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Research Article

Accuracy of Freehand Ventriculostomy in Resource-Limited Settings: Institutional Experience

Seyoum Debebe Alemu, MD[1], Abenezer Tirsit Aklilu, MD, PGD, FCS(ECSA)[2], Yabello Hirbo Guyolla, MD[3]*, Wondu Mekonnen Abebe, MD[4]

[1]Neurosurgery resident, Department of Surgery, College of Health Sciences, AAU, Addis Ababa, Ethiopia.

[2]Associate Professor of Neurosurgery, Department of Surgery, College of Health Sciences, AAU, Addis Ababa, Ethiopia.

[3]Assistant Professor of Neurosurgery, Surgery Department, Jimma University, Jimma, Ethiopia.

[4]General Surgeon, Bishoftu Hospital, Ethiopia.

***Corresponding Author:** Yabello Hirbo Guyolla, MD, Assistant Professor of Neurosurgery, Surgery Department, Jimma University, Jimma, Ethiopia.

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Abstract

Background: Freehand external ventricular drain (EVD) insertion remains the standard technique for managing acute hydrocephalus, though reported accuracy varies widely.

Objective: To prospectively evaluate the accuracy of freehand EVD placement and identify predictors of catheter misplacement.

Methods: Adult patients undergoing freehand EVD insertion between December 2020 and September 2021 at two tertiary centers were prospectively studied. Pre- and postoperative CT scans were assessed for catheter tip position, Evans index, midline shift, burr hole site, intracranial catheter length, number of attempts, and operator experience. Accurate placement was defined as catheter tip within the ipsilateral lateral ventricle. Associations were analyzed using chi-square tests and odds ratios (ORs) with 95% confidence intervals (CIs).

Results: Seventy-one patients (mean age 42.2 ± 15 years; 54.9% male) were included, mostly with obstructive hydrocephalus (78.9%). Accurate placement occurred in 46/71 (64.8%) cases. Misplacements were into the contralateral ventricle (14.1%), third ventricle (9.9%), or brain parenchyma/extraventricular (11.3%). Catheter length >60 mm was strongly associated with misplacement ($p < 0.001$; OR 8.73, 95% CI 2.29–33.29). Smaller ventricles (Evans index <0.30) ($p = 0.007$; OR 5.14, 95% CI 1.67–15.82) and ≥3 insertion attempts ($p = 0.007$; OR 5.20, 95% CI 1.66–16.26) increased misplacement risk and postoperative complications (70.0% vs 32.3%, $p = 0.0035$). Burr hole site and operator experience showed no significant effect.

Conclusion: Freehand EVD achieved accurate ventricular placement in 64.8% of cases. Excessive catheter length, small ventricles, and multiple attempts predicted misplacement, underscoring the need for improved training and selective image guidance.

Keywords: *External Ventricular Drain, Ventriculostomy, Kocher's Point, Frazier's Point, Accuracy, Evans Index*

Introduction

External ventricular drain (EVD) insertion is one of the most common and essential lifesaving procedures in neurosurgery. First described in 1744 by Claude-Nicholas Le Cat [1] the technique, materials, indications, and safety profile have evolved considerably. Current indications include hydrocephalus secondary to subarachnoid hemorrhage (SAH), intracerebral hemorrhage (ICH), intraventricular hemorrhage (IVH), posterior fossa masses, and traumatic brain injury (TBI)[2,3,4,5]

To improve accuracy, Ghajar introduced a ventricular catheter guide advocating a perpendicular trajectory to the skull surface[6]. In a retrospective comparison of freehand, stereotactic, and ultrasound-guided techniques, accurate placement was achieved in only 55% of freehand insertions versus 88% and 89% with the guided methods[2] Nevertheless, freehand EVD remains the standard of care because of its simplicity and rapid deployment in emergencies [6,7,8].

Accuracy rates for freehand EVD vary widely, from 7% to 45% [3]partly due to differing definitions. Kakarla et al.[9] proposed a three-grade anatomical scoring system based on catheter tip location, while Huyette et al. [7]and O'Leary et al. [10]defined accuracy by measuring distance from the foramen of Monro, with O'Leary further noting midline crossing. Misplacement into eloquent brain regions can cause serious complications, including coma, pial AV fistula, gaze palsy, and pseudoaneurysm, and may require catheter reinsertion. Non-infectious complications occur in approximately 5.6%, including hemorrhage and severe malposition [11]Multiple passes increase risks of hemorrhage, neurological injury, infection, and prolonged hospitalization [9].

