ScientificScholar®
Knowledge is power
Publisher of Scientific Journals

www.surgicalneurologyint.com

Surgical Neurology International

**Editor-in-Chief:** Nancy E. Epstein, MD, Professor of Clinical Neurosurgery, School of Medicine, State U. of NY at Stony Brook.

SNI: Neurovascular

**Editor**
Kazuhiro Hongo, MD
Shinshu University, Matsumoto, Japan

SNI®
Open Access

*Original Article*

# The long-term effect on functional outcome of endoscopic brainwashing for intraventricular hemorrhage compared to external ventricular drainage alone: A retrospective single-center cohort study

Talita Helena Martins Sarti, Marcos Devanir Silva da Costa, Daniel Paz Araujo, Rodrigo Akira Watanabe, Samuel Tau Zymberg, Ítalo Capraro Suriano, Sergio Cavalheiro, Feres Chaddad-Neto

Department of Neurology and Neurosurgery, Federal University of São Paulo, São Paulo, Brazil.

E-mail: Talita Helena Martins Sarti - talita.helena.ms@hotmail.com; Marcos Devanir Silva da Costa - marcoscostaneuro@gmail.com; Daniel Paz Araujo - danieldearaujopaz@gmail.com; Rodrigo Akira Watanabe - rodrigo.watanabe@unifesp.br; Samuel Tau Zymberg - zymberg@terra.com.br; Ítalo Capraro Suriano - suriano.ops@terra.com.br; Sergio Cavalheiro - sergiocavalheironeuro@gmail.com; *Feres Chaddad-Neto - feres.chaddad@unifesp.br

***Corresponding author:**
Feres Chaddad-Neto,
Department of Neurology and Neurosurgery, Federal University of São Paulo, São Paulo, Brazil.

feres.chaddad@unifesp.br

Received: 16 January 2024
Accepted: 07 March 2024
Published: 29 March 2024

**DOI**
10.25259/SNI_37_2024

**Quick Response Code:**

## ABSTRACT

**Background:** Intraventricular hemorrhage (IVH) is a complex condition with both mechanical and chemical effects, resulting in mortality rates of 50–80%. Recent reports advocate for neuroendoscopic treatment, particularly endoscopic brainwashing (EBW), but long-term functional outcomes remain insufficiently explored. This study aims to outline the step-by-step procedure of EBW as applied in our institution, providing results and comparing them with those of external ventricular drainage (EVD) alone.

**Methods:** We performed a retrospective analysis of adult patients with IVH who underwent EBW and patients submitted to EVD alone at our institution. All medical records were reviewed to describe clinical and radiological characteristics.

**Results:** Although both groups had similar baseline factors, EBW patients exhibited a larger hemoventricle (median Graeb score 25 vs. 23 in EVD, $P = 0.03$) and a higher prevalence of chronic kidney disease and diabetes. Short-term mortality was lower in EBW (52% and 60% at 1 and 6 months) compared to EVD (80% for both), though not statistically significant ($P = 0.06$). At one month, 16% of EBW patients achieved a good outcome (Modified Rankin scale < 3) versus none in the EVD group ($P = 0.1$). In the long term, favorable outcomes were observed in 32% of EBW patients and 11% of EVD patients ($P = 0.03$), with no significant difference in shunt dependency.

**Conclusion:** Comparing EBW and EVD, patients submitted to the former treatment have the highest modified Graeb scores and, at a long-term follow-up, have better outcomes, demonstrated by the improvement of the patients in the follow-up.

**Keywords:** Brainwashing, Hypertension, Intraventricular hemorrhage, Neuroendoscopy, Stroke

## INTRODUCTION

Intraventricular hemorrhage (IVH) is a multifactorial condition. It may be traumatic or, more commonly, secondary to systemic arterial hypertension, arteriovenous malformation or aneurysm rupture, coagulopathy, vasculitis, tumor hemorrhage, or Moyamoya disease.[5,9,35] It is rarely an isolated condition once it is associated with subarachnoid hemorrhage, which occurs in 15% of cases and is associated with intraparenchymal hematoma in 40% of cases. The presence of intraventricular hematoma is a negative predictor for outcome in intracerebral hemorrhage (ICH) even when analyzed separately. Mortality in this disease ranges from 50% to 80%.[23,34]

