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TACKLING INTRACRANIAL EPIDERMOID CYST WITH EGGSHELL TECHNIQUE – A CASE SERIES AND TECHNICAL NOTE.

Neurosurgery

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ABSTRACT

Objectives: Epidermoid cysts, originating from residual ectodermal cells, are rare intracranial tumors commonly found in the 3rd to 5th decade of life. Due to the adherence of the tumor capsule to surrounding eloquent brain tissue, their surgical excision poses a challenge to the operating surgeon. Therefore, we introduce a surgical technique termed the eggshell technique. The primary objective is to assess immediate treatment outcomes and investigate clinical parameters such as recurrence risk and postoperative complications. **Materials And Methods:** This retrospective study includes 16 cases of central nervous system epidermoid cysts. Data were collected on demographic characteristics, clinical presentations, and anatomical distributions. The study introduces and describes the eggshell technique as an effective surgical approach. **Statistical Analysis:** Descriptive statistics were used to summarize demographic data, clinical presentations, anatomical distributions, and treatment outcomes. Measures of central tendency and dispersion were employed for continuous variables, while categorical variables were summarized using frequencies and percentages. **Results:** The study identified demographic trends, common clinical presentations, and anatomical distributions of intracranial epidermoid cysts. The eggshell technique was successfully implemented in all cases with positive immediate treatment outcomes. Rates of recurrence and postoperative complications were also evaluated. **Conclusions:** The study underscores the effectiveness and innovation of the eggshell technique for managing intracranial epidermoid cysts. The detailed description of this eggshell surgical technique fills a gap in the existing literature, providing valuable insights into surgical management strategies. Further follow-up and research are warranted to validate these findings and explore long-term outcomes and patient quality of life post-surgery.

KEYWORDS

Intracranial epidermoid cyst, Ectodermal cells, Eggshell technique, Tumor capsule, Recurrence.

INTRODUCTION:

Epidermoid cysts originate from residual ectodermal cell remnants during neural tube closure, typically between the third and fifth weeks of embryogenesis. These cysts exhibit slow growth and typically manifest in individuals aged between the third and fifth decades of life. Their rarity, with an estimated incidence of 0.5–1.8% among intracranial tumors, underscores their infrequency [1-4]. Despite being termed cysts, these tumors are solid and encased in a collagenous capsule. Due to their infiltrative nature, they can extend along CSF (cerebrospinal fluid)-filled spaces. Tumor expansion primarily results from proliferation of the stratified squamous epithelium lining the cyst cavity, leading to accumulation of acellular keratin debris and cholesterol inclusions [5-7].

Current research indicates that liquefaction of cyst contents is often associated with infection or reduced vascularity. Approximately 90% of intracranial epidermoid cysts are intradural, though extradural occurrences within the intradiploic space of various cranial bones have been documented. Common sites include the CP angle (cerebellopontine angle) (about 40% of cases), parasellar region (around 30%), and fourth ventricle (5–18% of cases), with less frequent occurrences in the middle cranial fossa, diploic space, or spinal canal. The initial site of epidermoid formation may vary, influenced by arachnoid compartments and structures. As these cysts enlarge, expansion is guided by surrounding arachnoid membranes and neurovascular elements, potentially extending into diverse subarachnoid compartments [5].

Despite their slow growth, these tumors often adhere to critical neurovascular structures, causing compression-related morbidity and neurological deficits [7,8]. Surgical excision is preferred due to the lack of effective chemotherapy or targeted therapy, requiring meticulous maneuvers to navigate cysts around vessels and nerves, reducing recurrence risks up to 93% associated with incomplete capsule removal [9].

This study investigates clinicopathological features, demographics, radiological details, surgical approach, complications, management, and recurrence risks in sixteen cases of central nervous system epidermoid cysts over three years.

MATERIALS AND METHODS:

An observational retrospective study was conducted at a tertiary care hospital's Department of Neurosurgery from 2021 to 2024, focusing on patients who underwent surgical resection for intracranial epidermoid cysts, with follow-up extending to one year postoperatively. Sixteen patients with histopathologically confirmed epidermoid cysts were included, with informed consent obtained from adult participants and guardians of pediatric patients. The study adhered strictly to current neurosurgical ethical guidelines, without involving experimental protocols with human or animal subjects. Surgical procedures were performed by senior neurosurgeons following established protocols. Data encompassing demographic details, clinical history, radiological findings, surgical specifics, and postoperative outcomes were retrospectively gathered from medical records and imaging studies. Descriptive statistics, such as frequencies, percentages, means, and standard deviations, were applied for data analysis. Limitations of the study include its retrospective nature, the relatively small sample size,

short duration of follow-up, and potential biases inherent to observational studies.