Although several studies have evaluated freehand EVD accuracy, most are retrospective, and none have been reported from our setting. This study prospectively assesses the accuracy of successful ventriculostomy catheter placement, identifies factors associated with misplacement, and documents resulting complications. The findings aim to inform practice improvement and provide benchmark data for future research.

2. Methods

2.1 Study design and setting

We performed a prospective cross-sectional study at Tikur Anbessa Specialized Hospital (TASH) and Myungsung Christian Medical Center (MCM), Addis Ababa, Ethiopia, between December 1, 2020 and September 30, 2021.

2.2 Participants

All adult patients (≥18 years) undergoing freehand EVD insertion with available pre- and postoperative CT scans were included. Exclusion criteria: missing records, lack of postoperative CT, or insertion using image guidance.

2.3 Data collection

Patient demographics, indication, preoperative Evans index, midline shift, burr hole site (Kocher's vs Frazier's), intracranial catheter length (measured from outer table at burr hole to catheter tip on oblique reformatted CT (figure 1 and 2)), number of insertion attempts, operator experience (junior residents R2–R3 vs senior residents/consultants R4–R5/consultant), and complications were recorded. Catheter tip location categories: ipsilateral lateral ventricle (accurate), contralateral lateral ventricle, third ventricle, extraventricular/parenchymal (inaccurate). Successful intraoperative placement (CSF outflow) was recorded but accuracy was determined radiologically.

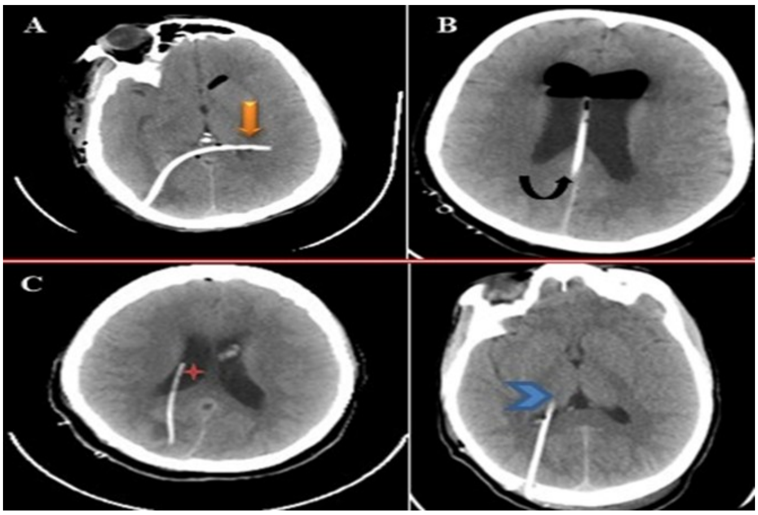

Figure 1. *Axial computed tomographic scans showing accuracy of external ventricular catheter tip location: (A) Contralateral parenchyma (orange block arrow). (B) Interhemispheric fissure (curved black arrow) (C) Ipsilateral ventricle (red star) (D) Ipsilateral thalamus (chevron).*