IVH causes an acute increase in intracranial pressure, which leads to secondary brain injury. The harmful effect of IVH is not purely mechanical, as it has a neurotoxic reaction when triggering the inflammatory cascade.[1,11,19] The circadian rate of clot dissolution was estimated to be 10.8 days, and approximately 13% of patients with IVH evolve with chronic hydrocephalus.[26]

The surgical treatment of IVH consists of ventricular drainage exclusively, ventricular drainage with fibrinolysis, and neuroendoscopy. The sole insertion of ventricular drainage is technically easy, does not require many instruments and equipment, is widely available, and allows intracranial pressure monitoring. However, it does not act on the neurotoxic effect of the clot and may obstruct and increase the risk of infection. Thus, the effects of attempting to remove IVH with alteplase administered through the external ventricular drain were studied. It is a safe method for specific conditions, such as low-volume supratentorial hemorrhage, stable clot, no severe disability, and no associated cause (aneurysm, arteriovenous malformation, and coagulopathy). However, this treatment did not substantially improve functional outcomes.[24]

In 1985, endoscopic evacuation of IVH was described.[14] Since then, many authors have published their case series and modifications of the technique. The lack of criteria for choosing the procedure, the non-systematized approach to the patient, and the wide variety of techniques contributed to producing frustrating results.[2,3,16,18,27] However, more recent reports have encouraged neurosurgeons to apply the method.[13,21,22,28-30,33] Studies comparing neuroendoscopy and external ventricular drainage (EVD) plus alteplase administration favor the former, which is associated with lower mortality rates, less shunting dependency, more effective clot removal, and better outcomes.[8]

There is a lack of information related to the long-term functional outcomes of intraventricular endoscopic brainwashing (EBW) treatment. Thus, we intend to describe our approach to this condition as well as the surgical procedure step by step, serving as a guide to similar centers. We also reported our results with the method and compared it with the sole implantation of an external ventricular drain in patients who presented IVH. In view of the above, we aim to describe our approach in patients presenting with IVH and to provide a step-by-step guide for neuro EBW for this condition. We also reported our clinical and radiological results with the procedure and compared them with solely EVD.

## MATERIALS AND METHODS

We performed a retrospective analysis of adult (age >18 years) patients who underwent EBW for IVH and patients who underwent EVD alone at the Department of Neurosurgery of the University of São Paulo Hospital. At least one member of the surgical team was involved in all neuro EBW procedures.

All medical records were reviewed to determine patient demography and outcome: sex, age, comorbidities, clinical presentation; level of consciousness graded by the Glasgow Coma Scale (GCS) before and after surgery; the timing of operation; disability graded by the modified Rankin scale (mRS) 1 week, one month and six months after surgery; and ventricular shunt dependence.

Radiological findings were analyzed through computed tomography (CT). The severity of ventricular hemorrhage was graded according to the modified Graeb score.[20] The ICH score was calculated for each patient.[25] The hemorrhagic site was determined by applying the Cerebral Hemorrhage Anatomical RaTing inStrument (CHARTS).[15] Angiography scans were analyzed to investigate secondary causes of IVH.

The exclusion criteria were patients with any data missing from the medical records, patients who underwent craniotomy or conservative treatment, and patients presenting with IVH resulting from cerebellar and brainstem hemorrhage.

Qualitative variables were analyzed by contingency tests using Fisher‘s exact test, depending on the sample size and the adequacy of the normal distribution for each set of samples. The Mann–Whitney test was used to analyze quantitative variables if the samples had a distribution pattern that was not normal. An $\alpha \leq 0.05$ was considered significant. Data analysis and graph creation were performed using GraphPad Prism 8 for macOS version 8.0.1.

### Operation and technical nuances

The same neurosurgical team performed all EBW procedures in a standardized manner. We started by evaluating the following aspects of the CT scan [Figure 1].

- The amount of blood in each of the lateral ventricles: It guides the choice of the laterality of the approach
- If the blood extends to the third ventricle, It is important to enter the third ventricle to remove as much of the clot as possible and to perform a third ventriculostomy.
- Identification of the coronal suture: It is of most importance to identify the coronal suture and to

