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Original Article

Histopathologic Spectrum of Cerebellopontine Angle Tumors with Cytological Correlation at a Tertiary Care Hospital

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ABSTRACT

Background: Cerebellopontine angle [CPA] tumors comprise a relatively narrow but clinically important group of posterior fossa lesions in which accurate intraoperative characterization helps guide surgical management. Histopathology remains the diagnostic standard, while squash smear cytology offers rapid provisional assessment.
Objectives: To evaluate the histopathologic spectrum of CPA tumors at a tertiary care teaching hospital and to correlate intraoperative squash smear cytology with final histopathological diagnosis.
Methods: This hospital-based observational study was conducted in the Department of Pathology, Osmania Medical College and its attached tertiary care teaching hospital. Fifty-two surgically sampled CPA lesions with both squash smear cytology and histopathology were analyzed. Immunohistochemistry using S100 and epithelial membrane antigen [EMA] was performed in doubtful cases.
Results: Females constituted 55.8% of cases, and the peak age group was 31-40 years [36.5%]. Schwannoma was the commonest lesion [71.2%], followed by meningioma [23.1%], hemangioblastoma [3.8%], and epidermoid cyst [1.9%]. Headache was the most frequent presenting symptom [65.4%]. Cytology-histopathology concordance was observed in 50 of 52 cases [96.2%]. Two histopathologically proven meningiomas were initially interpreted as schwannoma on squash smear cytology and were resolved on histopathology with immunohistochemical support where required.
Conclusion: Schwannoma constituted the dominant CPA tumor in this series, with meningioma as the next most frequent lesion. Intraoperative squash smear cytology showed high overall concordance with final histopathology and served as a valuable rapid diagnostic adjunct. Histopathology, supplemented by targeted immunohistochemistry in selected cases, remains essential for definitive diagnosis and for resolving morphologic overlap between meningioma and schwannoma.

Keywords: *Cerebellopontine angle; Squash smear cytology; Histopathology; Schwannoma; Meningioma; Intraoperative diagnosis.*

INTRODUCTION

The cerebellopontine angle [CPA] is a compact and anatomically complex region of the posterior fossa bounded by the petrous temporal bone, cerebellum, pons, and lower cranial neurovascular structures. Although the overall frequency of CPA tumors is low when compared with supratentorial neoplasms, these lesions are of major clinical relevance because even small masses in this location can produce cranial nerve dysfunction, cerebellar signs, brainstem compression, and

obstructive symptoms [1,2]. From a practical standpoint, the CPA is also a diagnostically distinctive compartment, as a limited number of tumor categories account for the majority of lesions, while a long tail of uncommon tumors and cystic lesions remains important in differential diagnosis [3-5].

Vestibular schwannoma is consistently reported as the commonest adult CPA tumor, constituting roughly 70%-80% of lesions in most large series, with meningioma ranking second and epidermoid cyst representing another important recognized entity [6-10]. Patients typically present with hearing impairment, tinnitus, imbalance, headache, facial sensory symptoms, or cerebellar complaints, depending on tumor size, direction of growth, and cranial nerve involvement [6-10]. Radiologic evaluation, particularly magnetic resonance imaging, has transformed preoperative localization and characterization of CPA masses; however, substantial imaging overlap persists among extra-axial lesions, especially when uncommon tumors, cystic lesions, or atypical growth patterns are encountered [5].

Beyond schwannoma and meningioma, the literature documents a broader CPA spectrum that includes epidermoid cyst, arachnoid cyst, lipoma, dermoid cyst, non-vestibular cranial nerve schwannomas, paraganglioma, metastatic deposits, melanocytoma, endolymphatic sac tumor, chondromatous lesions, chordoma, and rare hypervascular tumors such as hemangioblastoma [11]. Recognition of this diversity is important because management strategies, operative risks, and prognostic implications differ across lesions. Hypervascular masses, for example, can present significant intraoperative challenges, whereas cystic congenital lesions often require a different diagnostic and therapeutic perspective [9-11].

