



(REVIEW ARTICLE)



External ventricular drain complications in neurosurgery patients: A systematic review

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Abstract

Introduction: External ventricular drains (EVD) represent one of the most prevalent neurosurgical procedures, providing treatment of elevated intracranial pressure while also enabling real-time intracranial pressure monitoring. However, the incidence of complications is increasing, with the rate of EVD-associated hemorrhage alone ranging up to 41%. Additional complications, including misplacement, dislodgment, blockage and infection, brain abscess and subdural empyema, have also been vastly reported in neurosurgery patients.

Aims: The aim of this systematic review was to provide an updated assessment of the current literature regarding EVD complications in neurosurgery patients.

Methods: A thorough search strategy was conducted in accordance with the PRISMA guidelines, with the scope of literature being obtained from the literature databases PubMed, Scopus, and Web of Science. Once duplicates had been removed, the remaining citations were screened against the inclusion and exclusion criteria to ensure only relevant material was included in this systematic review.

Results: The search strategy identified 12 articles that discussed the incidence and risk factors of EVD complications in neurosurgery patients. Several complications were established, including aneurysm re-bleeding, hemorrhage, meningitis, and EVD-related infection. The literature also highlighted the vast number of risk factors to these complications, including fluctuations in serum sodium levels. No contradictions were apparent within the literature.

Conclusion: The incidence of EVD complications in neurosurgery patients is a cause for concern. Identifying potential risk factors in these patients is crucial in minimizing the likelihood of adverse events.

Keywords: EVD; External ventricular drains; Neurosurgery; Intracranial pressure

1. Introduction

External ventricular drains (EVD) represent one of the most prevalent neurosurgical procedures, providing treatment of elevated intracranial pressure whilst also enabling real-time intracranial pressure monitoring [1]. However, the incidence of complications is increasing, with the rate of EVD-associated hemorrhage alone ranging up to 41% [2]. Additional complications, including misplacement, dislodgment, blockage and infection, brain abscess and subdural

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empyema, have also been vastly reported in neurosurgery patients. Hence, the aim of this systematic review was to provide an updated assessment of the current literature regarding EVD complications in neurosurgery patients.

2. Material and methods

This systematic review aims to provide an updated assessment of the current literature regarding EVD complications in neurosurgery patients. In order to achieve this, several objectives were implemented: a) a search strategy was employed that enabled the construction of the review question, and subsequently the identification of the key terms to be utilized in the literature database search; b) any identified citations were screened against the inclusion and exclusion criteria to narrow down the scope of the literature; c) the remaining literature yielded was subject to data extraction and analysis of the EVD complications in neurosurgery patients, any similarities and contradictions apparent within the literature was also discussed.

The systematic literature search was conducted in line with the published Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines [3]. These guidelines consist of a 27-point framework, detailed in the PRISMA 2020 Checklist, and highlight the necessary outline of a systematic review [4].

2.1. Search Strategy

The PEO framework was employed to frame the review question and enable the identification of the key terms to be used in the search. This framework was chosen over alternative methods, including the SPIDER or PICO model, as our review is assessing the etiology and risk of EVD complications specifically in neurosurgery patients [5]. Table 1 provides an overview of this framework and the key terms identified as a result.

Table 1 PEO framework and the key terms to be used in the literature search

Population	Exposure	Outcome
Neurosurgery patients,	EVD	Development of complications

Using the key words identified in Table 1, the literature databases PubMed, Scopus, and Web of Science were searched to compile a concise list of literature relevant to this review. The reference list of the citations identified were then screened for any other potentially relevant literature. The referencing software EndNote X9 was employed to track citations and enable the removal of duplicate literature. Once these duplicates were removed, the abstracts of the remaining citations were screened by hand to ensure relevance before being assessed against the inclusion and exclusion criteria. Moreover, an initial assessment of any relevant material identified several medical subject headings (MeSH) terms that were then incorporated into our search strategy as additional key terms. The initial search strategy was conducted, with the literature being obtained, on the 5th August 2020. The bibliographies of the literature were also screened for further relevant citations on the 5th August 2020.