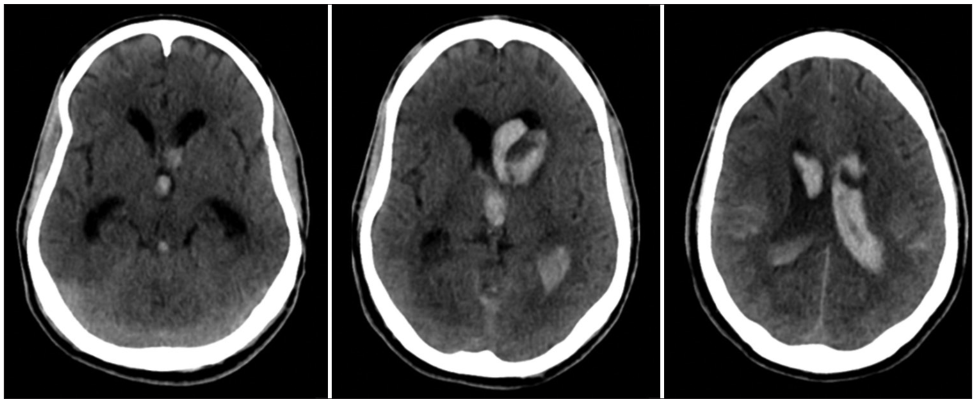

**Figure 1:** The axial computed tomography scan revealed that both lateral ventricles were inundated; however, the clot was more prominent on the left side once the hemorrhage originated at the left head of the caudate nucleus. It is also remarkable that the hemorrhage extended to the third ventricle.

calculate its distance from the nasion to proceed to trepanation at the Kocher point

- Calculate the trajectory: The intraventricular clot distorts the ventricular anatomy and prevents the identification of the structures. Thus, an accurate preoperative calculation allows for a secure endoscope introduction [Figure 2].

We performed neuroendoscopy with a rigid endoscope (Decq or Gaab lens 30°). The necessary equipment also includes Fogarty catheters 4F and 5F, approximately 12 L of warm lactate ringer or saline solution 0.9%, and two suction hoses connected separately. The necessary equipment is set up as demonstrated in Figure 3.

Each patient was positioned prone with the head flexed enough to place the endoscope entry point at the highest [Figure 4]. After calculating the trajectory and the points, we started the surgery. A parallel to midline frontal skin incision was made in the side of the ventricle that exhibited the largest amount of blood. We proceeded with a 14 mm burr hole in front of the coronal suture and 2.5 cm lateral to the median line. The dura mater was coagulated and incised, and the brain cortex was also coagulated at this point. It is important to keep the surgical field bloodless.

A rigid endoscope was used for all procedures, and the cerebral aqueduct and the fourth ventricle could not be accessible as with flexible endoscopes.[30]

We cannulated the ventricle with an introducer and sheath approximately 3–5 cm in depth (this value varied according to the previously calculated trajectory) until the corpus callosum was pierced. After entraining the lateral ventricle, the endoscope optic was coupled to the sheath. At this point, there was no anatomical landmark due to the clots in the ventricle [Figure 5a]. After continuous irrigation, we started intermittent aspiration with the hose connected directly to the working channel. It is important to make sure to touch the clot before aspirating to avoid lesions to the intraventricular structures. This step is slow and requires patience [Figures 5b and 5c]. The procedure is sufficient when ventricle structures are well recognizable [Figure 5d]. The clots that are adherent to the ventricle walls or the choroid plexus can be aspirated with a Fogarty 5F catheter (with its tip cut). This maneuver avoids energetic aspiration and further damage.

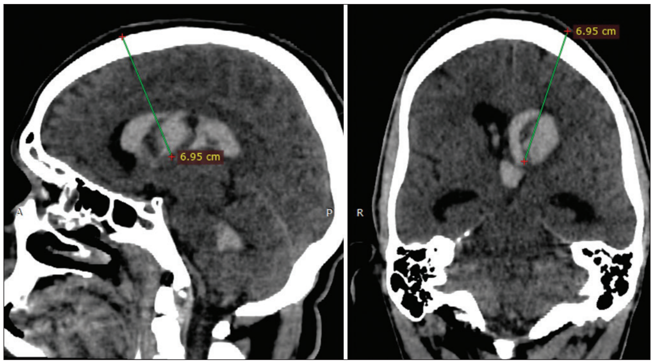

**Figure 2:** This example illustrates the simulation of the endoscope trajectory and the depth to achieve the third ventricle. This measurement is essential to avoid the prominent introduction of the endoscope at the beginning of the surgery when there is no anatomical clarity of the structures.