While radiology suggests the likely compartment and nature of the lesion, final diagnosis still depends on tissue examination. Intraoperative squash smear cytology is a rapid, economical, and technically simple adjunct in neurosurgical pathology, especially in centers where frozen section is limited or not routinely used. Previous studies have shown high diagnostic usefulness of squash cytology in central nervous system lesions, although interpretative pitfalls remain in tumors with overlapping spindle-cell, syncytial, or whorling morphology [12-14]. Such overlap is particularly relevant in the differential diagnosis of schwannoma and meningioma in the CPA. Against this background, the present study was undertaken to evaluate the histopathologic spectrum of CPA tumors at our institution and to correlate intraoperative squash smear cytology with final histopathological diagnosis. The objectives were to describe the clinicopathological profile of CPA tumors, determine the distribution of histological types, and assess the concordance and discordance between cytological and histopathological diagnoses.

MATERIALS AND METHODS

Study design and setting. This was a hospital-based observational study conducted in the Department of Pathology, Osmania Medical College and its attached tertiary care teaching hospital. The study was designed to evaluate the histopathologic spectrum of cerebellopontine angle [CPA] tumors and to assess the diagnostic concordance between intraoperative squash smear cytology and final histopathological examination. In keeping with established neurosurgical pathology practice, squash smear cytology was used as a rapid intraoperative diagnostic adjunct for central nervous system lesions [12-14].

Study population. All consecutive surgically sampled CPA lesions received during the study period and accompanied by both intraoperative cytology and subsequent histopathology were considered for analysis. A total of 52 cases fulfilled the study criteria. Relevant clinicopathological information, including age, sex, laterality, recurrence status, and presenting complaints, was retrieved from pathology records, requisition forms, and available case files.

Inclusion and exclusion criteria. Included cases were those arising in the CPA region for which adequate tissue was available for squash smear preparation and final histopathological examination. Cases with grossly inadequate smear material, autolyzed tissue, or incomplete histopathological records were excluded from analysis.

Intraoperative cytological evaluation. In all cases, squash smear cytology was performed first on fresh unfixed tissue received intraoperatively. A small representative fragment of the lesion was gently compressed between two clean glass slides to obtain thin smears. The smears were immediately fixed as appropriate and stained by toluidine blue as well as haematoxylin and eosin, a provisional cytological diagnosis was rendered and communicated intraoperatively.

Histopathological examination. After preparation of squash smears, the remaining tissue specimen was submitted for routine histopathological processing. Tissues were fixed in 10% neutral buffered formalin, processed through graded alcohols and paraffin embedding, sectioned at appropriate thickness, and stained with hematoxylin and eosin. The final diagnosis was established on detailed microscopic examination of paraffin sections.

Immunohistochemistry. Immunohistochemistry was performed in morphologically doubtful cases, particularly when distinction between schwannoma and meningioma was difficult on cytology and routine histopathology. The antibodies used were S100 and epithelial membrane antigen [EMA].

Cytology-histopathology correlation and analysis. The provisional squash smear diagnosis was compared with the final histopathological diagnosis in each case. Cases were categorized as concordant or discordant, and discordant diagnoses were reviewed for the nature of interpretative overlap. The collected data were entered into a structured proforma and analyzed descriptively. Categorical variables were expressed as frequencies and percentages.

Ethical considerations. The study was performed in accordance with institutional policy for record-based academic analysis. Patient identifiers were anonymized throughout data compilation and interpretation to maintain confidentiality.

RESULTS

A total of 52 cerebellopontine angle [CPA] tumors were evaluated in the present study. Females constituted 29 cases [55.8%], whereas males accounted for 23 cases [44.2%]. The largest proportion of patients belonged to the 31-40-year age group [36.5%], followed by the 41-50-year group [26.9%]. Left-sided lesions were observed in 26 cases [50.0%], right-sided lesions in 25 cases [48.1%], and bilateral involvement in 1 case [1.9%]. Recurrent tumors constituted 14 cases [26.9%], while 38 cases [73.1%] represented primary lesions [Table 1].

