DOI 10.4149/BLL_2024_113

Bratisl Med J 2024; 125 (11): 734–737

CLINICAL STUDY

Risk factors for external ventricular drainage infections

Veronika MAGOCOVA, Jan BANOCI, Vladimir KATUCH, Miroslav GAJDOS

Department of Neurosurgery, Medical faculty at Pavol Jozef Safrik University and University Hospital in Kosice, Slovakia.
vladimir.katuch@upjs.sk

ABSTRACT

INTRODUCTION: External ventricular drainage (EVD) is frequently used in neurosurgical interventions to drain cerebrospinal fluid (CSF). Nevertheless, it carries a high incidence of infectious complications, notably secondary meningitis and ventriculitis. In light of the previous rates of these EVD-related infections, we introduced a set of guidelines to lower the infection rate. This study aimed to assess the influence of the hospital-wide adoption of the EVD handling protocol on secondary infections related to EVD.

MATERIAL AND METHODS: We enrolled 171 patients scheduled for EVD placement for reasons other than infectious meningitis or ventriculitis from January 2021 to March 2024. A matched cohort of patients underwent logistic regression to adjust for and analyze regression discontinuity.

RESULTS: Infections were more prevalent in the group before the protocol's implementation (18.27% compared to 7.46%, p<0.0001). Regression analysis within the matched score cohort (n=104 in pre-protocol groups and n=67 in post-protocol groups) indicated that the period before the protocol was independently linked to a higher incidence of infections.

CONCLUSION: Implementing a stringent hospital-wide protocol for EVD handling can significantly diminish the rate of secondary infections associated with EVD *(Tab. 3, Fig. 1, Ref. 15)*. Text in PDF www.elis.sk

KEY WORDS: external ventricular drainage, meningitis, ventriculitis, infection.

Introduction

External ventricular drains (EVDs) are utilized in neurosurgery for monitoring intracranial pressure, temporary drainage of cerebrospinal fluid (CSF) due to ventricular system obstruction, or as part of treatment for infected internalized ventriculoperitoneal catheters (1). EVDs are associated with a significant incidence of nosocomial infections. Secondary meningitis and ventriculitis are recognized complications associated with elevated morbidity and mortality rates (2). Additionally, these infections are linked to prolonged stays in the intensive care unit, increased hospitalization, and elevated healthcare costs (3).

Diagnosing an infection related to a ventricular catheter can be challenging. For instance, patients with blood in the CSF may exhibit meningeal symptoms similar to infection. The primary neurological condition can also mask infection symptoms, and the neurosurgical intervention itself can induce a sterile inflammatory response, further complicating the diagnostic process for catheter-related infections (4). These diagnostic challenges can lead to delayed treatment of bacterial infections and unnecessary antimicrobial therapy (5).

Department of Neurosurgery, Medical faculty at Pavol Jozef Safrik University and University Hospital in Kosice, Slovakia

Address for correspondene: Vladimir KATUCH, MD, Assoc Prof, PhD, MBA, Department of Neurosurgery, Medical faculty at Pavol Jozef Safrik University and University Hospital in Kosice, Trieda SNP 1, SK-040 11 Kosice, Slovakia.
Phone: +0905 218 272

Various methods are available for preventing EVD infections, ranging from general measures like thorough skin disinfection and preoperative and perioperative antibiotic prophylaxis to reducing the duration of the surgical procedure. Others are more specific, such as antibiotic-impregnated drains (3), extended prophylactic antibiotic administration (6), or combinations thereof in protocols (7, 8). There may need to be more than the mere application of these measures, necessitating a comprehensive protocol. In recent years, numerous such protocols have been published (6, 8, 9, 10), resulting in a post-implementation infection rate of 0% (4). Our previous work examined our practice and recorded a high incidence of EVD infection at 18.27% (11).

The objective of our study was to examine the hypothesis that in this before-after intervention analysis, introducing a hospital-wide EVD protocol would decrease EVD infection rates.

Material and methods

We designed an experimental study comprising a prospective observational cohort compared with a retrospective observational cohort. Data were extracted from the patient record system and archived in an independent database. This database was also used in our previous study and prospectively updated. The pre-protocol group included patients with EVD from January 2021 to January 2023, while the post-protocol group comprised patients with EVD from February 2023 to March 2024. The study received approval from the Medical Ethics Committee (11).

EVD Surgical Protocol EVD placement followed the standard EVD placement protocol. Thirty minutes before incision, all

Tab. 1. Differences in EVD care before and after protocol implementation.