At this point, the foramen of Monro should be well identified. We advanced the endoscope into the third ventricle, and the steps performed at the lateral ventricle were repeated. The clots at this ventricle were not as adherent to the walls as in the lateral ventricle, and they cleared faster. It is necessary to evaluate two main points of obstruction: the foramen of Monro and the entrance to the cerebral aqueduct. If needed, aspiration with a Fogarty 5F catheter was attempted at these tender and dangerous regions. When the floor of the third ventricle was adequately visible, we proceeded with the third ventriculostomy by perforating the *tuber cinereum* and ballooning with a Fogarty catheter number 4 Fr.

**Figure 3:** The endoscope is disposable, as demonstrated here. The distal overture received continuous saline or lactate irrigation. A hose is connected to the proximal overture at the working channel, and intermittent aspiration is made during large clot cleaning.

**Figure 4:** The patient is positioned supine. The head is flexed until the entry point of the endoscope is the highest.

If both ventricles were extensively inundated, we repeated the procedure on the other side. If not, we performed a septostomy to communicate with both lateral ventricles. At the end of the surgery, we introduced a ventricular catheter working as an external ventricular drain and intracranial pressure monitoring. We set the drain up to 10 mmHg.

## RESULTS

Forty-seven patients with IVH treated surgically in our department between May 2013 and March 2023 were included in our study. The patients' mean age was 55 years (range 18–79). Thirty-six patients (80%) presented with GCS < 9.

IVH was due to hypertension in 23 patients (51.1%), spontaneous subarachnoid hemorrhage secondary to aneurysm rupture in 17 patients (37.7%), and other etiologies, such as vasculitis, sinus venous thrombosis, and sympathomimetic drug abuse, in 5 patients (11.1%). Concerning the anatomical location of hemorrhage, the thalamus was most common based on the CHARTS instrument. The median mGS was 25.

Twenty-five patients were treated with EBW and 20 with EVD. There were no differences between the EBW and EVD groups regarding age, arterial hypertension, heart disease, dyslipidemia, sympathomimetic drug abuse, smoking, and GCS score. The EBW patients were more likely to have chronic kidney disease (20% EBW group vs. 0 EVD group, $P = 0.05$) and diabetes (32% EBW group vs. 5% EVD group, $P = 0.03$). The demographic, clinical, and radiological characteristics of the patients from each group are provided in Table 1.

When comparing mGS from the EBW and EVD groups, the differences were statistically significant ($P = 0.03$). The patients who had EBW exhibited bulkier hemoventricle, with a median mGS of 25. The EVD group had a median mGS of 23.

Regarding the patients who had EBW, the mortality at 1 and 6 months was 52% and 60%, respectively, while that of the patients who underwent EVD surgery was 80% and 80%, with no significant difference between the mortality curves. There was a tendency (not statistically significant, $P = 0.06$) to have a lower short-term mortality rate in the EBW group. The average hospital stay after the operation was 38.5 days in the EBW group and 20.1 days in the EVD group, with no significant difference between them. A good outcome was considered when mRS ≤3, and in a short-term follow-up (1 month), it was achieved by 4 (16%) patients from the EBW group and 0 from the EVD group ($P = 0.1$). In the long-term follow-up, a good outcome (mRS ≤ 3) was achieved by 8 (32%) patients from the EBW group and 1 (11%) patient from the EVD group ($P = 0.03$).

Comparing the patients who had EBW and the patients who had EVD, there was no significant difference in shunt dependency between the groups. Forty-two per cent of the patients who underwent EBW became shunt dependent, and 66% who underwent EVD became shunt dependent as well.

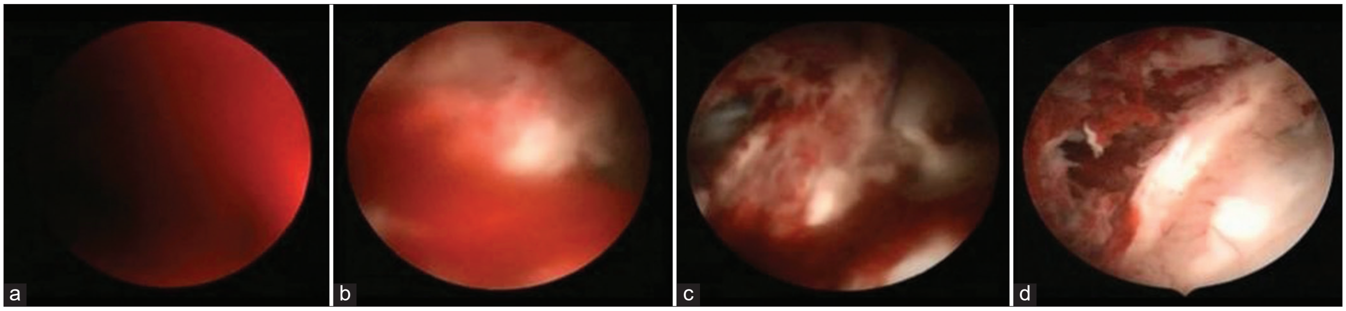

**Figure 5:** (a) The sequences show the initial aspect of the left ventricle soon after ventriculostomy and endoscope introduction. (b and c) After constant and patient washing, (d) the structures become more visible until the whitish wall of the ventricle is identified.