Table 1. Demographic and clinicopathological characteristics of the study population [N = 52]

Variable	Category	n [%]
Age group [years]	10-20	1 [1.9]
	21-30	8 [15.4]
	31-40	19 [36.5]
	41-50	14 [26.9]
	51-60	7 [13.5]
	61-70	2 [3.8]
	71-80	1 [1.9]
Sex	Male	23 [44.2]
	Female	29 [55.8]
Laterality	Left	26 [50.0]
	Right	25 [48.1]
	Bilateral	1 [1.9]
Recurrence status	Primary	38 [73.1]
	Recurrent	14 [26.9]

On final histopathological examination, schwannoma was the most frequent lesion and accounted for 37 of 52 tumors [71.2%]. Meningioma was the second most common diagnosis, seen in 12 cases [23.1%]. Hemangioblastoma was identified in 2 cases [3.8%], and epidermoid cyst in 1 case [1.9%]. Thus, the institutional histopathologic spectrum in the present series was limited to schwannoma, meningioma, hemangioblastoma, and epidermoid cyst [Table 2].

Table 2. Histopathologic spectrum of CPA tumors [N = 52]

Histopathological diagnosis	n [%]
Schwannoma	37 [71.2]
Meningioma	12 [23.1]
Hemangioblastoma	2 [3.8]
Epidermoid cyst	1 [1.9]

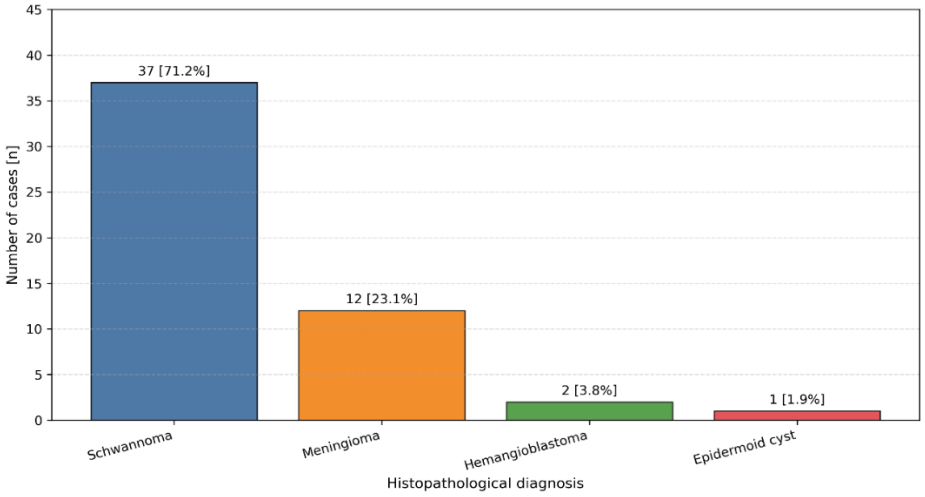

Figure 1: Histopathologic Spectrum of CPA Tumors

Headache was the most common presenting symptom and was recorded in 34 patients [65.4%]. Reduced hearing as the primary complaint was noted in 11 cases [21.2%], while 7 patients [13.5%] presented with both headache and reduced hearing. Additional associated symptoms included cerebellar manifestations in 11 cases [21.2%] and tinnitus in 2 cases [3.8%] [Table 3].

Table 3. Clinical presentation of the study population [N = 52]

Variable	Category	n [%]
Primary presenting symptom	Headache	34 [65.4]
	Reduced hearing	11 [21.2]
	Headache with reduced hearing	7 [13.5]
Additional associated symptoms	Cerebellar symptoms	11 [21.2]
	Tinnitus	2 [3.8]