2.2. Inclusion and Exclusion Criteria

The inclusion and exclusion criteria of this review set the boundaries for eligibility, with the population, exposure, and outcome forming the basis of these criteria. Studies were deemed relevant; hence, included in this review if they discussed: a) patients who had previously undergone neurosurgery; b) an EVD had been used in the treatment approach; c) the incidence of complication development following the insertion of an EVD. No limitations were placed on the study design of the literature. Moreover, no restrictions were placed on the geographical location of the study to ensure the full scope of relevant literature was obtained and assessed. However, restrictions were imposed on the publication language, with any citation published in a non-English language being excluded to prevent the misinterpretation of the findings during translation.

2.3. Data Extraction and Analysis

For each citation included, the study design, the number of patients included in the study, the complications experienced following the insertion or removal of the EVD and the risk factors to these complications were extracted. Moreover, any similarities and differences between the literature were also assessed, with any contradictions being discussed.

3. Results

3.1. Identification of the Literature

The search strategy yielded 351 citations, with PubMed, Scopus and Web of Science yielded 148, 127, and 76 records, respectively. This resulted in 351 records prior to duplicates being removed. EndNote X9 identified 165 duplicate articles to be removed, which yielded 186 records to be screened for relevance. A thorough screening of the titles and abstract of the 186 records identified 94 citations that were not deemed relevant to the systematic review and were subsequently removed. The remaining 92 citations were screened against the inclusion and exclusion criteria for relevance, with a total of 80 records being excluded as they did not meet these predefined eligibility criteria. Hence, a total of 12 full-text articles were included in this qualitative synthesis, with the incidence and risk factors of EVD complications in neurosurgery patients being compared and contrasted.

3.2. Data Extraction

The literature included in this systematic review was vast, with eight studies following a retrospective study design, three prospective studies, and one case series. A total of 3155 patients were assessed across the literature, all receiving an EVD. Several complications were established, including aneurysm re-bleeding, hemorrhage, meningitis, and EVD-related infection. The literature also highlighted the vast number of risk factors to these complications, including fluctuations in serum sodium levels. No contradictions were apparent within the literature. An overview of the data extraction is provided in Table 2.

Table 2 Data extraction

Author (year)	Study Design	Participants	Methods	Exposure	Outcome	Conclusion
Miller et al. (2017) [6]	Retrospective chart review conducted between March 2008 and June 2014 at the University of Minnesota.	A total of 482 participants, who had an EVD placed during the designed time period were identified.	A database was deduced to collate the data of all the participants relevant to the study design. Cranial imaging studies were also reviewed to identify and hemorrhage associated complications with either the placement of the drain or the removal.	EVD placed between March 2008 and June 2014 at the University of Minnesota.	Hemorrhage in 21.6% of patients. Two drains had to be replaced, and one patient died as a result of a large hemorrhage. On admission, decreased platelet levels and an increasing number of drain placement attempts was correlated with an enhanced risk of hemorrhage.	Hemorrhages are a frequent complication following both EVD placement and removal.
Velásquez et al. (2017) [7]	Retrospective analysis conducted over a 10-year period.	Over the analysis period, 435 consecutive patients with EVD pullout complications were assessed.	This incidence of drain pullout complications was deduced in the patient cohort, and the likelihood of complications arising as a result of the fixation technique.	EVD pullout.	The complication rate was 0.4%, with no complications being directly attributable to the fixation technique. A mean operative time of 60-seconds was also reported to fix the drain.	The evidence provided in this study suggests that a simple fixation technique is optimal to avoid complications post-pullout of an EVD in neurosurgery patients.

