Endoscopic Supracerebellar Infratentorial Retropineal Approach for Tumor Resection

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Key words
- Endoscopy
- Pineal tumor
- Supracerebellar infratentorial approach

Abbreviations and Acronyms
GCT: Germ-cell tumor
MRI: Magnetic resonance imaging
POT: Pineal origin tumor
S-C: Supracerebellar infratentoria


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BACKGROUND: **Lesions located in the pineal region represent a surgical challenge. Multiple approaches to this region have been described, each with its advantages and disadvantages. We report the first application of the endoscopic supracerebellar infratentorial approach for complete resection of a pineal tumor. Unlike transventricular endoscopy, this technique poses no risk to the fornices and can be applied independent of ventricular size.**

CASE DESCRIPTION: **A 21-year-old man sought treatment for diplopia. Magnetic resonance images of brain revealed a heterogeneous, contrast-enhancing mass that originated from the pineal gland. This tumor exerted the mass effect on the tectum and invaded to the bilateral dorso-medial thalamus and hypothalamus but caused no obstructive hydrocephalus. The results of a cytological study of the cerebrospinal fluid, alpha-fetoprotein, and beta-human chorionic gonadotropin were negative. The patient was referred for the surgical work-up.**

TECHNIQUE: **The patient was positioned in the semi-sitting position. The supracerebellar infratentoria corridor was accessed through two paramedian burr holes, which provided natural by-gravity cerebellar traction. The excellent illumination and magnification without sacrificing the inferior occipital sinus could be achieved with the aid of the endoscope. The pineal tumor was resected completely via the full-endoscopic approach. Postoperatively, the patient's diplopia resolved completely, and his hospital course was uneventful.**

CONCLUSIONS: **Taking the advantages of the endoscope and peculiar supracerebellar infratentoria corridor, we could successfully remove the gross-total tumor without violating the critical neurovascular structures. Moreover, this approach can be performed regardless of the size of the ventricle. Consequently, it is an excellent minimally invasive surgical option for resection of symptomatic pineal tumor.**

INTRODUCTION

Pineal region tumors include those arising from the pineal gland and as well as others involving the posterior third ventricle and quadrigeminal cistern. Primary pineal-origin tumors (POTs) are uncommon, comprising 0.4%-0.5% of intracranial lesions, with incidences that vary geographically (9, 15). Until recently, the results of surgery for POT, including mortality and morbidity, have been poor (19). Several surgical strategies have been described for the treatment of POT, including the supracerebellar infratentorial (3, 12) and occipital transtentorial microsurgical approaches (20), the transventricular endoscopic approach (6, 7, 17), and stereotactic aspiration (14). We report the first patient whose pineal tumor was entirely excised endoscopically via the supracerebellar infratentorial (S-C) approach.

CASE REPORT

History and Neurological Examinations

A 21-year-old man presented with diplopia and blurred vision during the period of 2 months. Initially, he consulted a local ophthalmologist, who diagnosed him as having a superior rectus muscle palsy. However, the patient's symptoms worsened 1 week before admission. Then, he was referred to our department for surgical assessment. Neurological examination revealed limitation of upward gaze and convergent nystagmus on attempted up-gaze (i.e., Parinaud sign). The patient had normal mental development and was sexually mature.

Magnetic resonance imaging (MRI) demonstrated a heterogeneous enhancing lesion approximately 1.2 × 2.5 cm in size that was located mainly in the pineal region. The tumor had directly invaded the dorsal-medial thalamus. Moreover, the tumor exerted mass effect on the superior colliculi, sparing the aqueduct (**Figure 1**). No obstructive hydrocephalus was present. There were no synchronous lesions in the brain or spine. The imaging findings were consistent with a primary POT. The findings of the cerebrospinal fluid examination were normal, with no atypical cells noted. Serum and cerebrospinal fluid, beta-human chorionic gonadotropin, and alpha-fetoprotein were assayed as tumor markers and found to be within normal values. According to the results, an intracranial germ-cell tumor (GCT) was highly suspected. We discussed the therapeutic modality of diagnostic radiotherapy or surgical option for histologi-

