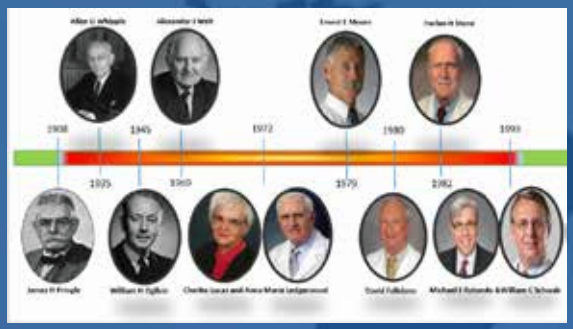
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Endoscopic Brain Biopsy: Single-Center Retrospective Experience (2012–2024)

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Abstract

Background: From Dandy's earliest endoscopic cauterization of the choroid plexus in hydrocephalus to Fukushima's first successful endoscopic brain biopsy (EB) in 1973, neuroendoscopic indications have expanded substantially.

Objective: To evaluate the effectiveness and diagnostic yield of endoscopic brain biopsy (EB).

Design, Setting, and Participants: Single-center retrospective series by the senior author. Between November 2012 and June 2024, 27 patients underwent intraventricular endoscopic biopsy (VEB) and 7 underwent intraparenchymal endoscopic biopsy (PEB).

Main Outcome(s) and Measure(s): Demographics, histopathology, operative times, adjunct procedures, hospital length of stay, and complications.

Results: In the VEB group, age ranged 6–70 years (mean 28) with a 2:1 female:male ratio. The most common diagnoses were pilocytic astrocytoma (26%), and metastasis and ependymoma (15% each). Pathology was inconclusive in 15%. Other diagnoses included glioblastoma (11%), germinoma (7%), and meningioma, pineoblastoma, and epidermoid cyst (each 4%). In the PEB group (age 25–70 years;

mean 59), glioblastoma was most frequent (72%); 14% had diffuse astrocytoma grade II and 14% were non-diagnostic. Typical operative times were 1.5–3 hours for VEB (depending on concomitant procedures) and up to 2 hours for PEB.

Conclusions and Relevance: EB achieved an 85% diagnostic yield in this series, comparable to published yields for stereotactic biopsy (~86%). In appropriately selected intraventricular and deep lesions, EB offers tissue diagnosis with the potential to address hydrocephalus in the same session.[10]

Key words: Endoscopic brain biopsy, Intraventricular tumors, Deep parenchymal lesions, Hydrocephalus management, Diagnostic yield

Introduction

Endoscopic brain biopsy (EB) has been in routine use for more than three decades, with historical roots in Walter E. Dandy's pioneering endoscopic procedures in the early 1900s and Fukushima's first successful EB of a pineal region tumor in 1973, which provided tissue and cerebrospinal fluid (CSF) for histology and tumor markers. Before EB, stereotactic biopsy or open surgery were the primary options but carried notable limitations.[5 6 7]

Intraventricular lesions may obstruct CSF pathways and cause secondary hydrocephalus, commonly presenting with headache, gait disturbance, cognitive and visual symptoms (e.g., Parinaud syndrome), nausea/vomiting, and other signs of intracranial hypertension. VEB is typically indicated for thalamic, tectal plate, pineal region, and third-ventricle lesions. In patients with obstructive hydrocephalus due to posterior third-ventricle or pineal tumors, endoscopic third ventriculostomy (ETV) with EB is frequently the first-line strategy. With neuronavigation, EB remains feasible even in small ventricles. Careful positioning (supine, head flexed), meticulous ependymal vessel protection, and minimal cortical transgression are critical.[1 2 4 5 7]

Instrument refinements in the 1990s facilitated widespread clinical adoption of EB by the early 2000s. This single-institution retrospective study (November 2012–June 2024) reports outcomes of EB performed for diagnostic purposes. [3]