Miller et al. (2015) [8]	Retrospective chart review conducted between March 2008 and June 2014.	During the study period, 73 EVDs were placed in 63 patients aged between 2 weeks and 17-years.	The incidence of hemorrhage with placement and removal of the EVD was reported.	EVD placement and removal.	Incidence of hemorrhage at drain placement was 10%, whilst the incidence of hemorrhage at drain removal was 21.9%.	It is highlighted that EVD placement and removal increase the incidence of hemorrhage in neurosurgery patients. Although no hemorrhage was clinically significant, the evidence provided may be used in decision making.
Rowe et al. (2018) [9]	Single center, nested case-control study conducted between June 1, 2011 and June 30, 2014.	A total of 81 patients were included in this study who had received an EVD during the study period.	The risk factors for developing new or enlarged intracranial hemorrhage after the placement of an EVD were identified.	EVD placement.	A third of the participants (33.3%) experienced a new or enlarged intracranial hemorrhage after placement of the drain. Of these patients, 22% of them had received an antiplatelet within 96-hours of the drain placement.	Antiplatelet use may be an independent risk factor for post-EVD placement intracranial hemorrhage.
Kyeung et al. (2014) [10]	Retrospective cohort study conducted between 2008 and 2010.	A total of 370 EVD procedures were identified in 276 patients.	A post-insertion CT scan was assessed for each patient to determine if any new hemorrhage was present. The effect of several variables was also assessed, including diagnosis at admission, endovascular treatment, anti-platelet medication, and a concurrent craniotomy operation.	EVD placement.	Hemorrhage was apparent in 20.5% of patients following the placement of the drain. However, this presentation was only symptomatic in 1.4% of cases. The only significant risk factor identified was the administration of pre-operative anti-platelet medication.	Preoperative anti-platelet medication may exacerbate the likelihood of EVD-related hemorrhage development.

Hussein et al. (2019) [11]	Prospective observational cohort study conducted between 2014 and 2017 at a Neurosurgical Department.	A total of 232 patients were identified, with drains being placed on 437 occasions amongst this cohort.	This study examined the risk factors for meningitis or ventriculitis following insertion of the EVD.	EVD placement.	The incidence of infection was 13.7 per 1000 drain days. Several risk factors were identified, including diabetes mellitus, CSF leak, drain opening, and the duration of the drain in days.	This study recommends that strict adherence to infection control, shortening drain duration, and avoiding unnecessary manipulation of the drain are significant in preventing the incidence of neurosurgical drain infections.
Jamjoom et al. (2017) [12]	Prospective, multicentre study conducted in the UK and Ireland, at 21 neurosurgical units, over a period of six months.	A total of 452 patients were identified, with the insertion of 495 EVDs amongst this cohort over the study period.	The primary objective was to measure the 30-day incidence of drain-related infection.	EVD placement.	The risk of infection was 9.3%. The cox regression analysis identified duration of drain placement for greater than eight days, regular sampling, and alternate day sampling as independent risk factors to drain-related infection.	This study highlights several risk factors for the development of EVD placement-related infections.
Lim et al. (2019) [13]	Case series conducted between March 2010 and December 2017.	122 patients were included who had an acute aneurysmal subarachnoid hemorrhage (aSAH) and the subsequent insertion of an EVD.	Besides reporting on the researchers' experience with EVD prior to endovascular treatment, the relation of hemorrhagic complications to the drain itself was also investigated.	EVD placement.	Drain-related hemorrhage arose in 14.8% of patients. Two independent risk factors were identified; use of an antiplatelet or anticoagulant agent administered on admission, and student use.	The insertion of an EVD prior to endovascular treatment in patients with aSAH did not increase the rate of rebleeding or incidence of drain-related hemorrhagic complications.