RESULTS:

The present study included sixteen cases of epidermoid cysts of the central nervous system that were operated on in the neurosurgery department over the last three years (Table 1). Their ages ranged from 15 to 46 years, with a median age of 30.5 years, and there was a slight male predominance. The majority of cases occurred in the third and fourth decades of life. Clinical symptoms varied and included headache, trigeminal neuralgia, facial palsy, hearing loss, vertigo, dizziness, seizures, and limb weakness, with symptom durations ranging from 2 weeks to 3-4 years. In our study, we found that the most common presenting symptom was headache, followed by trigeminal neuralgia, facial nerve involvement, other lower cranial nerve involvements, hearing difficulties, gait disturbances, seizures, and motor deficits. Anatomically, we found that cerebellopontine angle tumors were the most common, followed by others. Additional data included tumor sizes, preoperative hydrocephalus, postoperative complications, details of gross total excision, and recurrence (Table 2).

There were 10 cases in the cerebellopontine angle, 2 in the parafalcine region, 2 in the pineal region, and 2 in the fourth ventricle. Hereby, we are presenting details of one case from each location (Figures 1 and 2).

Table No.1 Master Chart Of All 16 Cases Of Intracranial Epidermoid Cysts

Case No.	Age/sex	Clinical features	Location	Clinical duration	Radiology	Surgical excision	Complications	Follow up
1	31Y/F	Right sided facial pain	Right cp angle	1month	A 2.5x1.3x2.5cm extra axial cystic lesion involving right cp angle T1 hypointense, T2 hyperintense, diffusion restricted suggestive of epidermoid cyst.	Complete	No	3months
2	27Y/F	Right sided hearing loss	Right sided cp angle	2years	Right cp lesion s/o epidermoid cyst of size 4*2.8*2.3 cm	Complete	No	1 year
3	26Y/M	Pain over right lower jaw	Right cp angle	7 months	Right cp angle mass around 7-8th nerve complex extending till trigeminal nerve.	Complete	No	1year
4	32Y/M	Right sided weakness 2-3 episodes of GTCS	Left Parafalcine	2 weeks	T1 hypointense, T2 hyperintense restriction on DWI with high ADC values in left fronto-parietal paraflacine area.	Complete	No	6 months
5	15Y/F	Right sided hearing loss Deviation of face to left	Right cp angle	1year	Right cp angle lesion of size 3*2.6*2 cm	Complete	Chemical meningitis	1year
6	42Y/F	Pain over left side of face	Left cp angle cistern sol extending to left perimsencephalic cistern	1 year	An extra-axial T2hyperintense area is seen in left cp angle cistern extending up to left half of perimesencephalic cistern, marked hyperintense signals measuring 2.5x1.3cm.	Complete	No	6months
7	18Y/M	Headache	Pineal region	1year	T1hypo,T2hyper restricted diffusion lesion in pineal region , compressing tentorium and aqueduct of sylvius with obstructive hydrocephalus	Complete	Chemical meningitis	1year
8	21Y/M	Diminution of vision and Headache	Pineal region	3months	A lobulated mass lesion is noted in quadrigeminal cisternal space in the region of pineal gland of size 2.7*3.1*2.2cm with obstructive hydrocephalus with periventricular ooze, papilledema secondary to mass lesion causing raised intracranial hypertension.	Complete	Pseudo-meningocele	6months
9	46Y/F	Left sided facial pain.	Left CP angle	4months	Lesion in left cp angle cistern measuring 2.5*2.1*2cm	Complete	No	6months
10	33Y/F	Numbness of left side of face, change in voice, and difficulty in deglutination.	Left CP angle	6months	A well-defined solid lesion involving the left cerebellar hemisphere and adjoining vermis with minimal extension into left CP angle measuring 5.8*4.2*3.6cm features with hydrocephalus	Complete	No	6months
11	33Y/F	Headache & LOC for 5min.	4th ventricular	4 months	A large heterogenous mass centred in fourth ventricle measuring 5*3.5*2.1cm T2 hyper, T1hypo, restricted diffusion with obstructive hydrocephalus	Complete	Pseudo-meningocele	6months