Area of Intervention	Before Protocol	After Protocol
Wound Coverage	Without official recommendation	Sterile coverage with change every 72 hours
CSF Sampling Frequency	Daily	Only when all other infection foci are excluded and clinical symptoms suggest meningitis
CSF Sampling Method	Without official recommendation	Sterile gloves, disinfection of sampling site immediately before and after sampling
Meningitis Treatment Strategy	Without official recommendation	Multidisciplinary meetings with infectious disease specialists

patients received either a single intravenous dose of 1500 mg of cefuroxime or, in case of allergy, 600 mg of clindamycin. After thorough hair removal with a shaver and skin disinfection, the patient was draped using standard sterile techniques, and a skin incision was made anatomically at the Kocher point – 2 cm ventral to the coronal suture, 3 cm lateral from the midline – frontal horn of the lateral ventricle. After creating a trephination hole, the dura was coagulated using bipolar coagulation and opened with a scalpel. A ventricular catheter for CSF drainage was then inserted. After obtaining CSF, the catheter was tunneled at least 4–6 cm from the insertion site and connected to an external CSF drainage system. The catheter was sutured to the skin to prevent dislocation and covered with a sterile dressing.

Postoperative EVD management protocol

The protocol included postoperative EVD care changes such as sterile dressing, frequency, method of CSF sampling, and meningitis treatment strategy (Tab. 1). CSF samples were collected according to the written protocol at insertion, upon suspicion of infection, 48–72 hours after starting antibiotic treatment, and after EVD removal.

In the pre-protocol period, CSF was routinely collected daily. In the post-protocol era, CSF was only collected if there was a strong suspicion of meningitis based on clinical symptoms, and other infection sites were ruled out. A neurosurgical resident collected CSF samples through a proximal 3-way needleless tap under strict aseptic measures. The rubber cap was disinfected with 70% alcohol, and 5 ml of CSF was collected and sent to the medical microbiology laboratory for culture and chemical analysis of glucose, proteins, and lactate concentration. Catheters were left in place if clinically indicated and changed only when malfunctioning or in cases of severe infections. Infection treatment strategies were regularly discussed during multidisciplinary meetings with infectious disease experts. Flow obstruction was usually resolved by flushing 2 ml of sterile 0.9% NaCl according to the same aseptic protocol.

Secondary EVD Infection Infection was defined according to the Centers for Disease Control and Prevention (CDC) criteria (12) as a positive CSF culture on the sampling day and at least two meningitis symptoms. Contamination was used when a patient had only one positive CSF culture for common skin pathogens, subsequent sample results were negative, and no treatment was initiated.

Statistical analysis and slope score

Comparison of patient data disease information and EVD data (CSF leakage, infection, CSF sampling frequency, and number of days with EVD) were evaluated. Continuous values were expressed as median ± interquartile range (IQR) and compared using analysis of variance and Student's t-test. Non-parametric data were compared using $\chi 2$ tests or the Mann–Whitney U test. Significant ($p<0.01$) associations identified by univariate analysis were further evaluated by binomial logistic regression analysis to determine independent predictors of EVD-related infection. A $p<0.05$ was considered significant.

Results

A total of 171 patients were included, with 104 patients in the pre-protocol group and 67 in the post-protocol group. EVD placement was primarily performed during urgent neurosurgical procedures before and after the protocol implementation (Tabs 2 and 3). Overall, there were 19/104 (18.27%) EVD-related infections in the pre-protocol patient group and 5/67 (7.46%) EVD-related infections in the post-protocol patient group ($p<.0001$) (Fig. 1). In the pre-protocol period, 64% of patients received Axetine or Clindamycin as perioperative prophylaxis, compared to only 2% of patients in the post-protocol period. In the post-protocol era,

Tab. 2. Characteristics of EVD infections and associated factors (n=104).

		Count	Percentage	Mean	Median
EVD type	Bactisiel	69	66.35	x	x
	Silverline	31	29.8	x	x
	Others	4	3.85	x	x
Duration of EVD	Total	x	x	12.83±12.27	9
	Without infection	x	x	9.98±8.11	10
	With infection	x	x	15.74±3.16	14
Samples from EVD	Total	x	x	2.41±3.77	3
	Without infection	x	x	1.58±1.74	1
	With infection	x	x	2.83±1.86	2
EVD infections		19	18.27	x	x
Infectious agent	Acinetobacter baumanii	4	3.84	x	x
	Staphylococcus haemolyticus	6	5.77	x	x
	Staphylococcus epidermidis	7	6.73	x	x
	Escherichia coli	1	0.96	x	x
	Pseudomonas aeruginosa	1	0.96	x	x

Tab. 3. Characteristics of implemented EVD and infectious complications after protocol implementation (n=67).

