENTS AND METHODS

From 2005 to 2010, 22 consecutive patients underwent 27 procedures for resections of brainstem cavernous malformations. Of these patients, 7 were men and 15 women, with a mean age of 43 years (SD 15 years; range, 8-69 years). Patients were drawn from Harborview Medical Center at the University of Washington in Seattle. Patient records were retrospectively reviewed, including outpatient, clinical, and surgical records and radiologic imaging.

Diagnostic workup for all patients included magnetic resonance (MR) studies, usually with computed tomography scans at the time of initial presentation as well as

**Table 1.** Deficits at Time of Presentation

| Deficit | % |
|---|---|
| CN deficit | 77 |
| Ataxia | 59 |
| Headache | 55 |
| Diplopia | 41 |
| Weakness | 27 |
| Sensory changes | 27 |
| Vertigo or dizziness | 23 |
| Dysphagia | 14 |

CN, cranial nerve.

**Table 2.** Surgical Approaches to Brain Stem Cavernous Malformations

| Sex | Age | Location | Approach | Volume, $cm^3$ | Depth | Entry Corridor | Intraoperative Neurophysiology | Preoperative Symptoms | Postoperative Symptoms | Follow-up | Pre mRS | Post mRS | Recurrence? |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| F | 23 | Mesencephalothalamic | Orbitozygomatic | 1.2 | At pial surface | Lateral midbrain | SEPs, MEPs, BAEPs unchanged | Left hemiparesis, left hyperreflexia. | Left hemiparesis, with improvement. | 20 | 4 | 2 | No |
| F | 50 | Mesencephalic | Lateral supracerebellar | 0.05 | Just beneath pial surface | Dorsal lateral midbrain | SEPs, MEPs, BAEPs unchanged | Headache, ataxia, diplopia. | Headaches persistent. Diplopia on extreme lateral gaze without functional impairment. | 32 | 2 | 1 | No |
| M | 58 | Mesencephalic | Lateral supracerebellar | 1.1 | At pial surface | Lateral midbrain | SEPs, MEPs, BAEPs unchanged | Multiple hemorrhages in past with rebleed and worsening of diplopia, gait ataxia, and right hemibody numbness. | Diplopia resolved. Right hemibody numbness slightly worse than pre-op, now stable. No impairment in work. | 25 | 2 | 1 | No |
| M | 8 | Mesencephalic | Occipital transtentorial | 0.08 | At pial surface | Tectal plate; inferior to superior colliculus | SEPs, MEPs, BAEPs unchanged | Vertigo, diplopia, headaches, nausea, emesis, 'syncopal' events. | Diplopia resolved, minor headaches. | 12 | 1 | 0 | No |
| F | 60 | Mesencephalic | Transpetrosal | 1.3 | Just beneath pial surface | Lateral midbrain | Left tibial and left median nerve SSEP responses showed a marked decline. No change in MEPs or BAEPs. | Somnolence, gait ataxia, left arm weakness and left hemibody numbness. | Postoperative hydrocephalus requiring shunt placement. Aspiration pneumonia. Persistent left hemiparesis; able to ambulate with assistance. Requiring nursing home care. | 4 | 4 | 4 | No |
| M | 37 | Mesencephalic | Orbitozygomatic | 0.2 | Beneath the pial surface | Medial crus cerebri | SEPs, MEPs, BAEPs unchanged | Mild left limb numbness. Partial right CN III and CN VI palsy. | Post-operative wound infection. Right ptosis and diplopia improved on follow-up. | 11 | 1 | 1 | No |
| F | 60 | Mesencephalic | Orbitozygomatic | 0.85 | 5 mm | Anterolateral midbrain | SEPs, MEPs, BAEPs unchanged | Diplopia, gait ataxia, headache, right hemiparesis. | Right hemiparesis improved, diplopia resolved. | 21 | 2 | 2 | No |
| M | 57 | Mesencephalic | Orbitozygomatic | 0.48 | At pial surface | Anterolateral midbrain | Right MEPs transiently decreased. SEPs and BAEPs unchanged. | Headache, dizziness, impaired tandem gait. | Post-operative jaw malocclusion, managed conservatively. | 22 | 2 | 1 | No |
| F | 38 | Mesencephalic | Orbitozygomatic | 1.3 | At pial surface | Anterolateral midbrain | SEPs, MEPs, BAEPs unchanged | Severe headache, tremors, dysphagia. | Mild right CN VI palsy. Tremor and dysphagia resolved. | 24 | 1 | 1 | No |