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Clinical Study

Brainstem cavernous malformations resected via miniature craniotomies: Technique and approach selection

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ABSTRACT

Brainstem cavernous malformations can cause devastating neurologic disability when they hemorrhage, which occurs at a higher rate in the brainstem than in other locations. Traditional access to these lesions requires a large craniotomy with extensive exposure and manipulation of vital structures. We present a case series of patients who underwent surgical resection of brainstem cavernous malformations using minimally invasive approaches at our institution from January 2012 to August 2014, all of whom had experienced at least one hemorrhage prior to presentation. Approach choice was determined by location of the cavernous malformation in relation to the brainstem surface. Resection occurred through our described standardized method. Postoperatively, there were three instances of transient neurologic symptoms, all of which resolved at time of last follow-up. All eight patients experienced neurologic improvement after surgery, with four patients showing no deficits at last follow-up. Approach selection rationale and technical nuances are presented on a case-by-case basis. With carefully planned keyhole approaches to cavernous malformations presenting to the brainstem surface, excellent results may be achieved without the necessity of larger conventional craniotomies. We believe the nuances presented may be of use to others in the surgical treatment of these lesions.

1. Introduction

Cavernous malformations have a natural history that is incompletely understood. Although supratentorial cavernous malformations appear to have low rates of symptomatic hemorrhages, clinically significant hemorrhages occur at a higher rate from cavernous malformations located in the brainstem [1,2]. Hemorrhage of a brainstem cavernous malformation (BSCM) is generally a poorly tolerated event, with significant risk of neurologic morbidity and mortality.

A number of management strategies have been proposed for these challenging patients [3,4]. We would propose that, given annual rehemorrhage rates from 5.1% to as high as 60.9% demonstrated in previous series and the decreased potential for improvement with each consecutive event, continued observation after a clinically significant hemorrhage seems unwise [1,2,5–7]. One strategy proposed to deal with these lesions is stereotactic radiosurgery, but this does not remove the lesion nor totally eliminate its potential to bleed [8,9]. Thus, despite the challenges of operating in the brainstem, surgery provides the only realistic possibility of a cure.

Recently, a variety of surgical techniques utilized to access and completely remove these lesions have been described. At the time of writing, most previous series of surgically treated BSCM have utilized traditional large craniotomies [1,9–12]. Our contention is that, because the brainstem is a deep structure, excellent access to a wide working angle can be achieved with well-placed mini craniotomies. We would argue that bigger craniotomies do not add more relevant working room at the target, but do unnecessarily expose uninvolved brain [13,14]. In this series we present our preliminary results of surgical resection of BSCM using minimally invasive craniotomies.

2. Methods

Patients with cavernous malformations treated surgically by the senior author from January 2012 to August 2014 were prospectively entered into a departmental database. We offered surgery to all patients with a BSCM that presented to the surface. Clinical and imaging records were reviewed and data collected. Extent of resection was determined by the operating neurosurgeon and a neuroradiologist. Neurologic outcomes were assessed immediately

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postoperatively and at 6 week follow-up by two neurosurgeons. This study was performed following all local institutional guidelines for human research.

2.1. Standard technique for removing BSCM

The specific approaches for accessing each BSCM are described in detail below. In short, we selected approaches that provided access along the long axis of the lesion, entering the lesion where the cavernous malformation presented closest to the surface of the brainstem. After accessing the BSCM, the technique for resection was standardized. We first bluntly enter the lesion with small fine tip bipolar forceps to evacuate blood and decompress the lesion. The lesion is then gently dissected away from the cavity, using suction and a Rhoton #1 microdissector, and delivered *en bloc*. At no point is cautery used to obtain hemostasis, as this is performed using Surgicel Nu-Knit (Ethicon for Johnson & Johnson Medical, Piscataway, NJ, USA). We approach all cavernous malformations with a goal of gross-total resection and focus our efforts towards staying entirely within the lesion.

3. Results

A total of nine patients with BSCM presented to our center in this time frame. One patient had a cavernous malformation in the middle of the pons with no clear safe entry plane into the lesion, and this patient was offered radiosurgery. The other eight patients were offered surgical resection via minimally invasive craniotomies as a first-line therapy, all of which were performed by the senior author. Patient data is presented in Table 1. The median age of the cohort was 44 years (range, 18–59 years); there were three women and five men. Four patients had midbrain lesions, two had pontine lesions, and two had medullary lesions. All patients presented to us for evaluation after having at least one hemorrhagic event. Symptoms varied based on the specific location of the lesion. Approach selection was similarly based on the precise anatomical characterization of the lesion.