Topjian et al. (2014) [14]	Retrospective observational study of patients admitted to a tertiary care PICU from January 2005 to December 2009.	388 patients managed with EVDs were included in this study.	The incidence of drain-related complications was recorded. Independent risk factors to these complications were also discussed.	EVD placement.	6% of patients presented with infections associated with their drain. The time to positive cultures was seven days after placement of the drain. Patients with drain-infections had a significantly longer drain duration.	This study highlights several risk factors to EVD-related complication, including longer drain duration and higher maximum drain output.
Yuen et al. (2018) [15]	Retrospective study conducted at a single centre between July 2013 and June 2015.	A total of 89 adult patients undergoing EVD insertion were included in this study.	This study reports on the surgeon experience, operative time, intraoperative antibiotic prophylaxis, need for revision surgery and the incidence of drain-associated infection.	EVD placement.	The overall infection rate was 4.8%, the hemorrhage rate was 7.8% and the revision rate was 13% in this cohort. Anticoagulation or antiplatelet administration did not appear to increase the incidence of hemorrhage.	The duration of the drain was highlighted as the only significant risk factor to infection.
Choudhri et al. (2014) [16]	Retrospective case series analysis conducted between 2008 and 2013.	One female and two male patients were discussed in this study, aged 40 to 75-years, who had an EVD placed and developed complications during the study period.	Admission and radiographic studies were assessed in patients presenting with drain-associated cerebrovascular injury.	EVD placement.	All three patients developed pseudoaneurysms.	Although rare, cerebrovascular injury still occurs in these patients.
Walker et al. (2012) [17]	Retrospective cohort study conducted between 1990 and 2010.	180 patients received first-time EVDs during the study period and were included in this study.	The patient demographics, etiology of hydrocephalus, length of stay, and duration of the EVD were recorded and analysed.	EVD placement.	The average patient age was 9.3 years, hospital length of stay was 22.5 days, and drain duration was 7.8 days.	Trauma and neoplasms are the most prevalent indications for EVD placement.

4. Discussion

This systematic review provide an updated assessment of the current literature regarding EVD complications in neurosurgery patients. Our findings highlighted several complications associated with the insertion or removal of an EVD. These included aneurysm re-bleeding, hemorrhage, meningitis, and EVD-related infection. We also emphasize the vast number of risk factors to these complications, including fluctuations in serum sodium levels and the EVD duration.

The risk factors associated with EVD complications identified are corroborated across the current literature. The use of an anti-platelet or anticoagulant agent administered on admission was consistently proposed as a risk factor, with Lim et al. detailing this to be the main contributing factor to EVD complications [13]. This factor poses a significant risk to intracerebral hemorrhage following EVD insertion. The current evidence, therefore, suggests several recommendations that must be considered for the placement of EVD in patients requiring anticoagulation. This concludes delaying surgery by a minimum of 24 hours in the event of a traumatic tap, delaying heparinization for a minimum of 60 minutes following catheter insertion, and ensuring that tight perioperative control of anticoagulants is maintained [18]. These guidelines may explain the contradictory evidence presented by Yuen et al. that suggests that anticoagulants and anti-platelet administration did not increase the incidence of hemorrhage [15].

