Review

Safe external ventricular drain management for infection prevention and control: a narrative review

Citation: Caroti G., Parente E., Beatrice Meucci B. "Safe external ventricular drain management for infection prevention and control: a narrative review" (2024) *infermieristica journal* 3(3): 205-212. DOI: 10.36253/if-2788

Received: May 29, 2024

Revised: June 15, 2024

Just accepted online: September 1, 2024

Published: September 30, 2024

Data Availability Statement: All relevant data are within the paper and its Supporting Information files. This article has been accepted for publication and undergone full peer review but has not been through the copyediting, typesetting, pagination and proofreading process, which may lead to differences between this version and the Version of Record

Competing Interests: The Author(s) declare(s) no conflict of interest.

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Abstract

Introduction: External ventricular drain (EVD) placement is a common neurosurgical procedure. Nurses play a crucial role in care, troubleshooting, and monitoring of EVD-related complications, making their education and training in this area of paramount importance. A well-trained nurse possesses the necessary knowledge and skills to recognize and respond promptly to EVD-related complications, such as infections, bleeding, and blockages. External ventricular drainage is associated with a high rate of nosocomial meningitis. The introduction of a well-implemented EVD care bundle can significantly decrease EVD infection rates. The support of the multi-item bundle for EVD is considered very important to reduce EVD-related infections.

Aim: To summarize the most recent available evidence for the prevention and control of EVD infections.

Methods: Comprehensive literature search had been done using the PubMed (Medline), Embase, CINAHL, and Cochrane databases. The narrative review was performed according to the PRISMA Extension for Scoping Review checklist (PRISMA-ScR).

Results: The query identified 4266 studies; after duplicate removal and exclusion of papers due to non-pertinent criteria, 26 studies were included.

Only three papers were related to pediatric patients and all were about EVD anchoring. Regarding the risk of infection, bundles and protocols are important for the reduction of the occurrence rate; however, staff adherence to these is fundamental.

Conclusion: Multidisciplinary staff and training are fundamental to improve EVD management. Avoiding routine or daily sampling reduces the EVD infection rate. When the procedure is requested, it is important to follow a strict protocol and to use sterile techniques. Hydrocolloid dressings, SecurAcath, gauze, and film dressings were used to anchor the cover EVD in the studies.

Keywords: Drain EVD; External ventricular; External ventricular catheter; EVD infection; EVD cover dressing.

Introduction

External ventricular drain (EVD) placement is a common neurosurgical procedure[1]. It is an intracranial cerebrospinal fluid drainage system, located within the cerebral ventricular system. It is also one of the oldest neurosurgical procedures since it has been used for more than two centuries[2]. There are diverse indications for EVD, which can have a therapeutic and life-saving role in patients with acute hydrocephalus[3]. EVD can also have a diagnostic role in measuring intracranial pressure and can be used to instill drugs, mainly antibiotics, into the cerebral ventricular system[4]. External ventricular Cerebrospinal Fluid (CSF) drains are used in patients of all ages, with different indications for neonates, children, and adults. In neonates, intraventricular hemorrhage is the most frequent cause of hydrocephalus, whereas in children, it is most commonly indicated for traumatic brain injury, neoplasm, hemorrhage, and infection[5]. In adults, subarachnoid hemorrhage is the main indication for external CSF drainage[6]. Nurses play a crucial role in care, troubleshooting, and monitoring of EVD-related complications, making their education and training in this area of paramount importance. A well-trained nurse possesses the necessary knowledge and skills to recognize and respond promptly to EVD-related complications, such as infections, bleeding, and blockages[7]. External ventricular drainage is associated with a high rate of nosocomial meningitis. Diagnosing ventricular catheter-associated infection can be difficult for example, in patients with a mixture of blood in the CSF, due to an underlying neurological condition that obscures the CSF characteristics typical of infection[8]. In such cases, symptoms of infection may be masked by the primary neurological condition, and neurosurgical intervention itself may cause a sterile inflammatory response, further hampering the diagnostic process of ventricular catheter-associated infections[9]. These diagnostic dilemmas may result in delayed treatment of patients with bacterial infections as well as unnecessary antimicrobial therapy[10]. The density incidence of external ventricular catheter-associated infection is 11 per 1000 catheter days (95% CI, 8–13), and 9–20% of patients with a ventricular cerebrospinal fluid drain develop catheter-associated infection[11]. Bacteria are introduced during surgery or routine care/manipulation of the drain. Infection may also be secondary to retrograde colonization from the distal end of the drain[12]. This latter is the most common cause of EVD-associated infection[11]. Causative bacterial pathogens are skin commensals such as Gram-positive coagulase-negative staphylococci, Staphylococcus aureus, and Gram-negatives Escherichia coli, Acinetobacter spp., and Klebsiella spp. [13]. Many bacterial pathogens can produce biofilms on the drain, hampering effective antimicrobial therapy[14,15]. Many studies have assessed the risk factors and interventions devised to reduce them. A literature review of 23 studies on 5,733 EVD insertions reported infection rates ranging between 0 and 22%[16]. However, there were inconsistencies between the definitions of the terms 'infection, contamination', and colonization. With the application of stringent criteria to define EVD infection (as "a single positive CSF culture obtained from a ventricular catheter or CSF from lumbar puncture"), the overall infection rate was found to be approximately 6% [16].