		Count	Percentage	Mean	Median
	Bactisiel	60	89.55	x	x
EVD type	Silverline	6	8.95	x	x
	Others	1	1.5	x	x
	Total	x	x	10.33 ±10.17	7
Duration of EVD	Without infection	x	x	7.41 ±6.24	5
	With infection	x	x	17.44 ±4.17	15
	Total	x	x	2.51 ±3.57	3
Samples from EVD	Without infection	x	x	2.17 ±1.94	2
	With infection	x	x	1.13 ±1.46	1
EVD infections		5	7.46	x	x
	Acinetobacter baumanii	0	0	x	x
	Staphylococcus haemolyticus	2	2.97	x	x
Infectious agent	Staphylococcus epidermidis	1	1.49	x	x
	Escherichia coli	1	1.49	x	x
	Pseudomonas aeruginosa	1	1.49	x	x

Taximed was administered as perioperative prophylaxis in 95% of cases, compared to only 27% in the pre-protocol group.

Discussion

Healthcare-associated infections, particularly secondary meningitis in neurosurgical patients with external ventricular drains (EVD), present a formidable challenge due to their potential for prolonged hospitalization, increased healthcare expenditures, and adverse patient outcomes, including mortality. To address this critical issue, healthcare facilities worldwide have implemented various protocols and strategies to reduce the incidence of secondary meningitis. This paper delves into the efficacy of a manipulation protocol in diminishing the likelihood of secondary meningitis in neurosurgical patients with EVDs.

In a quasi-experimental design utilizing a pre-post cohort approach, we observed a substantial decrease in the probability of secondary meningitis following the introduction of the manipulation protocol. Notably, the period preceding the protocol's implementation was significantly associated with a higher risk of secondary meningitis, underscoring the impact of the intervention.

When examining the infection rate, our findings revealed a notable decline from 18.27% to 7.46% in EVD-related infections with the implementation of the stringent EVD handling protocol. This reduction aligns with global efforts to mitigate the prevalence of secondary meningitis through diverse protocols and strategies employed in healthcare settings.

Identifying the precise intervention that contributed most significantly to the decreased infection rate poses a challenge. Nonetheless, heightened awareness regarding potential catheter system contamination emerges as a crucial factor in reducing infection rates. This emphasis on vigilance may play a pivotal role in driving success, known as the Hawthorne effect, where improved outcomes result from increased awareness and outcome measurement.

The reduced frequency of cerebrospinal fluid (CSF) sample collections is a fundamental aspect contributing to the lowered infection rate. Restricting CSF sampling to cases with suspected meningitis based on clinical symptoms and after ruling out other potential infection sources is pivotal. The number of CSF collections emerged as an independent risk factor for infection, emphasizing the importance of reasonably utilizing this procedure to minimize the risk of catheter contamination.

Healthcare-associated infections significantly impact the postoperative course of neurosurgical patients, leading to substantial morbidity and mortality. Despite being perceived as a routine neurosurgical procedure, the development of secondary meningitis from EVD carries significant costs, estimated at approximately 3,500 EUR per infected patient in Slovakia. From a healthcare economics perspective, implementing minimal interventions and modifying clinical practices can yield substantial benefits for patients and healthcare systems grappling with escalating costs.

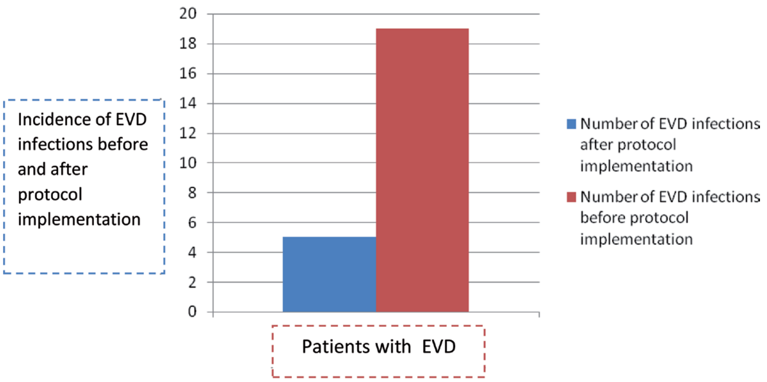

Fig. 1. Comparison graph of the number of EVD-infected patients before and after protocol implementation. The x-axis represents patients with established EVD, while the y-axis indicates the incidence of EVD infections before and after protocol implementation.