The adoption of endoscopic biopsy in our practice was not driven by the development of a novel technique, as endoscopic biopsy is already well established in neurosurgical practice. Rather, a temporary shortage of the Subdural Evacuation Port System (SEPS; Medtronic)—a device routinely used for bedside minimally invasive evacuation of chronic subdural hematomas—prompted a reassessment of available minimally invasive cranial access strategies. Our prior experience with SEPS-based bedside procedures had already facilitated familiarity with limited cranial access techniques, which supported the implementation of endoscopic biopsy in selected cases. During this period, the feasibility of utilizing an endoscope through a standard burr-hole trajectory was recognized, given its reliable navigability and visualization. Subsequent experience demonstrated that a stereotactic biopsy needle could be advanced with comparable precision through the same corridor. This pragmatic adaptation expanded procedural flexibility, allowing biopsy to be performed either awake under stereotactic guidance or under general anesthesia using endoscopic or stereotactic navigation, depending on patient condition and surgical indication. [16]

Material and methods

Study Design and Setting

This retrospective observational case series was conducted at the *Neurosurgery Service, University Hospital Center "Mother Teresa", Tirana, Albania,* and includes patients treated between *November 2012* and *June 2024.*

Standard technique involves a right paramedian frontal burr hole 2–3.5 cm anterior to the coronal suture at the cranial vertex. 0° Aesculap/ Minop endoscope was used routiely for these procedures. Neuronavigation facilitates safe trajectory planning to protect structures such as the fornices and caudate nucleus and may reduce postoperative seizures. It was utilized in all parenchymal endoscopic biopsy (PEB) procedures, comprising a total of 7 patients. To optimize diagnostic performance, we target collection of 5–10 specimens. When initial sampling is insufficient, a second pass is undertaken. [2 7]

Participants

Thirty-four patients underwent EB for diagnostic purposes:

- **Ventricular endoscopic biopsy (VEB):** 27 patients
- **Parenchymal endoscopic biopsy (PEB):** 7 patients

Data Collection

Data were extracted from hospital records and digitized operative documentation and included:

- Demographics (age, sex)
- Diagnosis
- Tumor location
- Histopathology
- Type of endoscopic procedure
- CSF diversion method
- Operative time
- Complications

• Subsequent oncological or surgical treatment
• Follow-up outcomes

Data were compiled using Microsoft Excel (Office 2016).

Results

Patient Characteristics

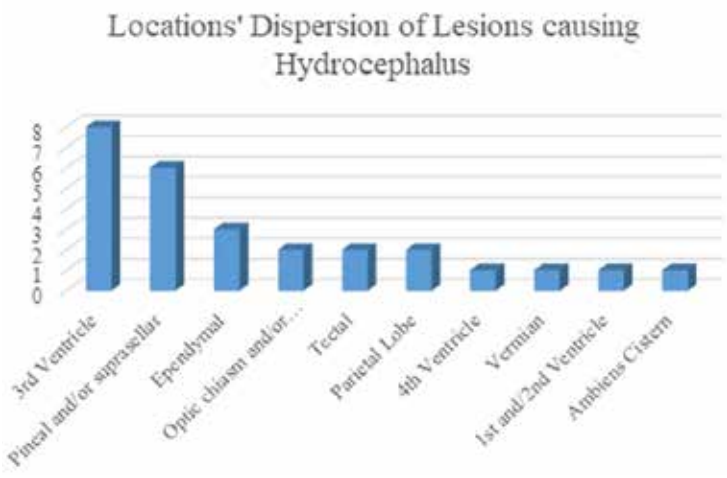
• **VEB group:** age 6–70 years (mean 27.9 ± SD 16.4), female 66%
• **PEB group:** age 25–70 years (mean 59 ± SD 11.2), female 57%.

Median follow-up ranged from 3 to 12 months.