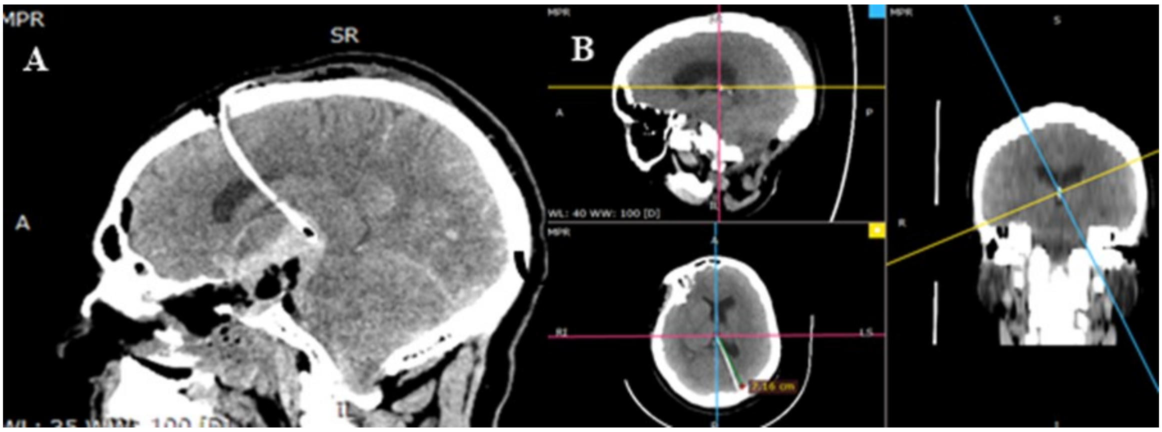

Figure 2. *Obliquely reformatted CT scan showing intracranial catheter length measurement: A) Intracranial catheter length measurement for Kocher's EVD. B) Intracranial catheter length measurement for Frazer's EVD.*

2.4 Statistical analysis

Data were entered into SPSS v23. Continuous variables are reported as mean ± SD. Categorical variables are presented as counts and percentages. Associations between categorical variables were assessed with chi-square tests. For 2×2 comparisons we computed odds ratios (OR) with 95% confidence intervals (CI). A p-value < 0.05 (two-sided) was considered statistically significant.

2.5 Ethics

Ethical approval was obtained from institutional review boards; informed consent was obtained from patients or surrogates.

3. Results

3.1 Patient characteristics

Seventy-one patients met inclusion criteria. Mean age was 42.2 ± 15 years and 39 (54.9%) were male. Most patients were treated at TASH (56/71, 78.9%). The commonest indication was obstructive hydrocephalus due to posterior fossa mass (56/71, 78.9%), followed by intraventricular hemorrhage (11/71, 15.5%) and post-infectious hydrocephalus (4/71, 5.6%). Comorbid hypertension was present in 5/71 (7%). (Table 1 — patient characteristics)

Table 1: Patient characteristics (n = 71)

Patient characteristics		**Frequency (%)**
Teaching hospitals	TASH	56 (**78.9%**)
	MCM	15 (**21.1%**)
Mean age in years		42.2±15
Sex	Male	39 (**54.**9)
	Female	32 (**45.1**)
Address	Urban	43 (**60.6**)
	Rural	28 (**39.4**)
Diagnosis	obstructive HCP secondary to PFM	56 (**78.9**)
	IVH	11 (**15.5**)
	post infectious HCP	4 (**5.6**)
Comorbidities	None	66 (**93**)
	Hypertension	5 (**7**)

** HCP = hydrocephalus; PFM = posterior fossa mass; IVH= intraventricular hemorrhage.*

3.2 Overall accuracy and catheter tip distribution

Radiologic analysis showed the catheter tip in the ipsilateral lateral ventricle in 46/71 patients (64.8%). Misplacements were observed as follows: contralateral lateral ventricle 10/71 (14.1%), third ventricle 7/71 (9.9%), and extraventricular/parenchymal locations 8/71 (11.3%).

3.3 Burr hole site and operator experience

Burr hole approaches: right frontal 14 (19.7%), left frontal 3 (4.2%), right parietal 31 (43.7%), left parietal 23 (32.4%). Accuracy was 14/17 (82.3%) for frontal (Kocher's) and 32/54 (59.3%) for parietal (Frazier's), but the difference did not reach statistical significance (chi-square p = 0.148). Operator experience (R2–R3 versus R4–R5/consultant) was not significantly associated with tip location (p = 0.308). (Table 2–3).

Table 2. Burr hole site and accuracy.

Burr hole site	***Accuracy, n (%)***		***Total***	
	Accurate	Inaccurate		
Frontal(Kocher's)	14(**82.3**)	3(**17.7**)	17	*P = 0.148*
Parietal(Frazer's)	32(**59.3**)	22(**40.7**)	54	

Table 3. Surgeon's experience versus tip location.