The shunt length plays a controversial role over time. A shunt length of ≥ 5 cm did not show statistically significant differences among studies, even in pediatric settings[17]. The introduction of a well-implemented EVD care bundle can significantly decrease EVD infection rates[18]. As cited in the Institute for Healthcare Improvement (IHI) definition, the bundle was created to support healthcare professionals in improving the care of patients undergoing specific high-risk treatments [19]. The IHI defines a bundle as "a contained set of evidence-based interventions, targeted on a specific population or subpopulation of patients and care settings that, when applied together, produce significantly better outcomes than if the same interventions were implemented separately"[20]. Bundle implementation has the greatest impact on health outcomes for patients, in which the hospital identifies gaps in best practice or persistence of poor health outcomes in a particular care setting. Evidence-based bundles for infection prevention and control have been shown to have a greater impact on reducing

infection risk than stand-alone implementation of individual improvement strategies[21]. The support of the multi-item bundle for EVD entry and management was found to be critical in reducing EVD-related infections[22]. This paper aimed to summarize the most recent available evidence for the prevention and control of EVD infections.

Materials and methods

The team involved in this narrative review was composed of two neurosurgical critical care nurses and a pediatric nurse who discussed the relevance of the research question and agreed on the research strategy and inclusion criteria.

With the assistance of a medical librarian, the team undertook a comprehensive literature search using the PubMed (Medline), Embase, CINAHL, and Cochrane databases. This narrative review was performed according to the PRISMA Extension for Scoping Review checklist (PRISMA-ScR)[23]. The query was formulated according to the Population, Intervention, Outcomes (PIO) methodology, as reported in the table below.

Table 1: PIO for bibliographic search

Population	Neurosurgical patient(s) with EVD
Intervention	Bundle, protocol, anchoring
Outcomes	Rate infection

The selected keywords were: external ventricular, drain OR EVD, external ventricular catheter.

Table 2: Query and database for bibliographic research

Database	Query
PUBMED	((external OR extra) AND ventric* AND (drainage OR drain OR catheter*)) OR ("external ventricular drain*"[tiab] OR "extraventricular drain*"[tiab] OR "extra ventricular drain*"[tiab]) OR (evd[TIAB] OR evds[TIAB]) NOT ebola
CINAHL	(external OR extra) AND ventric* AND (drain* OR catheter*)
EMBASE	('ventriculostomy catheter'/exp OR 'ventriculostomy catheter') AND [2016-2022]/py
COCHRANE	(((extern* OR extra*):ti,ab,kw)AND ((ventric*):ti,ab,kw) AND ((drain*):ti,ab,kw) OR (MeSH descriptor: [Drainage] explode all trees)OR ((catheter*):ti,ab,kw))OR (("external ventricular drain*"):ti,ab,kw)OR (("extraventricular drain*" OR "extra ventricular drain*" OR evd OR evds):ti,ab,kw)NOT (((ebola):ti,ab,kw) OR (MeSH descriptor: [Ebolavirus] explode all trees)OR (MeSH descriptor: [Hemorrhagic Fever, Ebola] explode all trees))) AND ((pediat* OR child*) OR (MeSH descriptor: [Child] explode all trees))

The inclusion criteria were adult and pediatric patients, monocenter and multicentric studies, systematic review, meta-analysis, RCTs, prospective studies, retrospective studies, scoping reviews, case reports, controlled studies, guidelines, books, full-text articles, all languages, and published from 2017 to December 2022.