Tumor Location

In the VEB group, lesions were located in:
• Third ventricle (30%)
• Pineal and/or suprasellar region (22%)
• Ependymal lesions (11%)
• Optic chiasm and/or fascicles (7%)
• Thalamic/tectal plate region (7%)
• Parietal Lobe lesions (7%)
• Fourth Ventricle (4%)
• Vermian lesions (4%)
• 1st and 2nd Ventricle (4%)
• Ambiens Cistern (4%)

Chart nr. 1: Locations' Dispersion of Lesions causing Hydrocephalus in VEB group



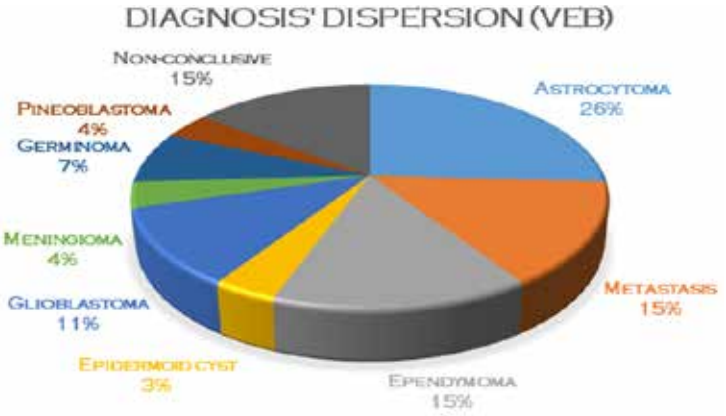
PEB lesions were located in deep parenchymal regions adjacent to the ventricular system:
• White Matter Lesions (43%)
• Splenium and/or corpus callosum lesions (29%)
• Gyrus Cinguli (14%)
• Rolandic region (14%)

Histopathological Diagnosis

Overall diagnostic yield was **85%** in VEB group and **86%** in PEB group.

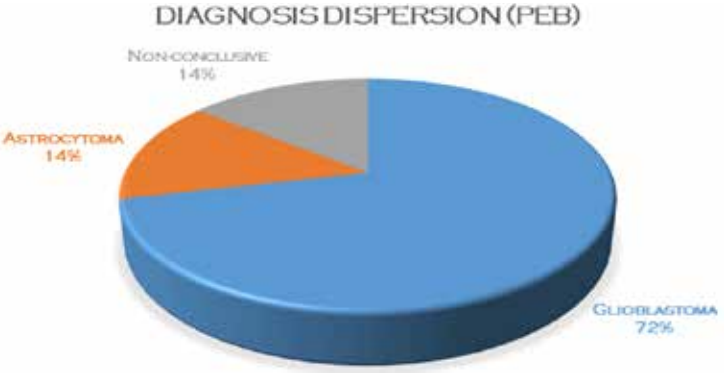
VEB diagnoses:
• Pilocytic astrocytoma – 26%
• Metastasis – 15%
• Ependymoma – 15%
• Glioblastoma – 11%
• Germinoma – 7%
• Meningioma – 4%
• Pineoblastoma – 4%
• Epidermoid cyst – 3%
• Non-diagnostic – 15%

Chart nr. 2: Diagnosis' Dispersion in VEB group



PEB diagnoses:
• Glioblastoma – 71%
• Diffuse astrocytoma (WHO grade II) – 14%
• Non-diagnostic – 14%

Chart nr. 3: Diagnosis' Dispersion in PEB group



CSF Diversion and Associated Procedures

- **ETV performed:** 8 patients
- **Ventriculoperitoneal shunt (VPS):** 10 patients (1 case as e secondary procedure after Ommaya reservoir placement)
- **ETV failure requiring VPS:** None
- **External ventricular drain (EVD):** 3 patients (temporary measure, later converted to VPS)
- **Septostomy:** 3 patients (performed after VPS, as a standalone second procedure)
- **Ommaya reservoir:** 2 patients (1 placed during the same session as EB, 1 case followed by VPS as a standalone second procedure)
- **Tumor resection:** 2 patients (after histopathologic results)
- **Chemotherapy follow-up:** 2 patients ((after histopathologic results)

Operative Time

- Ommaya reservoir placement: ~1.5 hours
- EVD placement (including hemostasis and ventricular lavage): ~3 hours
- VPS placement: ~2.25 hours
- PEB: ~2 hours

Complications and Mortality

Two deaths were recorded:

1. **Early postoperative hemorrhage:** One patient developed an intraventricular hemorrhage within 14 days postoperatively following biopsy of a clear cell ependymoma lesion with seeding. Despite external ventricular drainage and intensive care support, the patient died.
2. **Late mortality:** One patient died 1.5 years post-procedure due to systemic metastatic disease progression.