Conclusion

Overall, implementing a protocol in neurosurgical settings has proven to be crucial in reducing the incidence of secondary meningitis among patients with external ventricular drains. The significant decrease in infection rates, economic benefits, and improved patient outcomes highlight the importance of proactive infection control measures in healthcare settings.

Healthcare facilities must continue prioritizing infection prevention strategies, such as raising awareness, limiting unnecessary procedures, and monitoring outcomes. By investing in ongoing research and innovation in infection control, healthcare providers can further enhance patient safety, optimize resource utilization, and elevate the standard of care in neurosurgical practices.

In conclusion, the success of the manipulation protocol serves as a testament to the positive impact of evidence-based interventions in reducing healthcare-associated infections. By fostering a culture of continuous improvement and adherence to best practices, healthcare organizations can strive towards achieving better patient outcomes, reducing healthcare costs, and advancing the quality of care in neurosurgical settings. We demonstrated a significant decrease in the rate of EVD-related infections following the implementation of a hospital-wide protocol for EVD manipulation. Innovative approaches are needed to reduce the risk of secondary infections associated with EVD further.

References

1. **Van de Beek D, Drake JM, Tunkel AR.** Nosocomial bacterialmeningitis. N Engl J Med 2010; 362 (2): 146–154.

2. **Harris L, Munakomi S.** Ventriculitis. In: StatPearls (Internet). Treasure Island (FL): StatPearls Publishing; 2024 Jan. https://www.ncbi.nlm.nih.gov/books/NBK544332/.

3. **Edwards NC, Engelhart L, Casamento EM, McGirt MJ**. Cost-consequence analysis of antibiotic-impregnated shunts and external ventricular drains in hydrocephalus. J Neurosurg 2015; 122 (1): 139–147.

4. **Dorresteijn K, Jellema K, van de Beek D et al.** Factors andmeasures predicting external CSF drain-associated ventriculitis:a review and meta-analysis. Neurology 2019; 93 (22): 964–972.

5. **Ramanan M, Lipman J, Shorr A et al.** A meta-analysis ofventriculostomy-associated cerebrospinal fluid infections. BMC Infect Dis 2015; 15: 3.

6. **Alleyne CH Jr, Hassan M, Zabramski JM.** The efficacy and cost of prophylactic and perioprocedural antibiotics in patients with external ventricular drains. Neurosurgery 2000; 47 (5): 1124–7112.

7. **Leverstein-van Hall MA, Hopmans TE, van der Sprenkel JW et al.** A bundle approach to reduce the incidence of external ventricular and lumbar drain-related infections. J Neurosurg 2010; 112 (2): 345–353.

8. **Flint AC, Rao VA, Renda NC, Faigeles BS, Lasman TE, Sheridan W.** A simple protocol to prevent external ventricular drain infections. Neurosurgery 2013; 72 (6): 993–999.

9. **Dasic D, Hanna SJ, Bojanic S, Kerr RS.** External ventricular drain infection: the effect of a strict protocol on infection rates and a review of the literature. Br J Neurosurg 2006; 20 (5): 296–300.

10. **Korinek AM, Reina M, Boch AL, Rivera AO, De Bels D, Puybasset L.** Prevention of external ventricular drain--related ventriculitis. Acta Neurochir 2005; 147 (1): 39–45.

11. **Magočová V, Bánoci J, Kaťuch V, Gajdoš M.** Riziká vzniku infekcie vonkajšej komorovej drenáže. Folia Med Cassoviens 2024; 2 (18).

12. **Tunkel AR, Hasbun R, Bhimraj A et al.** 2017 Infectious Diseases Society of America's clinical practice guidelines for healthcare-associated Ventriculitis and meningitis. Clin Infect Dis 2017; 64 (6): e34–65.

13. **Pronovost P, Needham D, Berenholtz S et al.** An intervention to decrease catheter-related bloodstream infections in the ICU. N Engl J Med 2006; 355 (26): 2725–2732.

14. **Sedgwick P, Greenwood N.** Understanding the Hawthorne effect. BMJ 2015; 351: h4672.

15. **Timsit JF, Bouadma L, Ruckly S et al.** Dressing disruption is a major risk factor for catheter-related infections. Crit Care Med 2012; 40 (6): 1707–1714.

Received May 26, 2024.
Accepted July 15, 2024.