12	20Y/M	Headache	Interhemispheric	4months	5.9*6.5*5.9cm lesion in supratentorial region in between cerebral hemisphere on both sides of midline, restricted diffusion.	Complete	No	3months
13	30y/M	Headache Blurring of vision.	4th ventricular	3months	4th ventricular lesion of size 3*2.3*2cm with hydrocephalus	Complete	No	6months
14	40 Y /M	Facial deviation to left side Change in voice.	Right CP angle	3months	Right CP angle lesion of size 5.5*3.8*3.4cm	Complete	No	6months
15	26Y/M	Pain over right lower jaw.	Right CP angle	7months	Right CP angle lesion measuring in size 2.2*2*1.5cm.	Complete	No	6months
16	31Y/M	Pain over right side of face. Difficulty in chewing from right side of mouth.	Right CP angle	2years	Right CP angle lesion extending at quadrigeminal cistern measuring in size 3*3*2.8cm.	Complete	No	6months

Table No.2 Clinical Features And Results Of Various Other Parameters From The Study.

Clinical features		
Symptoms	**No. of cases**	**Percentage**
Headache	6	37.5%
Trigeminal neuralgia	4	25%
Facial involvement	4	25%
Lower cranial involvement	3	19%
Visual deterioration	2	12.5%
Hearing loss	2	12.5%
Gait disturbances	2	12.5%
GTCS	1	6.25%
Motor deficit	1	6.25%
Results of various other parameters from the study		
Parameters	**Variables**	**Numbers (%)**
Primary anatomical locations	Cerebello-pontine angle	10
	Parafalcine region	2
	Pineal region	2
	4th ventricle	2
Tumor maximum dimension	2-5cm	12
	>5cm	4
Pre-operative hydrocephalus	Present	5 cases
Post-operative complications	Chemical meningitis	2
	Pseudo-meningocele	2
Resection	Gross total excision	16
Recurrence		00 (till now)

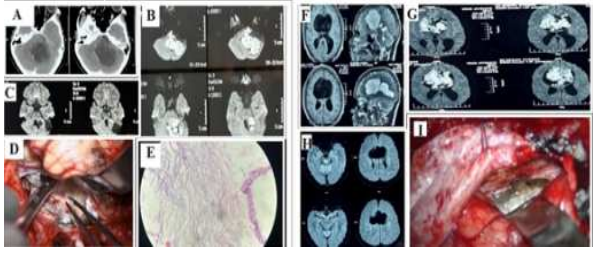

Fig. 1 Illustrative Case no.1 & 2- Left CP angle and Interhemispheric epidermoid cyst

A- CT Brain (P)-hypodense non enhancing lesion in left half of cerebellum, vermis, left cerebello-pontine and premedullary cistern.

B- MRI Brain (DWI) Pre-op- diffusion restriction in left cerebellar region.

C- MRI Brain (DWI) Post-op- complete excision of previous lesion in left cerebellar region.

D- Intra-operative appearance pearly white with surrounding white capsule.

E- HPE section show a cystic structure lined by stratified squamous epithelium and composed of abundant keratin flakes and cyst wall is devoid of adnexal glands s/o epidermoid cyst

F- MRI Brain(T1-Weighted)- hypointense lesion in anterior interhemispheric fissure

G- MRI Brain (DWI)-diffusion restriction in anterior interhemispheric fissure s/o epidermoid cyst

H- MRI Brain (DWI) post op- complete excision of interhemispheric fissure epidermoid cyst

I- Intra operative image – after retracting right hemisphere we can see pearly white lesion suggestive of epidermoid cyst

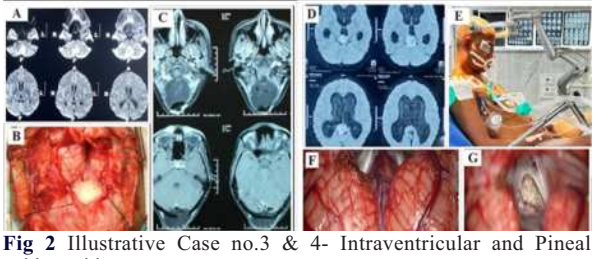

Fig 2 Illustrative Case no.3 & 4- Intraventricular and Pineal epidermoid cyst

A- MRI Brain (DWI)-Diffusion restriction both finding s/o epidermoid cyst.