**Table 1:** Comparison between the groups of EBW and EVD.

| Variable | EBW (*n*=25) (%) | EVD (*n*=20) (%) | *P*-value |
|---|---|---|---|
| Median age (years) | 58 | 55.5 | 0.6 |
| Chronic diseases | | | |
| Arterial hypertension | 14 (56) | 11 (55) | >0.9 |
| Diabetes | 8 (32) | 1 (11) | 0.03 |
| Chronic kidney disease | 5 (20) | 0 | 0.05 |
| Heart disease | 4 (16) | 2 (10) | >0.9 |
| Smoking | 5 (20) | 4 (20) | >0.9 |
| Sympaticomimetc drug | 1 (4) | 0 | >0.9 |
| Glasgow coma scale at admission | | | |
| ≤8 | 20 (80) | 16 (80) | >0.09 |
| >8 | 5 (20) | 4 (20) | |
| ICH score | | | |
| ≤3 | 24 (90) | 18 (90) | 0.5 |
| >3 | 1 (4) | 2 (66.6) | |
| mGS (median) | 25 | 23 | 0.03 |
| Etiology | | | |
| Hypertension | 14 (56) | 9 (45) | 0.55 |
| Subarachnoid hemorrhage | 8 (32) | 9 (45) | 0.53 |
| 1-month mRS | | | |
| ≤3 | 4 (16) | 0 | 0.1 |
| >3 | 21 (84) | 20 (100) | |
| 6-month mRS | | | |
| ≤3 | 8 (33) | 1 (5) | 0.03 |
| >3 | 17 (68) | 19 (95) | |
| Length of hospital stay (median in days) | 38.5 | 20.1 | 0.3 |
| 30-day mortality | 13 (52) | 16 (80) | 0.06 |
| Overall mortality | 15 (60) | 31 (80) | 0.2 |
| Shunt dependence | 5 (41.6) | 2 (66.6) | 0.5 |

ICH score: Intracerebral hemorrhage score, mGS: Modified Graeb score, mRs: Modified Rankin scale, EBW: Endoscopic brainwashing, EVD: External ventricular drainage

## DISCUSSION

Isolated spontaneous IVH is a rare condition. IVH is usually associated with subarachnoid hemorrhage or intracerebral hematoma, presenting worse outcomes and an increased mortality rate when secondary to those conditions. The mortality rate has been reported to be 72% when combined with supratentorial ICH and 50–80% when isolated.[5,9,23,35]

Intraventricular hematoma has direct mechanical effects by impeding cerebrospinal fluid circulation and is also a chemical process that culminates with an inflammatory response and neurotoxin release.[11] After an acute and severe phase, the patients may progress to hydrocephalus, requiring one or more surgical procedures to treat it. Thus, the primary goal when treating IVH is to establish normal intracranial pressure by reassuming cerebrospinal fluid circulation and removing intraventricular clots.

EVD is a simple and fast procedure that promptly normalizes intraventricular pressure; however, it does not affect the neurotoxic consequences of IVH. EVD combined with a fibrinolytic agent has already been proposed. Although it has been shown to be safe, it may be associated with infection and rebleeding. Moreover, it did not satisfactorily (at least 80%) remove the intraventricular clot or improve functional outcome (modified Rankin ≤3 scale).[6,12,19,24,26]