All patients received a gross-total resection. There were two instances of transient incomplete cranial nerve palsies, and one patient experienced transient ataxia; all three patients saw complete resolution of these symptoms at last follow-up. There were no other perioperative complications. At last follow-up, four patients were completely neurologically normal, one had functional improvement from their preoperative status, and one patient who presented in a coma was awake and partially improved at last follow-up. Two patients had stable deficits.

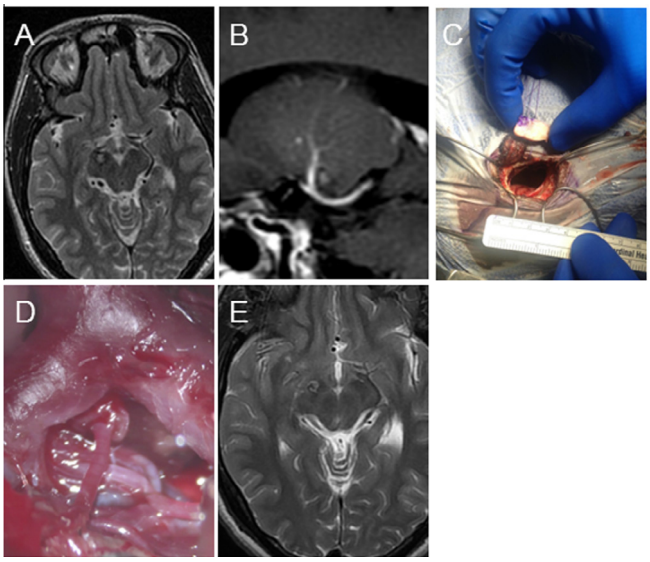

Fig. 1. Patient 1: Eyebrow approach. Preoperative axial T2-weighted (A) and sagittal post-gadolinium T1-weighted (B) MRI demonstrates a cavernous malformation in the right cerebral peduncle presenting to the surface anteriorly. Eyebrow craniotomy (C). Given the height of the lesion, the best corridor is through the supracarotid triangle (D). Follow-up T2-weighted axial MRI demonstrates complete resection (E). (This figure is available in colour at http://www.sciencedirect.com/).

3.1. Patient 1: Cerebral peduncle cavernous malformation resected via eyebrow craniotomy

The eyebrow approach was chosen for this cavernous malformation of the cerebral peduncle (Fig. 1A, B) because it gave an excellent anterior to posterior approach medial to the temporal lobe and uncus. Along this axis, its working angles are similar to that achieved by the larger cranio-orbital approach.

After performing a supraorbital craniotomy (Fig. 1C), we take care to drill the orbital groove flat. Once we have opened the dura, the frontal lobe is gently retracted after allowing for cerebrospinal fluid (CSF) relaxation via the opening of the optico-carotid cisterns. The key to providing good working access to the anterior midbrain is extensive arachnoidal dissection. This involves

Table 1
Patient demographics and clinical characteristics

Patient	Age/Sex	Presentation	Location	Approach	Previous bleeds	EOR	Complications	Outcome
1	30/M	Incidental finding	Cerebral peduncle	Eyebrow	1	GTR	Transient mild hemiparesis	No neurologic deficits
2	18/F	Hemiparesis	Lateral midbrain	Posterior subtemporal	2	GTR	Transient fourth nerve palsy	Resolved hemiparesis
3	48/M	Dysarthria, weakness (wheelchair bound)	Posterolateral midbrain and pons	Lateral supracerebellar	3	GTR	None	Improved weakness, able to walk
4	59/M	Coma	Tectum	Midline supracerebellar	1	GTR	None	Marginally improved (awake)
5	30/F	Hemiparesthesia	Posterolateral pons, fourth ventricle	Suboccipital – telovelar	1	GTR	Transient ataxia	Stable hemiparesthesia
6	56/M	Ataxia, nausea, vomiting	Posterolateral pons, fourth ventricle	Suboccipital – telovelar	2	GTR	Transient sixth nerve palsy	Symptom resolution
7	56/M	Horner syndrome	Posterolateral medulla	Suboccipital – telovelar	1	GTR	None	Stable Horner syndrome
8	40/F	Hemiparesis, hemiparesthesia, dysphagia	Obex	Limited suboccipital	3	GTR	None	Symptom resolution

EOR = extent of resection, F = female, GTR = gross-total resection, M = male.