No permanent neurological deficits were observed in surviving patients.

Non-diagnostic biopsies occurred predominantly in hemorrhagic or necrotic lesions of the posterior third ventricle and were recommended biopsy retake.

In the VEB group, non-diagnostic biopsy results occurred in one patient with a lesion of the left lateral ventricle and in another patient with Neurofibromatosis type 1 who presented with an undetermined lesion of the optic pathways causing secondary hydrocephalus. In the PEB group, one female patient with multiple white-matter lesions had a non-diagnostic biopsy; however, neurological follow-up at six months led to a diagnosis of multiple sclerosis.

Discussions

Tumors of the posterior third ventricle and pineal region represent less than 1% of intracranial neoplasms and encompass a heterogeneous spectrum of pathologies, including germ cell tumors, gliomas, and intrinsic ventricular lesions. Given the marked variability in treatment strategies and prognosis, **accurate tissue diagnosis remains essential** to guide oncologic management and avoid unnecessary or inappropriate interventions.[1 2 5 7]

Endoscopic biopsy (EB) has evolved as a valuable diagnostic tool in this setting, particularly in patients presenting with obstructive hydrocephalus, where cerebrospinal fluid (CSF) diversion can be addressed during the same operative session. In our series, the overall diagnostic yield of EB was 85%, which is consistent with previously reported ranges for both endoscopic and stereotactic biopsy techniques. However, the principal contribution of our experience lies not in outcome equivalence, but in the **technical and procedural considerations** that influence diagnostic success and safety.[4 6 8 9 13 14 16]

Technical and Procedural Considerations

Our experience confirms that **trajectory planning and lesion selection** are critical determinants of diagnostic yield. Navigation-assisted targeting allows precise identification of solid, contrast-enhancing tumor regions while minimizing injury to eloquent structures such as the fornices and caudate nucleus. In intraventricular lesions, careful planning of the burr-hole entry point enables a single-corridor approach that facilitates both biopsy and CSF diversion when required.[1 2 7]

We observed that **adequate tissue sampling is essential** to avoid non-diagnostic results. In our practice, obtaining **at least 5–8 biopsy specimens** from different depths of non-necrotic tissue under direct visualization improved diagnostic reliability. Both non-diagnostic cases in the VEB group were associated with lesions that were either infiltrative or not truly neoplastic, highlighting the inherent limitation of biopsy when radiologic suspicion does not correspond to focal tumor pathology. Similarly, the single non-diagnostic PEB case ultimately diagnosed as multiple sclerosis underscores the importance of correlating biopsy findings with longitudinal clinical and radiological follow-up.[1 5 7 10 11 12 15]

Role of CSF Diversion and Adjunct Procedures

Hydrocephalus was a prominent feature in our cohort, reinforcing the advantage of EB as a **combined diagnostic–therapeutic procedure**. Endoscopic third ventriculostomy

(ETV), ventriculoperitoneal shunting (VPS), septostomy, and reservoir placement were performed based on intraoperative findings and ventricular anatomy. Importantly, septostomy was not uniformly performed but selectively used, as a standalone maneuver, emphasizing that these steps should be **planned rather than incidental**.

External ventricular drainage was employed as a temporary measure in selected cases; however, it was not considered definitive therapy. Reported operative times reflect the **entire surgical workflow**, including biopsy and adjunct procedures, rather than isolated device placement. This distinction is important when interpreting procedural duration and comparing techniques across studies.

Safety and Complication Management

Hemorrhage remains the most significant risk associated with EB, particularly in high-grade gliomas, vascular lesions, and deep-seated tumors. In our series, hemorrhagic complications were rare but clinically significant. Consistent with prior reports, meticulous hemostasis using **warm saline irrigation, tamponade, and bipolar coagulation**, combined with routine early postoperative imaging, proved essential for complication detection and management.