Neuroendoscopic procedures for the treatment of IVH are not a novelty.[14] The evolution of radiological diagnosis and intraoperative techniques increased the efficiency of the approach and technical development, respectively. The overall mortality rates in our cohort (60% for the EBW group and 80% for the EVD group) were higher than those reported in the literature. We hypothesize that the patients who presented to our institution were more severely compromised and had more IVH clots. Short-term mortality was lower in the EBW groups, but there was no significant difference ($P = 0.06$). The long-term mortality rate was similar in both groups. Longatti described short-term and long-term (> six months) as 12% and 24%, respectively, for patients who had neuroendoscopic aspiration of intraventricular clots.[21,30] Chen *et al*. found 30-day and 90-day mortality rates between 12.5% and 20.8% for patients who had thalamic hemorrhage with intraventricular extension and who had EVD or endoscopic procedures. There was no significant difference.[7] Zhang *et al*. compared two surgical methods for IVH and found that five of 22 patients died in the neuroendoscopy group, and two of 20 patients died in the EVD group.[36] Johnson *et al*. studied the insertion of an EVD catheter and endoscopic washout for patients with massive IVH. The authors found that the mRS at six months of 5 or 6 was 52.2% and 31.2% for each group, respectively, with no significant difference.[17] Zhou *et al*. also compared surgical methods for severe thalamic hemorrhage with ventricular extension. Furthermore, these same authors demonstrated that there was a significant increase in the mortality of patients in the EVD group (28.57%) compared to the neuroendoscopic group (12.1%).[37]

The EBW group had a modified Graeb score significantly higher than the EVD group (median value of 25 vs. 23, $P = 0.03$). This indicates that patients who underwent brainwashing surgery had worse IVH than patients who underwent EVD. It isn't easy to compare this result with the previous studies reported because they calculated the intraventricular inundation by the Graeb score, and we reported our results based on the modified Graeb score. We encourage new studies to use the mGS, which is more closely related to IVH volume and outcome than the Graeb score.[10]

Studies that reported the outcome after neuroendoscopic surgery showed a favorable outcome, measured by the Glasgow Outcome Scale (GOS).[7,21,30] When comparing neuroendoscopic and EVD placement, some studies did not show any difference in mRS at six months[36] or GOS at three months,[31] despite some demonstrating a tendency of better outcome with endoscopic washout.[36] These studies explain that the outcome is determined mainly by the initial level of consciousness on arrival at the hospital and the primary pathology that caused the IVH.[7,36] In contrast, our study demonstrated better long-term functional outcomes (mRS ≤ 3) in the EBW group (32% vs. 5%, $P = 0.03$).

When analyzing shunt dependency, our study did not find significant differences between the groups. This is the opposite of our initial hypothesis because the washout technique allows mechanical removal of the clot, and other studies have demonstrated a significant reduction in permanent shunt. The shunt dependency rates were reduced more than 4–5 times in some studies.[4,7,17,30,32,36,37] The EBW group demonstrated 41.6% shunt dependency compared to 66.6% of the EVD group. This difference was not statistically significant, as the sample was small.

Our study has some limitations. It was a retrospective and single-center study. Many patients could not be included due to the lack of data in the medical records. In addition, the data collection of 45 patients and a heterogeneous sample has significant limitations. However, it was the first national experience reported in the literature to the best of our knowledge.

## CONCLUSION

The present study described our surgical planning and technical nuances. Besides some limitations, we demonstrated that patients with IVH are severely clinically compromised at admission (GCS < 9). Comparing EBW and EVD, patients who had the former treatment have the highest modified Graeb scores and, at a long-term follow-up, have better outcomes, as demonstrated by the improvement of the patients in the follow-up.

### Acknowledgments

The authors would like to thank Ph.D. Raphael Wuo-Silva for his contribution to the editing and final review of this manuscript.

### Ethical approval

The Institutional Review Board has waived the ethical approval for this study.

### Declaration of patient consent

The authors certify that they have obtained all appropriate patient consent.

**Financial support and sponsorship**

Nil.

**Conflicts of interest**

There are no conflicts of interest.

**Use of artificial intelligence (AI)-assisted technology for manuscript preparation**

The authors confirm that there was no use of artificial intelligence (AI)-assisted technology for assisting in the writing or editing of the manuscript and no images were manipulated using AI.