In 2016, Fried and colleagues wrote evidence-based guidelines and recommendations based on the literature concerning the management of EDV.[24]

Our aim was to survey the literature after their article and assess any new developments.

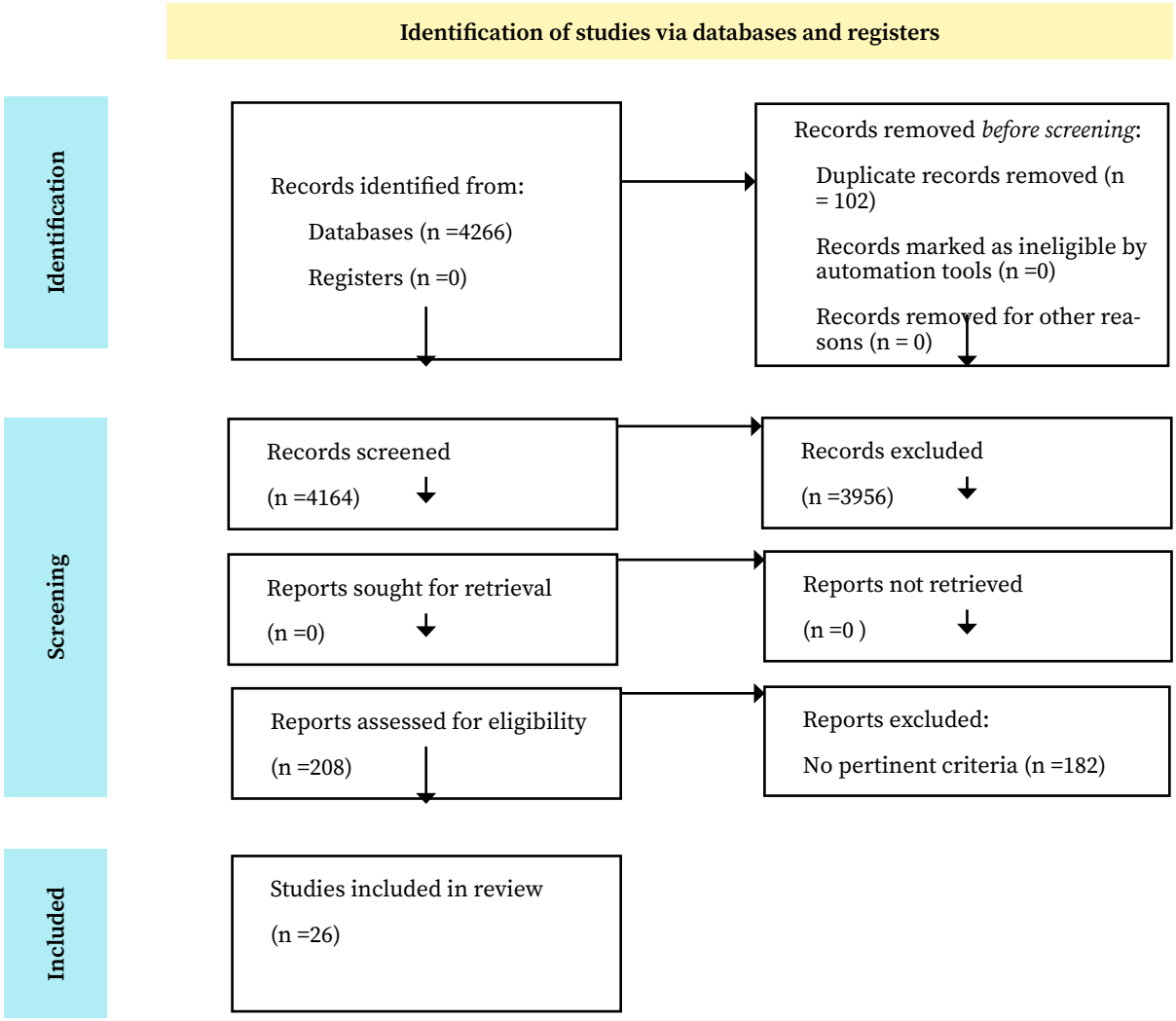
Exclusion criteria were in vitro and animal studies.