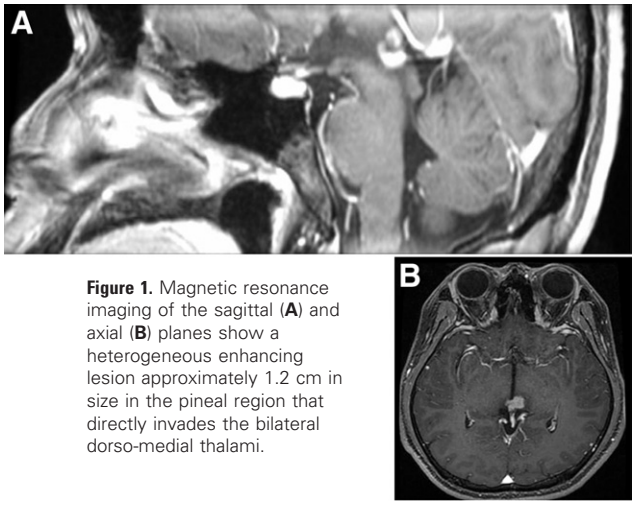

Figure 1. Magnetic resonance imaging of the sagittal (**A**) and axial (**B**) planes show a heterogeneous enhancing lesion approximately 1.2 cm in size in the pineal region that directly invades the bilateral dorso-medial thalami.

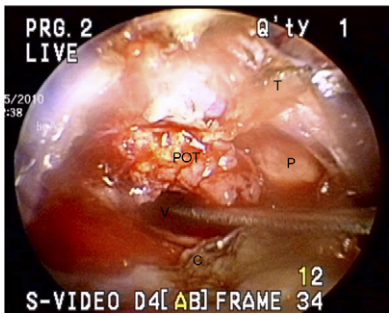

Figure 3. Intraoperative photography showing the pineal tumor was debarked centrally by the pituitary curettes. The pineal origin tumor (POT), tentorrium (T), pulvinar nuclus (P), and cerebellar culmen (C), and the posterior third ventricle (V) are visible.

cal verification. The patient chose surgical treatment and attempted resection.

Operative Technique

The patient underwent preoperative contrast MRI examination of the brain to obtain thin-cut volumetric images. These images data were transferred to the VectorVision flex (BrainLab, Feldkirchen, Germany) to integrate them into the intraoperative navigation system. The patient was placed in the semi-sitting position, and we took appropriate precautions for balanced general anesthesia. Transesophageal echocardiography and a right internal jugular venous catheter were applied for the detection and treatment of air embolism during surgery. The vector-reference system was used to localize the torcular herophili. Two 25-mm burr holes were made just beneath to the transverse sinus inferior wall approximately 25 mm distal to the midline (**Figure 2**). The paramedial location was selected to avoid the occipital sinus. Moreover, the bilateral burr holes provided a wide, cooperative working space. One hole was for endoscopic illumination and the other for introducing instrumentation. The dura was incised in cruciate fashion. A 18-cm long, rigid 0-degree endoscope tube with an outer diameter of 4 mm, a built-in suction irrigation system, and an inlet for various microinstruments (Karl Storze, Tuttlingen, Germany), enclosed within the sheath, was introduced into left burr hole.

After fixing the endoscope to the scope holder with a flexible arm, we introduced the dissectors and curettes, into the other burr hole under endoscopic visualization. We adopted the retrograde lysis of the fibrous band and then opened the arachnoidal trabeculae of the posterior wall of the bilateral ambient cisterns under the bilateral petrous apices. The sequential opening of the torcular herophili and bilateral ambient cisterns leads to more relaxation of the cerebellum. The thick arachnoidal band tethering the superior vermis and culmen were dissected sharply to expose the precentral cerebellar vein. We switched the position of endoscope through both holes when we encountered fibrous bands or arachnoidal trabeculae. We carefully coagulated the vein and dissected using endo-scissors (Karl Storze).

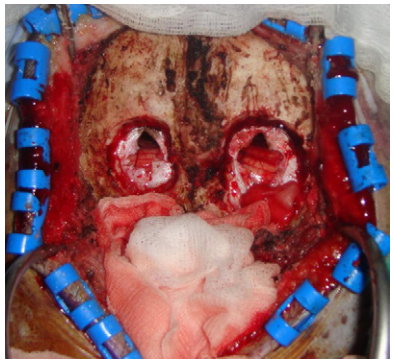

Figure 2. Intraoperative photography showing the two 25-mm burr holes placed just beneath to the transverse sinus inferior wall, approximately 25 mm distal to the midline (coronal view).

Video

Video available at WORLDNEUROSURGERY.org

The pineal tumor was gray in color with a relatively soft texture. It was located slightly to the left side, tightly juxtaposed between the left pulvinar thalami and posterior medial choroidal artery. After identifying the pineal vein and feeding arteries, we dissected the wall of tumor and cauterized the blood supplies. Piecemeal central debarking was performed by the use of pituitary curettes (Aesculap, Boston, Massachusetts, USA; **Figure 3**). After gross decompression, we removed the residual wall with Kerrison forceps. We excised the tumor until we reached the posterior third ventricle through the para-pineal region, a small entry zone approximately 3 mm lateral to pineal gland, underneath the internal cerebral vein and parallel to the upper margin of the superior colliculi. The tumor over dorsal-medial thalamus was grasped without incident. After gross total resection, the anatomy of the posterior incisural space was clearly seen under the 0-degree endoscope (Karl Storze) and after another check with a 30-degree endoscope (Karl Storze). The durotomies were closed with silk sutures and then covered by Gelfoam sheets (Upjohn Co., Kalamazoo, MI). A layer of tissue fibrin sealant (Confluent Surgical, Waltham, MA) was sprayed over the dura. The remainder of the closure was accomplished in the standard way.