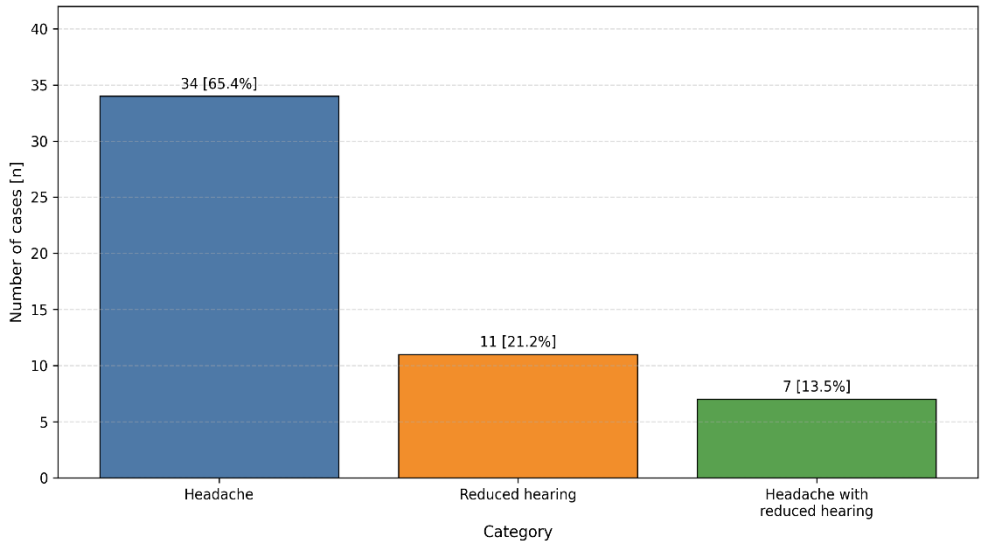

Figure 2: Clinical Presentation of the Study Population, Primary Presenting Symptom

Cytohistological correlation showed high overall agreement between intraoperative squash smear cytology and final histopathology. Thirty-seven cases diagnosed as schwannoma on cytology were confirmed on histopathology, and all 10 cytologically diagnosed meningiomas were concordant. However, 2 of the 12 histopathologically proven meningiomas had initially been interpreted as schwannoma on squash smear cytology. The single epidermoid cyst and both hemangioblastomas were correctly identified on cytology. Overall concordance was observed in 50 of 52 cases [96.2%], whereas discordance was present in 2 cases [3.8%] [Tables 4 and 5].

Table 4. Cytology-histopathology correlation of CPA tumors [N = 52]

Squash smear cytology diagnosis	Final histopathological diagnosis	n
Schwannoma	Schwannoma	37
Schwannoma	Meningioma	2
Meningioma	Meningioma	10
Epidermoid cyst	Epidermoid cyst	1
Hemangioblastoma	Hemangioblastoma	2

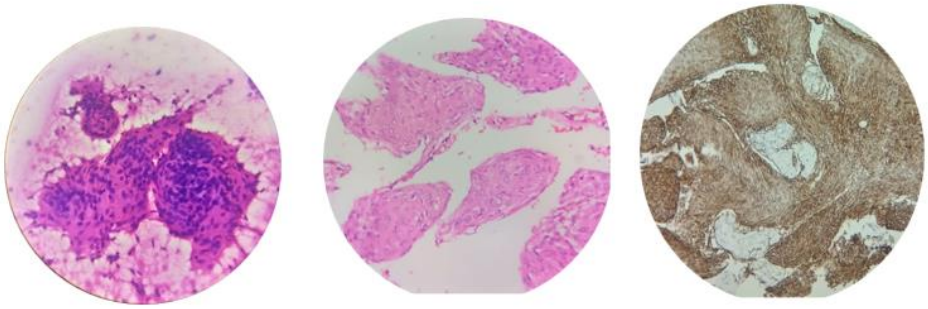

Fig3: Meningioma(A)cytology,(B)histopathology(C) EMA IHC showing cytoplasmic staining

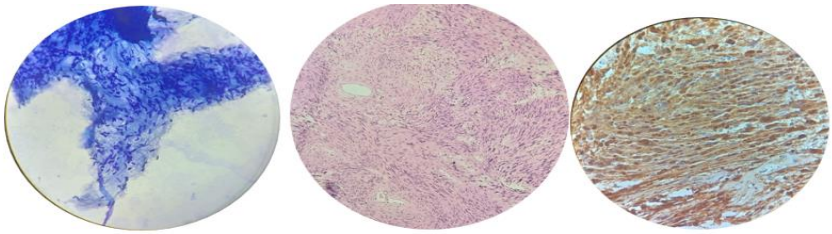

Fig4: Schwannoma(A)cytology showing spindle cells showing kinking of nuclei(B)histopathology showing characteristic hypo and hypercellular areas(C) S100 IHC showing diffuse nuclear and cytoplasmic staining.

