

Feasibility, Safety, and Outcomes of the Endoscopic Endonasal Transclival Approach for Ventral Brainstem Cavernous Malformations: A Systematic Review

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- **Brainstem cavernous malformations (CMs)** are rare vascular lesions associated with a high risk of hemorrhage, neurological deterioration, and substantial morbidity, particularly when located in the ventral midline brainstem.
- **Microsurgical management remains the primary treatment option** but is technically demanding due to the dense concentration of critical nuclei and fiber tracts, as well as the limited availability of safe entry zones.
- **The endoscopic endonasal transclival approach (EETA)** provides a direct midline corridor to ventral brainstem CMs, avoiding cerebellar retraction and minimizing manipulation of lateral neurovascular structures.
- This systematic review included **18 studies (15 clinical and 3 cadaveric)**, encompassing 20 patients with ventral midline brainstem CMs treated via EETA.
- Most lesions were located in the **ventromedial pons (90%)**, and a significant proportion of patients had a history of prior hemorrhage (60%), often with multiple bleeding episodes.
- **Gross total resection (GTR) was achieved in 90%** of patients, demonstrating a high rate of anatomical success with this approach.
- Long-term neurological outcomes were favorable, **with 85% of patients showing clinical improvement** at follow-up and the majority experiencing resolution or marked reduction of preoperative deficits.
- **The most frequent complication was postoperative CSF leakage (20%)**, underscoring the critical role of multilayer skull base reconstruction and vascularized nasoseptal flaps.
- Other neurological complications were generally transient, including cranial nerve deficits and motor worsening, with **no perioperative mortality reported**.
- Anatomical studies confirmed **that safe application of EETA depends on strict midline lesion localization, pial surface contact, and favorable sphenoid sinus pneumatization**.
- With careful patient selection, advanced surgical expertise, and robust reconstruction strategies, **EETA represents a feasible and anatomically logical alternative for ventral midline brainstem CMs**.

BACKGROUND & AIM

Cerebral cavernous malformations (CMs) are vascular lesions prone to recurrent microhemorrhages and occur in approximately 0.5% of the population. Brainstem CMs represent a particularly critical subgroup due to the compact anatomy of vital nuclei and fiber tracts, as well as the limited availability of safe entry zones. Although they constitute a minority of intracranial CMs, brainstem lesions carry a disproportionately high risk of hemorrhage, neurological deterioration, and surgical morbidity.

Ventral midline brainstem CMs, especially those involving the anterior pons and medulla, are among the most surgically challenging lesions. Conventional transcranial approaches often require extensive bone removal and manipulation of the brainstem or neurovascular structures. The endoscopic endonasal transclival approach (EETA) has emerged as a minimally invasive alternative that provides a direct midline corridor to the ventral brainstem while avoiding cerebellar retraction and lateral neurovascular displacement. Despite these theoretical advantages, clinical experience with EETA in this setting remains limited, and anatomical variability continues to pose challenges. This study aims to evaluate all published cases of ventral midline brainstem CMs treated via EETA, focusing on surgical techniques, postoperative complications, and functional outcomes.

METHODS

A systematic literature review was conducted in accordance with PRISMA 2020 guidelines and registered in PROSPERO (ID: CRD420251137070). Four databases (PubMed/MEDLINE, Web of Science, Scopus, and Cochrane) were searched from inception to October 29, 2025, using MeSH terms and Boolean operators related to “Endoscopic Endonasal Transclival Approach” and “Brainstem Cavernous Malformations.” Reference lists were also manually screened.

Eligible studies included patients with ventral midline brainstem CMs treated via EETA. Clinical studies (RCTs, cohorts, case series, and case reports) and relevant cadaveric studies were included. Reviews, editorials, conference abstracts without full text, animal/in vitro studies, transoral approaches, laterally located lesions, expanded approaches, and non-CM pathologies were excluded.