## REFERENCES

1. Adams RE, Diringer MN. Response to external ventricular drainage in spontaneous intracerebral hemorrhage with hydrocephalus. Neurology 1998;50:519-23.
2. Auer LM. Endoscopic evacuation of intracerebral haemorrhage: High-tecsurgical treatment-a new approach to the problem? Acta Neurochir (Wien) 1985;74:124-8.
3. Backlund EO, von Holst H. Controlled subtotal evacuation of intracerebral haematomas by stereotactic technique. Surg Neurol 1978;9:99-101.
4. Basaldella L, Marton E, Fiorindi A, Scarpa B, Badreddine H, Longatti P. External ventricular drainage alone versus endoscopic surgery for severe intraventricular hemorrhage: A comparative retrospective analysis on outcome and shunt dependency. Neurosurg Focus 2012;32:E4.
5. Brott T, Thalinger K, Hertzberg V. Hypertension as a risk factor for spontaneous intracerebral hemorrhage. Stroke 1986;17:1078-83.
6. Charidimou A, Schmitt A, Wilson D, Yakushiji Y, Gregoire SM, Fox Z, *et al*. The cerebral haemorrhage anatomical rating instrument (CHARTS): Development and assessment of reliability. J Neurol Sci 2017;372:178-83.
7. Chen CC, Liu CL, Tung YN, Lee HC, Chuang HC, Lin SZ, *et al*. Endoscopic surgery for intraventricular hemorrhage (IVH) caused by thalamic hemorrhage: Comparisons of endoscopic surgery and external ventricular drainage (EVD) surgery. World Neurosurg 2011;75:264-8.
8. Costa MD, Lopes RR, Serrato-Avila JL, Cavalheiro S, Chaddad-Neto F. Endoscopic brainwash after clipping a ruptured aneurysm of the communicating segment of the intracranial carotid artery. Surg Neurol Int 2020;11:396.
9. Daverat P, Castel JP, Dartigues JF, Orgogozo JM. Death and functional outcome after spontaneous intracerebral hemorrhage. A prospective study of 166 cases using multivariate analysis. Stroke 1991;22:1-6.
10. Fiorindi A, Saraceno G, Zanin L, di Bergamo LT, Feletti A, Doglietto F, *et al*. Endoscopic evacuation of massive intraventricular hemorrhages reduces shunt dependency: A meta-analysis. Asian J Neurosurg 2022;17:541-6.
11. Gaberel T, Magheru C, Emery E. Management of non-traumatic intraventricular hemorrhage. Neurosurg Rev 2012;35:485-94.
12. Goh KY, Hsiang JN, Zhu XL, Poon WS. Intraventricular recombinant tissue plasminogen activator for treatment of spontaneous intraventricular haemorrhage in pregnancy. J Clin Neurosci 1999;6:158-9.
13. Hamada H, Hayashi N, Kurimoto M, Umemura K, Nagai S, Kurosaki K, *et al*. Neuroendoscopic removal of intraventricular hemorrhage combined with hydrocephalus. Minim Invasive Neurosurg 2008;51:345-9.
14. Hanley DF, Lane K, McBee N, Ziai W, Tuhrim S, Lees KR, *et al*. Thrombolytic removal of intraventricular hemorrhage in treatment of severe stroke: Results of the randomized, multicentre, multiregion, placebo-controlled CLEAR III trial. Lancet 2017;389:603-11.
15. Hemphill JC 3rd, Bonovich DC, Besmertis L, Manley GT, Johnston SC. The ICH score: A simple, reliable grading scale for intracerebral hemorrhage. Stroke 2001;32:891-7.
16. Horvath Z, Veto F, Balas I, Kover F, Doczi T. Biportal endoscopic removal of a primary intraventricular hematoma: Case report. Minim Invasive Neurosurg 2000;43:4-8.
17. Johnson JR, Idris Z, Abdullah JM, Alias A, Haspani MS. Prevalence of shunt dependency and clinical outcome in patients with massive intraventricular haemorrhage treated with endoscopic washout and external ventricular drainage. Malays J Med Sci 2017;24:40-6.
18. Kamikawa S, Inui A, Kobayashi N, Tamaki N, Yamadori T. Intraventricular hemorrhage in neonates: Endoscopic findings and treatment by the use of our newly developed Yamadori-type 8 ventriculoscope. Minim Invasive Neurosurg 2001;44:74-8.
19. Li N, Liu YF, Ma L, Worthmann H, Wang YL, Wang YJ, *et al*. Association of molecular markers with perihematomal edema and clinical outcome in intracerebral hemorrhage. Stroke 2013;44:658-63.
20. Li Y, Zhang H, Wang X, She L, Yan Z, Zhang N, *et al*. Neuroendoscopic surgery versus external ventricular drainage alone or with intraventricular fibrinolysis for intraventricular hemorrhage secondary to spontaneous supratentorial hemorrhage: A systematic review and meta-analysis. PLoS One 2013;8:e80599.
21. Longatti PL, Fiorindi A, Martinuzzi A. Neuroendoscopic aspiration of hematocephalus totalis: Technical note. Neurosurgery 2005;57(4 Suppl): E409.
22. Longatti PL, Martinuzzi A, Fiorindi A, Maistrello L, Carteri A. Neuroendoscopic management of intraventricular hemorrhage. Stroke 2004;35:e35-8.
23. Mayfrank L, Kissler J, Raoofi R, Delsing P, Weis J, K€uker W, *et al*. Ventricular dilatation in experimental intraventricular hemorrhage in pigs. Characterization of cerebrospinal fluid dynamics and the effects of fibrinolytic treatment. Stroke 1997;28:141-8.
24. Morgan T, Awad I, Keyl P, Lane K, Hanley D. Preliminary report of the clot lysis evaluating accelerated resolution of intraventricular hemorrhage (CLEAR-IVH) clinical trial. Acta Neurochir Suppl 2008;105:2017-20.
25. Morgan TC, Dawson J, Spengler D, Lees KR, Aldrich C, Mishra NK, *et al*. The Modified Graeb Score: An enhanced tool for intraventricular hemorrhage measurement and prediction of functional outcome. Stroke 2013;44:635-41.