Table 5. Overall concordance between squash smear cytology and histopathology [N = 52]

Parameter	n [%]
Concordant cases	50 [96.2]
Discordant cases	2 [3.8]

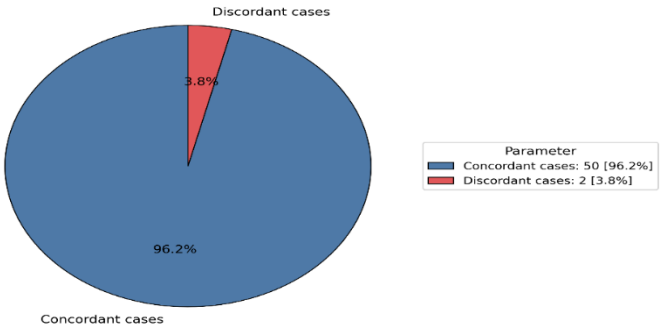

Figure 4: Overall concordance between squash smear cytology and histopathology

DISCUSSION

The present study showed that schwannoma was the predominant cerebellopontine angle [CPA] tumor, accounting for 71.2% of all lesions, followed by meningioma in 23.1%, whereas hemangioblastoma and epidermoid cyst were distinctly

uncommon. This distribution is in close agreement with the established literature, which consistently identifies vestibular schwannoma as the most frequent CPA lesion and meningioma as the second most common pathology in adults [6-8]. In most reported series, schwannomas constitute the large majority of CPA tumors, often representing nearly three-fourths or more of cases, while meningiomas form the next major group and epidermoid cysts and other rare lesions account for only a small residual fraction [6-8]. Therefore, the tumor profile observed in the present study appears representative of the expected pathological spectrum in a tertiary referral center, despite the relatively limited number of cases.

The age distribution in the current series showed a peak in the 31-40-year age group, and females marginally outnumbered males. This pattern is biologically plausible when interpreted in relation to the known epidemiology of individual CPA lesions. Vestibular schwannoma typically presents in early or middle adult life and often shows either an approximately balanced sex distribution or only a mild female predominance in some cohorts [6-8]. By contrast, meningioma is well known to occur more commonly in women, usually during middle age and later adult life, and this female preponderance has been repeatedly documented in both intracranial meningioma series and CPA-specific studies [6-8]. Epidermoid cysts, although rare, often become symptomatic in younger or middle-aged adults because they are congenital lesions that enlarge slowly over time before producing clinical manifestations [9-11]. Hemangioblastoma is also an uncommon CPA lesion and is generally seen in adults, often in the third to fifth decades, either as an isolated tumor or in association with syndromic disease [9-11]. Thus, the demographic pattern in the present study appears to reflect the predominance of schwannoma and the smaller but important contribution of meningioma within the case mix.

With regard to clinical presentation, headache was the leading symptom in our cohort, followed by reduced hearing, while mixed symptom complexes included cerebellar manifestations and tinnitus. This differs somewhat from the classic symptom profile described for vestibular schwannoma, in which unilateral sensorineural hearing loss, tinnitus, vertigo, and impaired balance are usually emphasized as the most common presenting features [9,10]. However, the findings in the present study remain clinically credible because CPA tumors produce symptoms not only through involvement of the vestibulocochlear nerve but also through compression of adjacent cranial nerves, cerebellar structures, and the posterior fossa compartment [9,10]. Schwannomas typically arise from the vestibular division of the eighth cranial nerve and therefore frequently manifest with auditory and vestibular symptoms, whereas meningiomas, because of their extra-axial dural origin, may produce a broader pressure-related symptom complex depending on tumor size and local extension [9,10]. Similarly, rare lesions such as epidermoid cyst and hemangioblastoma may present with headache, gait imbalance, or other posterior fossa symptoms once sufficient mass effect has developed [9-11]. The predominance of headache in our study may therefore reflect relatively late referral, larger lesion size at presentation, or symptomatic mass effect at the time of diagnosis rather than early incidental detection.