B- Intra operative image – pearly white lesion in 4th ventricle.

C- MRI Brain (T1+C)- Post operative changes with Pseudo-meningocele

D- MRI Brain (DWI)- Diffusion restriction in pineal region with obstructive hydrocephalus

E- Intra-operative position – sitting position

F- Intra-op – surgical approach – supra-cerebellar infratentorial.

G- Intra-op pineal region – pearly white lesion s/o epidermoid cyst.

DISCUSSION:

Epidermoid cysts are developmental anomalies arising from remnants of ectodermal cells during the closure of the neural tube in the third week of embryogenesis. Despite their congenital origin, these cysts often remain asymptomatic until the second to sixth decades of life, owing to their slow growth rate. Their enlargement is primarily attributed to the accumulation of keratin and cholesterol resulting from the shedding of epithelial cells. The delayed clinical presentation can be explained by the cysts' tendency to expand within the available cisternal spaces without causing significant mass effect [10,11]. In our study, we observed that the majority of cases occurred in individuals during their fourth decade of life.

From 2021 to 2024, our institute performed a total of around 850 intracranial surgeries. Among these cases, we operated on 16 cases (1.8%) diagnosed with epidermoid cysts. The age of these patients ranged from 15 to 46 years, with a median age of 30.1 years, demonstrating a male predominance. Regarding the distribution of epidermoid cysts by location aligns with existing literature, which commonly identifies the cerebellopontine angle and posterior fossa as typical sites for these tumors[12].

Hydrocephalus is considered uncommon due to the chronic nature of the lesion and the ability of cerebrospinal fluid (CSF) to permeate through its crevices. Rarely, pre-excision CSF diversion may be necessary. However, in our study, five patients presented with hydrocephalus and elevated intracranial pressure, all of whom showed

improvement after definitive surgery[13]. This could be explained by the large lesion in the track of CSF flow.

Epidermoid cysts can range in size from small masses measuring millimeters to large ones up to 10 cm in diameter. In our current series, tumor sizes have varied from 2 cm to 6 cm in diameter. Their characteristic pearly white appearance is due to a thin wall and the presence of compact, flaky keratin inside. Microscopically, epidermoid cysts are composed of layered, anucleate squames derived from a thin, well-differentiated squamous epithelium, often containing keratohyalin granules. The cyst lumen is filled with lamellated keratin, while the surrounding connective tissue forms the cyst wall.

The main differential diagnoses for epidermoid cysts include arachnoid cysts, dermoid cysts, cystic neoplasms, neurocysticercosis, and neuroenteric cysts. Differentiating these entities typically relies on CT or MRI imaging of the brain. Conventional MRI images can sometimes effectively distinguish between epidermoid tumors and arachnoid cysts, as both lesions appear very hypointense on T1-weighted images and hyperintense on T2-weighted images. However, Fluid-attenuated inversion recovery (FLAIR) and diffusion-weighted (DW) sequences are particularly useful for diagnosing epidermoid cysts. DW imaging, which shows restricted diffusion, helps delineate the borders of epidermoid cysts, indicating their solid nature[11].

Technical Nuances and Description of Eggshell Technique:
· Surgical Approaches Based on Tumor Location:
- Cerebellopontine angle (CPA) for epidermoid cysts: Retrosigmoid approach in sitting position.
- 4th ventricle tumors: Telo-velar approach (sitting position)
- Pineal region tumors: Supracerebellar and infratentorial approach (sitting position)
- Interhemispheric epidermoid cysts: Midline-based frontoparietal craniotomy (supine position)

· Controversy Regarding Extent of Tumor Removal:
- The goal of surgery is complete removal of tumors [14-16].
- Microscopic meticulous sharp dissection is advocated for removing every bit of tumor capsule.
- However, the capsule can adhere to important neurovascular structures around the brainstem, making complete removal challenging.
- Some suggest a conservative approach involving decompression and removal of the non-adherent portion of the capsule to avoid damage to critical structures [13,17].