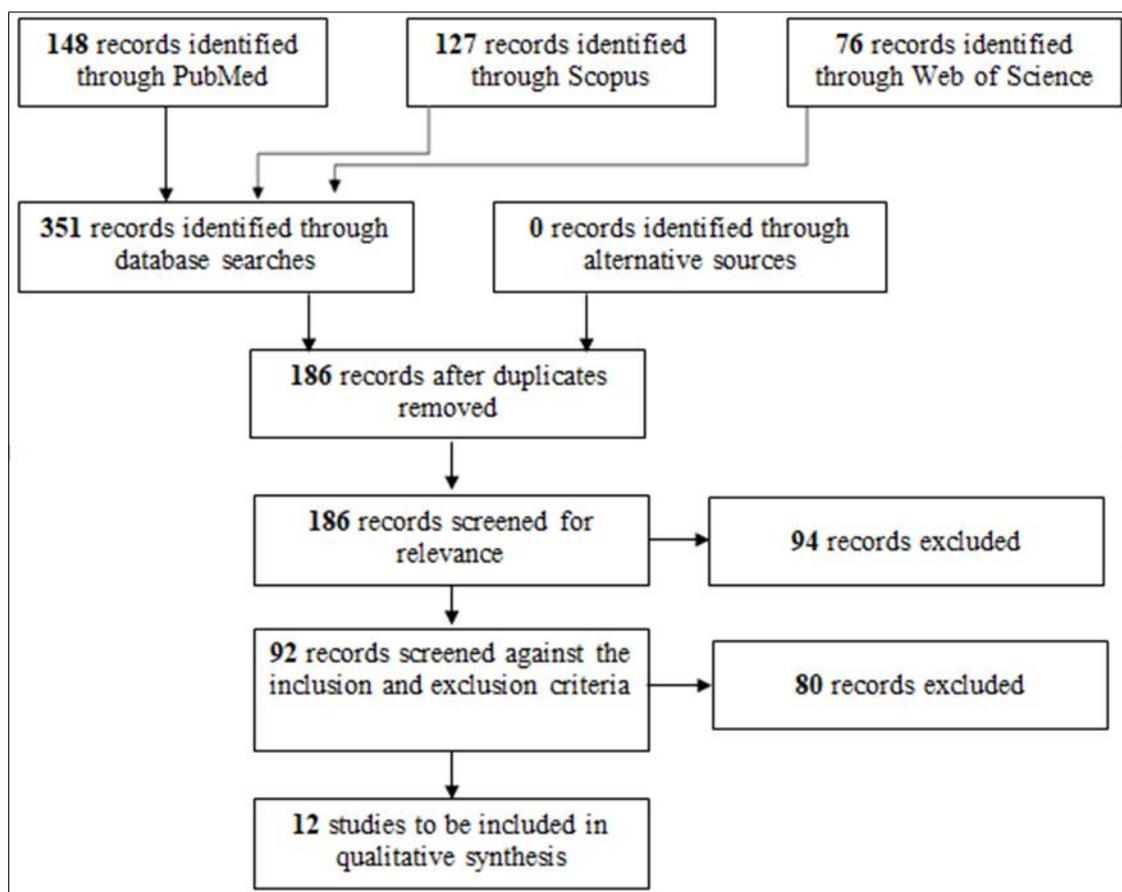


Figure 1 PRISMA flowchart

Fluctuations in serum sodium levels and the duration of EVD were also identified as a risk factor for complications. Beyond the literature included in this review, an additional study by Topjian et al. exclusively assessed the impact of serum sodium level fluctuations on the incidence of mortality and morbidity in children in a pediatric intensive care unit following the insertion of EVD. This study concluded that hyponatremia is common in patients managed with EVD; yet, this is a risk factor for EVD complications and is associated with seizures and in-hospital mortality [19]. Although this study focused on a pediatric population, the results of this review suggest that this risk factor is universal. However, hyponatremia is not widely discussed in the current literature concerning patients managed with EVD and requires further investigation. EVD duration and the replacement of EVD, on the other hand, is identified as a significant risk factor that increases a patient's risk of infection during their hospital stay. Zakaria et al. adopted a standardized protocol to analyze 428 EVDs spanning 381 patients who underwent placement of an EVD and observed complications in 8.3%

of this cohort. An increased EVD duration resulted in a substantial increase in infection, although not significant. While the replacement of an EVD was associated with a significantly increased risk of infection [20].

The primary limitation of our systematic review is the limited literature and lack of consistency in the findings. Although a large number of studies briefly discuss EVD-associated complications, the risk factors for these complications are largely underreported. Moreover, the methodology, as apparent in Table 2, is dissimilar between the studies discussed. Therefore, limited comparisons can be made between the current literature as non-modifiable risk factors, such as age, are rife amongst the cohorts.

5. Conclusion

The incidence of EVD complications in neurosurgery patients is a cause for concern. Identifying potential risk factors in these patients is crucial in minimizing the likelihood of adverse events. The findings discussed in this review highlight that aneurysm re-bleeding, hemorrhage, meningitis, and EVD-related infection are all prevalent complications associated with the insertion or removal of an EVD and should be monitored accordingly in the patient's care. Further investigations are warranted to corroborate both the non-modifiable and the modifiable risk factors to these EVD complications.

Compliance with ethical standards

Disclosure of conflict of interest

No conflict of interest.

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