The timing of complications in most events occurrs within the first postoperative hours. This supports the practice of structured postoperative monitoring rather than prolonged hospitalization, contributing to reduced hospital stay and resource utilization.

EB in Relation to Stereotactic Biopsy

Stereotactic biopsy remains an established and effective technique with high diagnostic yield. However, EB offers distinct advantages in selected patients, particularly those with ventricular lesions and hydrocephalus. The ability to perform **biopsy and CSF diversion in a single session**, under direct visualization, provides procedural flexibility and may reduce the need for staged interventions. Our experience suggests that EB should not be viewed as a replacement for stereotactic biopsy, but rather as a **complementary technique**, best suited to anatomically favorable lesions where intraventricular access offers added therapeutic value.

Limitations

This study is limited by its retrospective, single-center design and modest sample size. Operative strategies evolved over the study period, and molecular diagnostic techniques were not uniformly available in earlier cases. Prospective studies comparing EB and stereotactic biopsy with standardized outcome measures would further clarify optimal patient selection and cost-effectiveness.

Practical Implications

Based on our experience, EB is most effective when:

1. Lesions are intraventricular or abutting the ventricular system
2. Adequate, multi-sample tissue acquisition is planned
3. CSF diversion strategies are predefined rather than reactive
4. Hemostasis is meticulously secured before ventricular decompression

When applied under these conditions, EB provides reliable diagnostic information while simultaneously addressing hydrocephalus, thereby offering meaningful procedural value beyond diagnostic equivalence alone.

Conclusions

In this single-center experience, EB achieved an 85% diagnostic yield, comparable to that reported for stereotactic biopsy, while offering the added advantage of simultaneous cerebrospinal fluid diversion in patients with obstructive hydrocephalus. This approach is particularly advantageous for lesions that are intraventricular or adjacent to the ventricular system. Diagnostic success depends on careful trajectory planning, adequate multi-site tissue sampling, and meticulous hemostasis. While EB does not replace stereotactic biopsy, it serves as a complementary technique, best suited to patients with ventricular involvement and hydrocephalus.

Technical Pearls

Key practical considerations for safe and effective endoscopic biopsy (EB) in intraventricular and deep parenchymal lesions:

1. **Trajectory Planning:** Preoperative imaging and neuronavigation should be used to select a burr-hole entry that avoids eloquent structures (fornices, caudate nucleus) and allows a single-corridor approach for both biopsy and CSF diversion.
2. **Tissue Sampling:** Obtain **at least 5–8 specimens** from enhancing, non-necrotic tissue at different depths to maximize diagnostic yield. Consider a second biopsy if initial sampling is insufficient.
3. **Adjunct Procedures** – Predefine CSF diversion strategies rather than performing reactive interventions. Septostomy should be performed selectively based on ventricular anatomy.

4. **Hemostasis and Safety** – Ensure meticulous hemostasis before ventricular decompression. Early postoperative imaging facilitates prompt complication detection.
5. **Correlation and Follow-Up** – Integrate biopsy results with longitudinal clinical and radiological follow-up to detect non-diagnostic or evolving lesions.

Declarations

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Conflict of interest: There are no relevant conflicts of interest to be identified in this study.
Data Availability: Any study data requirement is available by request to main author, who can be reached by e-mail.
Consent: Patient privacy is reserved and consent is obtained.
Ethical approval: Ethical approval is not needed for the study, because patient privacy and identity are well preserved and not demonstrated.
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Figure nr. 1: Intraoperative intraventricular view of subependymal lesion located at third ventricle floor and choroid plexus and biopsy sampling