Surgeons experience	***Tip location***		***Total***	
	Ipsilateral lateral ventricle	Others		
Less experienced (R2 and R3)	15 (**21.1%)**	12 (**19.9%**)	27	*P = 0.308*
Experienced (R4,R5,and consultant)	31 (**43.7%**)	13 (**18.3%**)	44	

3.4 Intracranial catheter length

Mean intracranial catheter length from burr hole to tip was 79.9 ± 19 mm. Using a threshold of 60 mm, catheters >60 mm were associated with markedly higher misplacement. Misplacement occurred in 22/43 (51.2%) when catheter length was >60 mm vs 3/28 (10.7%) when ≤60 mm (p < 0.001). OR for misplacement with catheter length >60 mm was 8.73 (95% CI 2.29–33.29).

3.5 Evans index (ventricular size)

Mean preoperative Evans index was 0.34 ± 0.06. An Evans index <0.30 was associated with a higher rate of misplacement: 12/19 (63.2%) misplacement vs 13/52 (25.0%) when Evans index ≥0.30 (p = 0.0069). OR for misplacement with Evans index <0.30 was 5.14 (95% CI 1.67–15.82).

3.6 Number of attempts and complications

The mean number of insertion attempts was 2.85 ± 1.6 (range 1–8). Successful EVD drainage on insertion did not always predict correct catheter tip location. When insertion attempts were ≥3 the misplacement rate increased (20/40 inaccurate vs 5/31 inaccurate when <3 attempts; p = 0.0067; OR 5.20, 95% CI 1.66–16.26). Postoperative complications (intracerebral hemorrhage, pneumocephalus, ventriculitis) were more frequent with ≥3 attempts: complication rate 28/40 (70.0%) vs 10/31 (32.3%) for <3 attempts (p = 0.0035). (Table 4)

Table 4. Number of attempts and postoperative complications.

Number of attempts	*Postoperative complications*					
	ICH	**Pneumocephalus**	**Ventriculitis**	**None**	**Any complications**	
<3 (n = 31)	3	6	1	21	32.3%	*P = 0.0035*
≥3 (n = 40)	9	12	7	12	70.0%	

3.7 Summary of significant associations

Significant predictors of misplacement included intracranial catheter length >60 mm ($p < 0.001$), Evans index <0.30 ($p = 0.0069$) and ≥3 insertion attempts ($p = 0.0067$). Burr hole site and surgeon experience were not significantly associated with misplacement.

Table 5. Key Predictors of Ventriculostomy Misplacement.

Predictor	**Category**	**Inaccurate** n (%)	**p-value**	**Odds Ratio** (95% CI)
Catheter length	>60 mm vs ≤60 mm	22/43 (51.2%) vs 3/28 (10.7%)	<0.001	8.73 (2.29–33.29)
Evans index	<0.30 vs ≥0.30	12/19 (63.2%) vs	0.0069	5.14 (1.67–15.82)
Insertion attempts	≥3 vs <3	20/40 (50.0%) vs 5/31 (16.1%)	0.0067	5.20 (1.66–16.26)

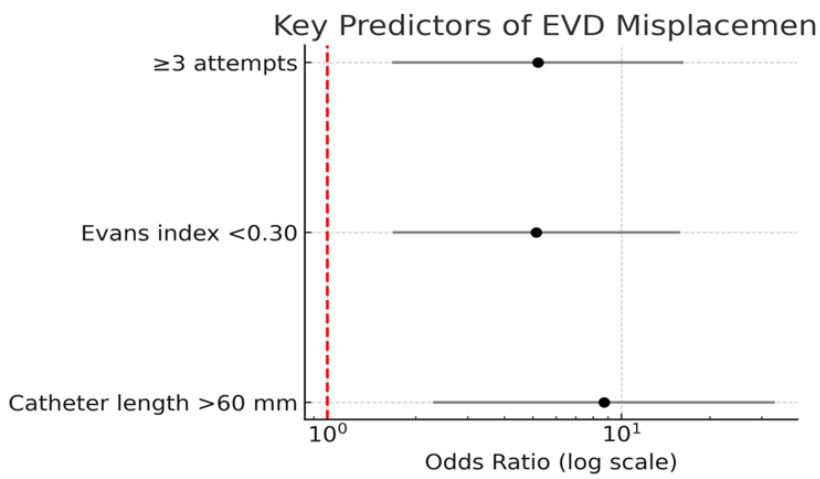

Figure 3. *EVD misplacement forestplot graph.*

4. Discussion

Freehand ventriculostomy, guided by superficial anatomical landmarks, remains the standard technique for managing acute hydrocephalus and for intraoperative brain relaxation during posterior fossa surgery [6,7,8] However, successful CSF return does not guarantee optimal catheter tip placement, as the proximal perforations may lie within the ventricle even when the tip resides in parenchyma [4].