26. Mould WA, Carhuapoma JR, Muschelli J, Lane K, Morgan TC, McBee NA, *et al*. Minimally invasive surgery plus recombinant tissue-type plasminogen activator for intracerebral hemorrhage evacuation decreases perihematomal edema. Stroke 2013;44:627-34.
27. Nakano T, Ohkuma H, Ebina K, Suzuki S. Neuroendoscopic surgery for intracerebral haemorrhage: Comparison with traditional therapies, Minim Invasive Neurosurg 2003;46:278-83.
28. Neki H, Shibata A, Komine H, Kohyama S, Yamane F, Ishihara S, *et al*. Use of flexible endoscopic aspiration for an intraventricular small floating clot with hemorrhage: A technical note. Neurosurg Rev 2021;44:2363-7.
29. Oertel JM, Mondorf Y, Baldauf J, Schroeder HW, Gaab MR. Endoscopic third ventriculostomy for obstructive hydrocephalus due to intracranial hemorrhage with intraventricular extension. J Neurosurg 2009;111:1119-26.
30. Oka K, Go Y, Yamamoto M, Kumate S, Tomonaga M. Experience with an ultrasonic aspirator in neuroendoscopy. Minim Invasive Neurosurg 1999;42:32-4.
31. Rainov NG, Burkert WL. Urokinase infusion for severe intraventricular hemorrhage. Acta Neurochir (Wien) 1995;134:55-9.
32. Shimizu Y, Tsuchiya K, Fujisawa H. Endoscopic surgery for thalamic hemorrhage with intraventricular hemorrhage: Effects of combining evacuation of a thalamic hematoma to external ventricular drainage. Asian J Neurosurg 2019;14:1112-5.
33. Toyooka T, Kageyama H, Tsuzuki N, Ishihara S, Oka K. Flexible endoscopic aspiration for intraventricular casting hematoma. Acta Neurochir Suppl (Wien) 2016;123:17-23.
34. Tuhrim S, Horowitz DR, Sacher M, Godbold JH. Validation and comparison of models predicting survival following intracerebral hemorrhage. Crit Care Med 1995;23:950-4.
35. Yasargil MG, Yonekawa Y, Zumstein B, Stahl HJ. Hydrocephalus following spontaneous subarachnoid hemorrhage. Clinical features and treatment. J Neurosurg 1973;39:474-9.
36. Zhang Z, Li X, Liu Y, Shao Y, Xu S, Yang Y. Application of neuroendoscopy in the treatment of intraventricular hemorrhage. Cerebrovasc Dis 2007;24:91-6.
37. Zhou H, Cha Z, Wang L, Chen M, Zhang Q, Tang J. Clinical efficacy and safety of neuroendoscopic surgery for severe thalamic hemorrhage with ventricle encroachment. Neurosurg Rev 2022;45:2701-8.

**How to cite this article:** Sarti TMH, da Costa MDS, Paz Araujo D, Watanabe RA, Zymberg ST, Suriano IC, *et al*. The long-term effect on functional outcome of endoscopic brainwashing for intraventricular hemorrhage compared to external ventricular drainage alone: A retrospective single-center cohort study. Surg Neurol Int. 2024;15:109. doi: 10.25259/SNI_37_2024