Postoperatively, the patient had no new-onset neurological deficit. An MRI scan was per-

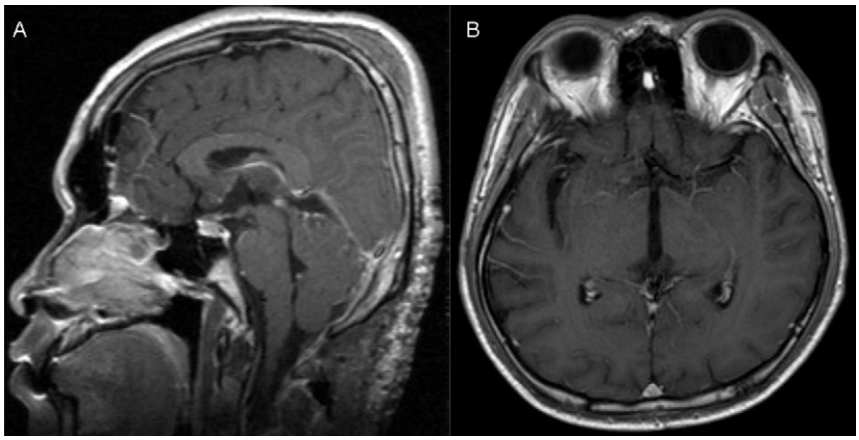

Figure 4. Postoperative sagittal T1-weighted MRI scans after gadolinium administration of the sagittal (**A**) and axial (**B**) planes demonstrating postoperative changes and confirming removal of the tumor.

formed within 24 hours after the operation, which confirmed the complete resection (**Figure 4**). Pathology revealed a picture of mixed GCT of germinoma with teratoma. The adjuvant radiation therapy of 45 Gy was increased 2 weeks later. At his 6-month and 12-month postoperative visits, the patient's the diplopia resolved, and he was not taking any pain medication.

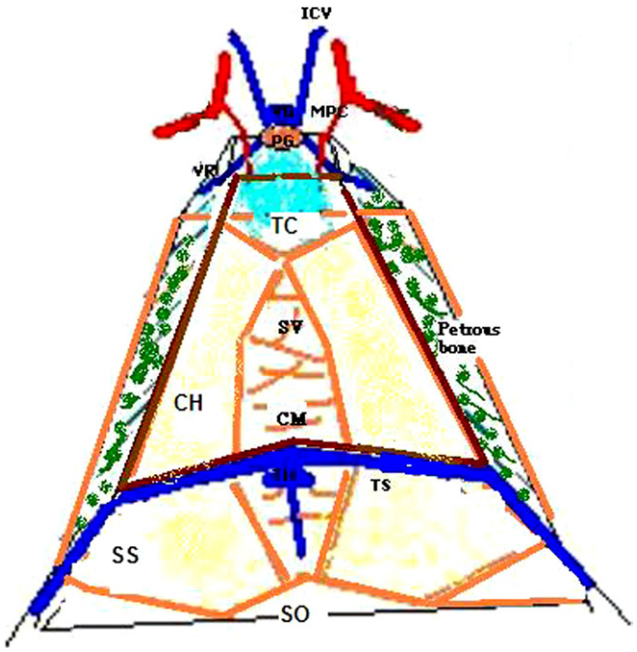

Figure 5. The diagram demonstrates S-C corridor" had six faces and the gross shape looked like a quadrilateral frustum. The bilateral faces are composed of petrous part of temporal bone. The roof is composed of tentorium cerebella. The floor of quadrilateral frustum is cerebellar culmen. The broad bottom is suboccipital bone. The apex is the pineal gland and the plane of the opening to the quadri-geminal cistern. Cm, culmen; CH, cerebellar hemisphere; ICV, internal cerebral vein; MPC, medial posterior choroidal artery; PG, pineal gland; TC, tentorium cerebelli; TS, transverse sinus; TH, torcula herophill; SO, suboccipital bone; SS, sigmoid sinus; SV, superior vermis; VG, vein of Galen; VR, vein of Rosenthal.