There is no universal standard for defining optimal catheter tip position. Attempts to improve accuracy have included the Ghajar guide [6], which reduces the average distance from the foramen of Monro but is limited in cases with anatomical shift. Other authors have proposed radiologic grading systems, including millimetric distance to the foramen of Monro [7, 9], anatomical grading [9], and two-point accuracy scales [12]. In this study, accuracy was defined as tip placement in the ipsilateral lateral ventricle. Several key findings emerge.

First, freehand EVD placement resulted in ipsilateral lateral ventricular tip location in 64.8% of cases. This accuracy is comparable to several prior series that report placement accuracy between ~56% and 76% but lower than some reports (e.g., those reporting >80% accuracy when image guidance or strict protocols are used)[7], [9], [13]. The high use of Frazier's point and frequent reliance on improvised noncommercial catheters (nasogastric tube) (85.9%) may have contributed to reduced accuracy.

Second, the mean intracranial catheter length was 79.9 ± 20 mm. intracranial catheter length >60 mm (representing deeper trajectories often used with Frazier's point) strongly predicted misplacement (OR 8.73). This suggests that longer trajectories increase the risk of traversing non-target structures or crossing midline. This parallels Abdo et al. [3] findings. In our cohort, a majority of procedures used Frazier's point (parietal approach) because many EVDs were placed in the setting of posterior fossa surgery to facilitate brain relaxation; this likely contributed to longer catheter length on average.

Third, smaller ventricles (Evans index <0.30) significantly increased the odds of misplacement (OR 5.14). Small ventricles reduce the target volume and make freehand placement less forgiving; this is consistent with prior reports showing lower success with small ventricular size[4].

Fourth, the mean number of passes was 2.85 ± 1.6, higher than reports in previous studies [7], [14], [15]. ≥3 insertion attempts were associated with both misplacement (OR 5.20) and a higher rate of postoperative complications. Multiple passes increase the risk of parenchymal injury, hemorrhage, and infection and should be minimized. Our data reinforce the clinical principle that repeated blind passes are harmful and that consideration of alternative strategies after a limited number of unsuccessful attempts is prudent.

Operator experience (junior vs senior residents/consultant) and burr hole side/location did not show statistically significant associations with accuracy; however, small cell counts and the predominance of trainee-performed insertions could limit the power to detect modest effect sizes.

Collectively, these findings argue for a tiered approach to freehand EVD placement: freehand insertion remains a practical option — particularly in emergencies — but when ventricular size is small, the planned trajectory is long, or the initial attempts fail, early use of adjuncts (bedside ultrasound, neuronavigation, or intraoperative fluoroscopy) should be considered to reduce misplacement and complications.

Limitations and Strengths

This study did not evaluate revision rates, length of stay, or mortality associated with misplacement. However, it represents the first prospective analysis of freehand EVD accuracy in Ethiopia and the first local assessment of the relationship between number of passes and catheter malposition.

5. Conclusions

Freehand EVD placement achieved an accuracy of 64.8%. Longer catheter trajectory, smaller ventricles, and multiple attempts increased risk of misplacement and complications. Although freehand techniques are widely accepted, our findings highlight important limitations and underscore the need for improved accuracy in practice.

Authors' Contributions

SD: investigation, formal analysis, visualization, writing—original draft.

YH: formal analysis, visualization, conceptualization, writing—review and editing.

AT: validation, conceptualization, supervision.

WM: visualization, editing.

All authors read and approved the final manuscript.

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None.

Competing Interests

The authors declare no competing interests.

Data Availability

Datasets used and/or analyzed during the current study are available from the corresponding author on reasonable request.

Ethical Approval

Approval was obtained from the institutional review boards of participating hospitals; informed consent was obtained.