Results

The query identified 4266 studies; after duplicate removal and exclusion of papers due to non-pertinent criteria, 26 studies were included (Table 3).

We found 1667 studies on Pubmed®, 292 on Cinahl®, 2261 on EMBASE® and 46 on COCHRANE®. Only three papers were related to pediatric patients and all were about EVD anchoring[25,26,,27] .

Table 3: PRISMA 2020 flow-chart



The use of bundle and standardized protocols to prevent EVD infection

An accurate care permit to prevent possible EVD complications such as infection[28]. Regarding the risk of infection, bundles and protocols are important for the reduction of the occurrence rate; however, staff adherence to these is fundamental[28]. Hussein and colleagues have conducted a prospective observational study and they have examined risk factors for meningitis or ventriculitis. In total, 232 patients with 437 drains (212 EVDs, 92 LDs, and 133 ICPs) were included. During an Infection Control intervention to improve staff adherence to Infection Control practices, they observed that the infection rate decreased from 17.3 per 1000 drain days before the intervention to 7.9/1000 after the intervention[29]. Hong et al. [30] evaluated the effect of a multi-item bundle approach for EVD placement and care on the occurrence of EVD-related infections comparing patients before and after bundle introduction over a 5-year period. The pre-bundle group (A) comprised 141 patients and the post-bundle group (B) comprised 208 patients. The pre-bundle implementation group developed an EVD-related infection in 41/141 patients (29.1%) while in the post-bundle implementation group 10/208 (4.8%) ($p < 0.0001$). Over the next five years, there was a reduction in EVD-related infections from 29.1% to 4.8%, not only due to the use of bundles. The bundle was composed of multi-item EVD insertion and EVD care protocols. The EVD care protocol consisted of hand disinfection and sterile gloving before EVD manipulation, drainage changes using an alcoholic scrub disinfectant, daily drainage change by a physician, and scalp disinfection at the time of dressing changes. They continued antibiotic prophylaxis, CFS samples from 3-way tap, no replacements for EVD, and avoided EVD flushing in occluded EVD. Remove the EVD as soon as possible.

In a retrospective study, Talibi et al.[18] highlighted how the introduction of an EVD care bundle reduced the infection rate from 27% during the pre-bundle period to 10% during the post-bundle phase (p<0.001). Whyte et al. [31] in a quasi-experimental study, elaborated a bundle in which they included protocols and procedures for surgical site preparation, CSF withdrawals, and dressing management. They also emphasized how nursing care in drainage management should be standardized to minimize the risk of infection. However, there was no significant difference between the preoperative and postoperative groups (p= 0.89). Walek et al.[32] suggested that standardization of the EDV management procedure, from drain line to dressing, can cumulatively reduce the overall infection rate over time. Thus, these protocol interventions correlated with an estimated net reduction of 4.70 EVD infections/1000 EVD days (95% CI, 4.09 to 5.31; P < 0.001) between 2007 and 2019. In a retrospective study by Flint et al. [33], pre- and post-introduction of the protocol showed only one EVD infection out of 308 in 7 years (2005-2011). Lord et al.[34] in their systematic review, state that adoption of the bundle reduces surgical wound infection. The protocols focus on common points such as the use of a checklist, sterile technique in placement and during the procedure, haircutting, catheter type, tunneling, use of occlusive dressings, antibiotic prophylaxis, reduction in the frequency of CSF withdrawals, aseptic technique for retrieval and drain handling, routine EVD exchanges for long dwell time and all protocols included a staff training phase. The promotion of the protocol and bundle resulted in a reduction in EVD-related infections. Phan et al.[10], in their retrospective study, stated that there was no significant change in EVD infections post-protocol changes in 2006-2010. They introduced in "the EVD care protocol", the placement of EVD transduction systems in the operating room, the stop of antibiotic prophylaxis after 24 hours, the collection of cerebrospinal fluid (CSF) samples on the second or third day, and interruption of elective EVD changes[10]. They highlighted how multiple drains increased the risk of infection (p = 0.001); instead, antibiotic prophylaxis reduced it (p = 0.044). In their systematic review, Sieg et al.[35] reported a decrease in ventriculitis rate from 27% to 9%. They also performed a meta-analysis of the results of published studies and showed how the introduction of a protocol reduced infection rates, even if the quality of the studies was low. Walek et al. (32) in their longitudinal work showed an estimated reduction in EVD infections with the protocol (p<0.001). At the same time, Walek et al.[36] hypothesized that Prolonged EVD time was associated with a non-significant decrease in the incidence of EVD infections (2.0% risk for 1–7 days, 1.9% risk for 8–14 days, 1.6% risk for >14 days) because they used evidence-based infection protocols, including minimal catheter manipulation after insertion, no routine CSF sampling, and regular cleaning of the site with chlorhexidine in alcoholic solution. Zakaria et al.[37], in their retrospective study, used a standard protocol and identified 381 patients with 428 EVDs; the infection EVD rate was 1.86% (8 of 428). The same study showed that EVD replacement in the same access hole was significantly associated with the risk of infection.