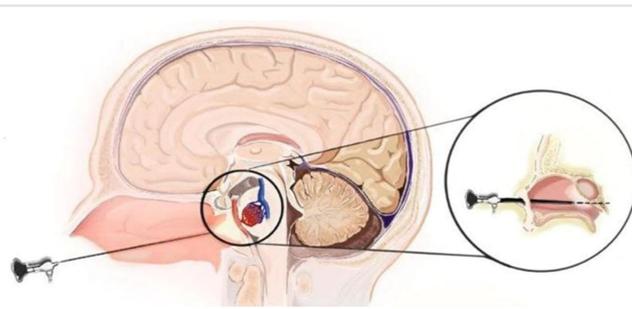


Figure 1: Schematic Illustration of Endoscopic Endonasal Transclival Technique for approaching a ventral brainstem cavernous malformation

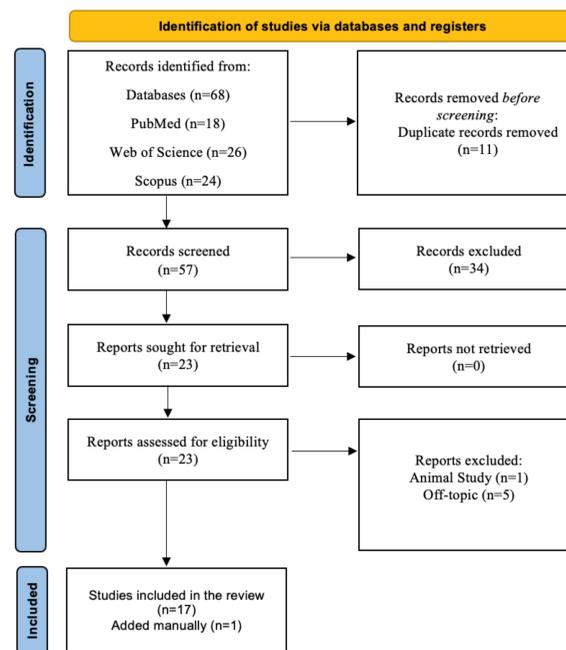


Figure 2: The PRISMA flow diagram summarizes the selection of 18 studies for inclusion from 68 identified records after screening and eligibility assessment

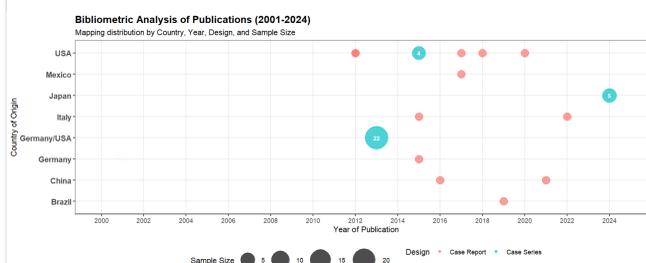


Figure 3: Bibliometric Analysis of the included studies

RESULTS

A total of 18 studies (15 clinical and 3 cadaveric) met inclusion criteria, encompassing 20 patients with ventral midline brainstem CMs treated via EETA. The median age was 31 years (range 14–69), with female predominance (70%). Most lesions were located in the ventromedial pons (90%), with fewer cases in the midbrain and medulla. Cranial nerve deficits were highly prevalent (85%), and motor weakness was observed in 70% of patients. Diplopia, facial numbness, dysphagia, and abducens palsy were among the most common cranial nerve-related findings. A prior hemorrhage was documented in 60% of patients, frequently with multiple bleeding episodes, and conservative management had been attempted in 60% before surgery. Gross total resection was achieved in 90% of cases. At follow-up (1 month–6 years), 85% of patients demonstrated neurological improvement, 10% remained stable, and one patient experienced a transient postoperative deficit that subsequently resolved. The most frequent complication was postoperative CSF leakage (20%), often requiring revision reconstruction and lumbar drainage. Other neurological complications, including cranial nerve deficits and motor worsening, were generally transient, and no perioperative mortality was reported. Anatomical and radiological studies supported the feasibility of EETA, indicating that safe application depends on strict midline lesion localization, proximity to the pial surface, and favorable sphenoid sinus pneumatization.

CONCLUSIONS

EETA is an emerging option for ventral midline brainstem CMs. By providing a direct midline corridor and reducing the need for brainstem retraction and extensive neurovascular manipulation, it adheres to modern minimally invasive principles. In carefully selected patients, particularly those with midline, ventrally exophytic lesions and favorable sphenoid sinus anatomy, it can achieve high resection rates with favorable neurological outcomes. These advantages, however, must be balanced against the technical demands of skull base reconstruction and the risk of postoperative CSF leakage, which remains the most relevant complication. With continued refinement of reconstruction strategies and increasing institutional experience, EETA may play a growing role as a surgical alternative for this challenging subset of brainstem lesions.

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