DISCUSSION

POTs, an uncommon but intriguing group of neoplasms affecting children and young adults, have been systematically classified by histology (15). Resection is superior to other treatment modalities for POT that are benign or radioresistant (16). Malignant tumors may also be amenable to resection or may contain a cyst requiring removal or aspiration (5). For germinoma in the pineal region, treatment strategies vary; some authors currently prefer direct surgical removal, whereas others advocate stereotactic biopsy followed by radiotherapy or chemotherapy (11, 18). In addition to pure germinoma, there are germinomas with syncytiotrophoblastic giant cells and mixed GCTs, including germinoma. The primary goal of surgery should be to obtain a sufficient volume of tumor tissue for histological examination. Many types of POTs are not sensitive to radiation, and the radical removal of them can often improve the overall response to treatment, including adjuvant radiotherapy or chemotherapy (15).

However, posterior approaches to the pineal region and the posterior portion of the third ventricle are difficult to execute, given the complexity and importance of the vital neurovascular structures that are tightly packed in these areas (1, 2). As discussed by Stein (13), the infratentorial-supracerebellar approach allows adequate exposure of lesions positioned in the midline.

In the past two decades, neuroendoscopy has come to the forefront for the management of complex hydrocephalus and intracranial cysts. In a cadaver-based anatomic study, Cardia et al. (2) and Youssef et al. (21) demonstrated the viability of the S-C approach for endoscope-assisted techniques. In our own observation, the S-C gap unveiled a corridor into which we fit the endoscope and pistol-typed instruments. This space, known for "S-C corridor," has six faces and the gross shape of a quadrilateral frustum. The lateral faces were composed of one tentorium cerebelli, one cerebellar culmen, and two petrous bone aspects. The broader bottom of the bone comprised the suboccipital bones. The apex of the frustum was the plane of the opening to the quadri-geminal cistern (**Figure 5**). On account of its unique position related to the pineal region, we defined this space as the "retro-pineal frustum" space.

In the middle of the space was the fibrous band, into which was embedded some bridging veins and thickened arachnoidal trabecu-

lae. We adopted the retrograde neurolysis of the fibrous band then opened the arachnoid trabeculae of the posterior wall of the bilateral ambient cisterns under the bilateral petrous apices. This sharp "figure-of-eight" disconnection separated the anterior traction force between the tentorium and cerebellum. The major force adhering the cerebellar arachnoid membrane to the tentorium was the bridging veins, including precentral cerebellar veins, veins into the tentorial sinus, and veins into occipital sinus (2, 10). The tentorium edges converge directly to the point where the vein of Galen is located (8). The endoscope was therefore directed slightly inferior to the tentorium along a trajectory guided by these significant landmarks. By means of this method, bridging veins between the top cerebellar and tentorium were coagulated and divided gradually.

There was ample room for an endoscope along this trajectory, and no additional cerebellar retraction was required after dissecting the trabeculae and bridging veins. The reasons for dual burr holes were 1) to facilitate the bimanual manipulation of instrument, decreasing the fighting of scope and instrument; 2) to save time with drilling and resection in comparison to conventional large suboccipital craniectomy or craniotomy; and 3) to decrease the chance of a potential air-embolism during the breach of the occipital sinus.

However, the full-endoscopic method is not free of disadvantages; there some limitations, including the following: 1) for a medium-sized tumor (≤3 cm), it is sufficient to dissect the peripheral portion and adjacent tissue, creating enough room to manipulate the para-pineal window. However, because of the bulky nature of the larger tumor, even after internal debulking, made the separation difficult. 2) Positional factoring, as the approach implies, is indicated for midline or paramidline lesions at the level between the roof of the third ventricle and upper tectal region. We have tried to advance the scope with available instruments, but the anterior limit was the foramen of Monro. 3) The texture of the tumor, as well as the limited length of certain instruments, such as the forceps, grasper, curettage, and probe, plays a vital role in determining its resectability. The harder it is to halve the tumor, the less of it can be resected, and vice versa. 4) The most challenging issue of endoscopic surgery remains hemorrhagic control under the 2-dimensional scope visualization. We can address some incidental oozing and even intentional vascular ligation with bipolar coagulation. However, in the case of vigorous bleeding, this approach should then be converted into open method to take great control of the bleeding source.

We learned that the cystic lesion could be gross-totally removed by full-endoscopic resection (4, 7). For solid tumors, the access depends on the working distance, angle, and the controlled skills under the two-dimensional display. From the literature, we found that this might be the new technique with potential development and insight. In careful selection of these patients, a full-endoscopic complete resection is promising and demonstrates minimal complications.

CONCLUSION

Taking the advantages of the endoscope and peculiar S-C corridor and our concept of cone anatomy, we could successfully remove the gross total tumor without violating the critical neurovascular structures. Moreover, this approach can be performed regardless of the size of the ventricle. A determination of its long-term efficacy, however, requires that more clinical experiences are performed for verification.

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