EVD anchoring and cover dressing

Frassanito et al. conducted two studies on the use of devices for subcutaneous anchoring (Secur Acath ®) for EVD (26,27).

In 2016, they performed a preliminary experiment for the use of SecurAcath® to anchor EVD in 29 patients. In 2018, they performed a retrospective study of 209 patients from 0 – 18 years. They found no complications related to the use of these devices, particularly in cases of dislocation, accidental removal, kinking or tearing of the catheter, skin erosion, or infections. In the case of CSF leak, they successfully used skin glue. They stated that the use of these devices is safe and highly effective for the securement of EVD[26,27]. In their scoping review, Sakamoto et al. discussed cover dressing (27). They recommend that the dressing must be performed using a sterile technique to avoid local and systemic infections. They suggested that dressing made with gauze must be changed daily. Instead, the dressing made with film must be changed weekly. Velasquez et al. anchored EVD with a hydrocolloid dressing in pediatric patients. They reported only two EVD dislodgements (0,4%) and no case of obstruction caused by the fixation material (staples and hydrocolloid dressing)[28]. Waqar et al. evaluated the efficacy of chlorhexidine dressing in avoiding EVD infection through a systematic review and meta-analysis. They concluded that a chlorhexidine dressing could reduce the risk of EVD infection[38].

Discussion

There are many strategies to reduce the risk of EVD Infection, including bundles, protocols, and

standardized anchoring. However, complications of mechanical origin can be partially prevented by EVD medication. The literature suggests the use of bundles and protocols made by all health categories and sharing protocols with staff in a meeting before use. It could offer the possibility to create questions, understand every part, and share the target in a short and long time.

The medical literature agrees that routine or daily CSF sampling increases infection rates. Every time the EVD is manipulated or opened, there is a possibility that bacteria and viruses will enter. However, in these two articles [32,38] the professionals (nurses, surgeons, anesthesiologists, etc.) who perform the EDV management procedure were not well identified.

Therefore, further studies are needed to evaluate whether chlorhexidine dressing is safe and useful in patients with EVD. ERIs continue to be a source of significant morbidity and mortality in neurosurgical intensive care units[39]. The EVD infection control protocol dramatically reduces the rate of EVD infection from 9.8% to 0.8%[40]. In the 2017, the Infection Diseases Society of America in their guidelines for EVD placement recommend the use of catheters with antimicrobials, unscheduled EVD change, and the use of a standardized protocol[41]. Despite the use of a large query, we found only three articles on EVD care in the pediatric population. They are all about EVD anchoring[26,27,28]. EVD anchoring is an important problem in pediatric patients but we need more studies about it.

Limitations

This narrative review had some methodological limitations. The study had a limitation period from 2017 to 2022. The articles that were referenced did not focus on a specific context such as only intensive care unit but also in patient wards.

As a very complex and specific topic, it would be good to have further studies in neurosurgical settings to identify a standardized bundle in neurosurgical departments.

Conclusion

Multidisciplinary staff and training are fundamental to improve EVD management[25,26,27]. Avoiding routine or daily sampling reduces the EVD infection rate. When the procedure is requested, it is important to follow a strict protocol and to use sterile techniques[28,29,30]. Hydrocolloid dressings, SecurAcath®, gauze, and film dressings were used to anchor the cover EVD in the studies [27,31,33,41]. In conclusion, reducing the risk of EVD complications is a complex process, including infection, dislocation, and obstruction, in which various factors play a crucial role. The application of standardized protocols and bundles, as well as the standardized management of shunt dressings, are fundamental for the decrease of EVD infections. The topics discussed should be explored with more studies. It would be interesting to explore the impact of individual professionals in bundle interventions.

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