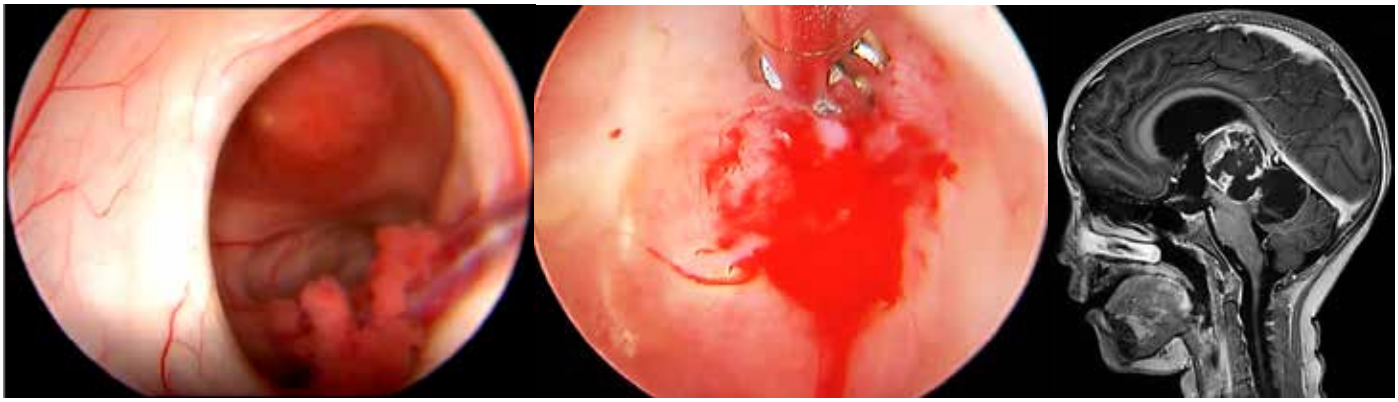


Figure nr. 2: Cranial MRI showing a heterogenous mass that occupies left lateral ventricle, para-trigonal periventricular ipsilateral region with wide oedema

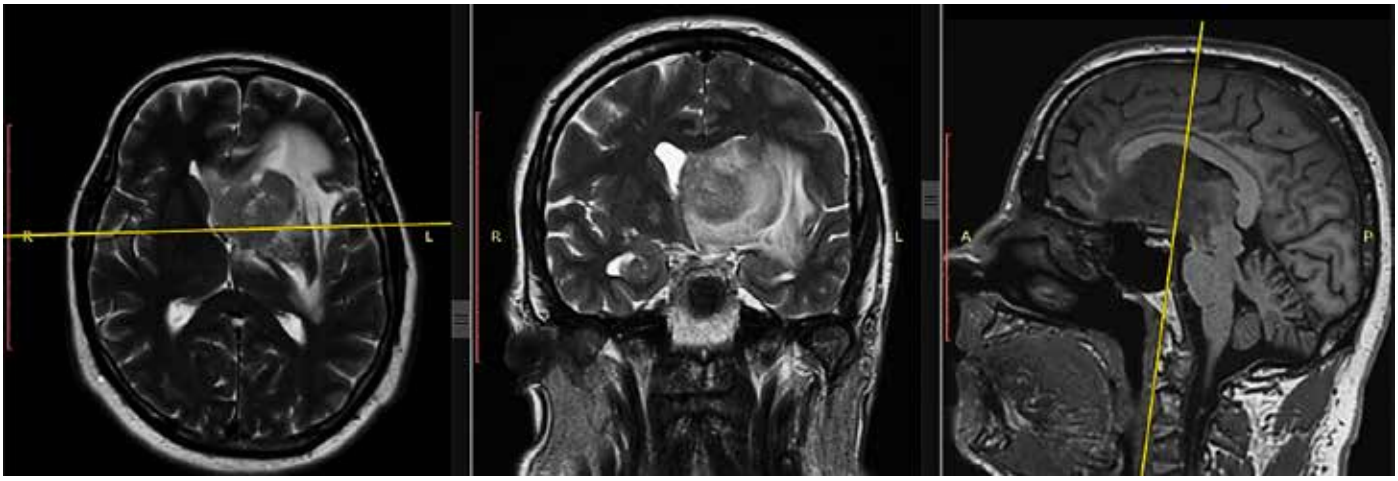


Figure nr. 3: Intraoperative view of neuro-navigation use for intraparenchymal biopsy sampling