An important strength of the present study is the strong cytohistological correlation observed between intraoperative squash smear cytology and final histopathology. The overall concordance rate of 96.2% supports the utility of squash smear cytology as a rapid and dependable intraoperative diagnostic method in CPA and other central nervous system lesions, in keeping with previous studies that have reported high diagnostic accuracy for smear-based intraoperative assessment [12-14]. This is of practical significance because intraoperative cytology can assist the neurosurgical team in immediate lesion characterization and operative decision-making. In the present series, the only discordant cases were 2 meningiomas that were initially interpreted as schwannoma on squash cytology. This observation is important because both lesions can display spindle-cell morphology, variable cellular cohesion, and architecturally overlapping fragments on smear preparations .Fibrous variant of meningioma exhibits ,spindle-shaped cells arranged in fascicles or bundles ,these fibroblast like spindle cells can lead to a misdiagnosis as schwannoma. In such circumstances, permanent paraffin sections remain decisive, and selective immunohistochemistry is particularly helpful, with S100 favouring schwannoma and epithelial membrane antigen [EMA] supporting meningioma.

Although only four histopathological entities were encountered in this series, the differential diagnosis of CPA lesions is substantially wider. In addition to vestibular schwannoma and meningioma, the literature describes a broad range of uncommon masses in this region, including epidermoid cysts, arachnoid cysts, non-vestibular cranial nerve schwannomas, lipoma, dermoid cyst, paraganglioma, melanocytoma, metastasis, endolymphatic sac tumor, ependymoma, astrocytoma, medulloblastoma, and other skull-base lesions that may extend into or mimic the CPA [9-11]. These uncommon lesions differ in age of occurrence, biological behavior, and clinical presentation. Epidermoid cysts are slow-growing congenital lesions that may remain silent for years, whereas intra-axial tumors such as ependymoma or astrocytoma presenting in the CPA are distinctly unusual and may clinically simulate extra-axial masses [9-11]. Likewise, hypervascular lesions such as hemangioblastoma are rare but important considerations because they may pose distinctive radiological and operative challenges [9-11]. Awareness of this broader pathological spectrum is essential, particularly in tertiary centers, because unusual lesions can mimic the common CPA tumors clinically, radiologically, and even on intraoperative cytology.

Taken together, the findings of the present study reinforce the well-established dominance of schwannoma and meningioma within CPA pathology, while also highlighting the occasional presence of rare lesions such as hemangioblastoma and epidermoid cyst. The study further demonstrates that intraoperative squash smear cytology shows excellent concordance

with final histopathology and remains a valuable adjunct in the evaluation of CPA tumors. At the same time, the observed diagnostic overlap between schwannoma and meningioma emphasizes that accurate diagnosis in this region requires an integrated approach based on clinical findings, radiology, intraoperative cytology, final histomorphology, and selective immunohistochemistry. Thus, even though the institutional spectrum in the present series was limited, the study contributes meaningful clinicopathological data and places local observations within the broader context of the reported CPA literature [6-14].

Limitations

This was a single-center study with a modest sample size and a restricted histopathologic spectrum. Detailed radiologic subclassification, tumor size analysis, and long-term postoperative outcome assessment were not incorporated. Immunohistochemistry was applied selectively in doubtful cases rather than uniformly across all lesions. The small number of discordant cytology-histopathology pairs also limited lesion-specific comparative interpretation and reduced the breadth of inferential analysis.

CONCLUSION

In this institutional series of cerebellopontine angle tumors, schwannoma was the dominant lesion and meningioma was the second most frequent diagnosis, while epidermoid cyst and hemangioblastoma were rare. Intraoperative squash smear cytology showed high overall concordance with final histopathology and proved to be a dependable rapid diagnostic adjunct in the operative setting. The principal diagnostic pitfall involved misclassification of a small subset of meningiomas as schwannoma on cytology, emphasizing morphologic overlap between these lesions. Final histopathological examination, supported by focused immunohistochemistry in selected cases, remains essential for definitive diagnosis. Even with a limited institutional spectrum, awareness of the wider range of reported CPA lesions strengthens clinicopathological interpretation and academic value.

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