· Principle for Dealing with Tumor Capsule:
- The tumor capsule is approached with an "eggshell" technique.
- Eggshell technique:
The tumor is not dissected from outside the capsule unless the capsule is completely free from surrounding tissue. When the capsule adheres to surrounding tissue, we employ a technique akin to "eating a boiled egg," delicately removing the contents with a spoon while leaving the eggshell intact. This method, known as the eggshell technique, aims to preserve the thinnest possible membrane, often the pseudo capsule formed by the reaction of the epidermoid with the surrounding pia-arachnoid. We strongly advise against aggressively dissecting this pseudo capsule, as doing so can lead to hemorrhage due to vascular manipulation on the pial surface of the surrounding brain. This tumor reaction also contributes to capsule rupture and chemical meningitis.

This approach aims to achieve gross total excision while minimizing the risk of immediate complications (such as injury to critical structures) and reducing the likelihood of tumor recurrence. This strategy balances the imperative of complete tumor removal with the need to preserve neurological function by avoiding damage to vital brain structures during surgery. It reflects a nuanced approach that takes into consideration both surgical feasibility and long-term patient outcomes. Partial removal of the lesion can lead to recurrence, often occurring after a prolonged period due to the tumor's slow growth rate. MRI is useful for detecting early recurrence, and subsequent surgery is typically recommended only when the recurrent lesion becomes symptomatic. In our series, the follow-up period was relatively short, possibly explaining why we did not observe any recurrence or symptomatic recurrence in any case.

Postoperative complications include transient cranial nerve palsies, with aseptic meningitis being the most common, followed by pseudo-meningocele. Aseptic meningitis results from the secondary release of irritant material from the tumor into the subarachnoid space, and incomplete resection of the capsule can contribute to this complication [14]. Among our 16 cases, two patients developed chemical meningitis, managed successfully with dexamethasone and lumbar drainage, while two patients had pseudo-meningocele, treated with repeated lumbar punctures and compression dressings. Patients with cerebellopontine angle tumors experienced transient facial and lower cranial nerve involvement, which resolved at discharge or initial follow-up.

A review of the available literature on intracranial epidermoid cysts was conducted using structured data headings, focusing on patients' demographics, clinical presentation, tumor locations, surgical outcomes, complications, and follow-up periods. This table aims to provide a clear and comprehensive overview of central nervous system epidermoid cysts based on the reviewed cases [1,5,18] [Table 3]. Other studies in literature do not elaborate on the surgical technique which has been described in our article.

Table 3- Comparison Of Our Study With Available Literature

	Our study	Maria Mihaaela pol et al;2023	Daniel kiss-bodolay et al;2024	Sana Ahuja et al;2024
Study period	2021-2024	2012-2021	2000-2022	2020-2023
Number of patients	16	36	22	15
Median age of presentation (Range)	30.5years (15 to 46years)	40.4years(1-73years)	43years (9-78years)	24years (1.5-45years)
Symptom duration	2weeks to 2years	1-4years	NA	2days to 2.5years
Most common location	Cebello-pontine angle (62.5%) f/b parafalcine and posterior fossa	Cerebello-pontine angle (38.9%)	Cerebello-pontine angle (36%) and supratentorial (31%)	Cerebello-pontine angle (27%) and posterior fossa (27%)
Most common symptom	Headache (37.5%) fb trigeminal neuralgia and facial nerve involvement	Headache (77.9%) f/b Dizziness (36.1)	Cranial nerve involvement f/b gait disturbances fb trigeminal neuralgia	Headache (40%) fb lower limb weakness and giddiness
Presence of hydrocephalus	5 cases (31%)	6 cases (16.7%)	NA	1 case (7%)
Post op complications	4cases (25%) (2 cases chemical meningitis and 2 cases CSF leak.	25% (aseptic meningitis)	NA	NA
Gross total excision	All cases	83.3% (30 cases)	41% after 1st surgery, 98% after second surgery	93%(14Cases)
Follow up	3months to 1year	6months-10years	6years +/- 2years	3months to 3years
Tumor recurrence	Zero (till now)	22.2% (8 cases) median time of recurrence 7.5years	NA	No recurrence at follow up

CONCLUSION:

Intracranial epidermoid cysts are benign lesions, and their long-term prognosis depends on achieving maximal safe resection. The primary surgical challenge lies in the adherence of the cyst capsule to surrounding structures. The eggshell technique serves as a valuable method to facilitate maximal resection while preserving neurological function.

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