References

1. E. J. O. Kompanje and E. J. Delwel, "The first description of a device for repeated external ventricular drainage in the treatment of congenital hydrocephalus, invented in 1744 by Claude-Nicolas Le Cat," *Pediatr Neurosurg*, vol. 39, no. 1, pp. 10–13, 2003, doi: 10.1159/000070872.
2. T. J. Wilson, W. R. Stetler, W. N. Al-Holou, and S. E. Sullivan, "Comparison of the accuracy of ventricular catheter placement using freehand placement, ultrasonic guidance, and stereotactic neuronavigation: Clinical article," *J Neurosurg*, vol. 119, no. 1, pp. 66–70, 2013, doi: 10.3171/2012.11.JNS111384.
3. M. G. Abdoh *et al.*, "Accuracy of external ventricular drainage catheter placement," *Acta Neurochir (Wien)*, vol. 154, no. 1, pp. 153–159, Jan. 2012, doi: 10.1007/s00701-011-1136-9.
4. A. K. Toma, S. Camp, L. D. Watkins, J. Grieve, and N. D. Kitchen, External ventricular drain insertion accuracy: Is there a need for change in practice?, *Neurosurgery*, vol. 65, no. 6, pp. 1197–1200, Dec. 2009, doi: 10.1227/01.NEU.0000356973.39913.0B.
5. Alderson, J. Charles & Wall D. Continuous-pressure controlled external ventricular drainage for treatment of acute hydrocephalus: evaluation of risk factors. Japanese Soc Biofeedback Res. 1992;19(5):709–15.
6. J. B. G. Ghajar, "A guide for ventricular catheter placement Technical note," 1985.
7. D. R. Huyette, B. J. Turnbow, C. Kaufman, D. F. Vaslow, B. B. Whiting, and M. Y. Oh, "Accuracy of the freehand pass technique for ventriculostomy catheter placement: Retrospective assessment using computed tomography scans," *J Neurosurg*, vol. 108, no. 1, pp. 88–91, Jan. 2008, doi: 10.3171/JNS/2008/108/01/0088.
8. P. C. L. U. K. Y. Y. C. K. E. Lee JH, "Accuracy of the free hand placement of an external ventricular drain (EVD)."
9. kIM lj, C. W. T. N. S. R. Kakarla UK, "Safety and accuracy of bedside external ventricular drain placement. Vol. 63, Neurosurgery. 2008. - Google search
10. M. D. , PHD. , M. K. M. D. , D. A. H. M. D. , SHAUN T. O'LEARY, "Efficacy of the Ghajar Guide revisited," *J Neurosurg*, vol. 92, May 200AD.
11. V. M. Srinivasan, B. R. O'Neill, D. Jho, D. M. Whiting, and M. Y. Oh, "The history of external ventricular drainage: Historical vignette," *J Neurosurg*, vol. 120, no. 1, pp. 228–236, Jan. 2014, doi: 10.3171/2013.6.JNS121577.
12. A. Saladino, J. B. White, E. F. M. Wijdicks, and G. Lanzino, "Malplacement of ventricular catheters by neurosurgeons: A single institution experience," *Neurocrit Care*, vol. 10, no. 2, pp. 248–252, Apr. 2009, doi: 10.1007/s12028-008-9154-z.
13. Y. G. Park, H. J. Woo, E. Kim, and J. Park, "Accuracy and Safety of Bedside External Ventricular Drain Placement at Two Different Cranial Sites : Kocher's Point versus Forehead," *J Korean Neurosurg Soc*, vol. 50, no. 4, pp. 317–321, 2011, doi: 10.3340/JKNS.2011.50.4.317.
14. S. B. Phillips, F. Delly, C. Nelson, and S. Krishnamurthy, "Bedside external ventricular drain placement: Can multiple passes be predicted on the computed tomography scan before the procedure?," *World Neurosurg*, vol. 82, no. 5, pp. 739–744, Nov. 2014, doi: 10.1016/J.WNEU.2013.08.030.

15. A. AlAzri, K. Mok, J. Chankowsky, M. Mullah, and J. Marcoux, “Placement accuracy of external ventricular drain when comparing freehand insertion to neuronavigation guidance in severe traumatic brain injury,” *Acta Neurochir (Wien)*, vol. 159, no. 8, pp. 1399–1411, Aug. 2017, doi: 10.1007/S00701-017-3201-5.