Evidence-Based Nursing Care Practices for External Ventricular Drain Insertion and Maintenance: A Systematic Review

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Abstract

Incidences of external ventricular drain (EVD)-related infections are high and dramatically affect patient's hospital course. The fact that 44 percent of patients with an external cerebrospinal fluid (CSF) drainage require a permanent CSF diversion procedure (eg VP shunt placement) at a later time point represents a challenge in case of an ongoing EVD-associated infection. Systematic review following Preferred Reporting Items for Systematic Reviews and Meta-analyses (PRISMA) guidelines for design, conduct and reporting was conducted to find out the available evidences for EVD insertion and best care practices to prevent infection and other complications. The search engine data base was PubMed and Google scholar. The search key words were 'external ventriculostomy drainage' and 'ventricular drain'.The data was evaluated from studies and summarised in the pre-defined data extraction form. Narrative review was performed by systematically analysing the available research evidences. On modified search 86 studies were obtained. For the final review 15 studies were included in which free full text was available in English and were published in last five years. The key practice areas are summarised under insertion practices and maintenance practices. The key areas of best maintenance practices include placing and fixing of drainage system, monitoring drainage of CSF and documentation, maintenance of closed drainage system, CSF sampling, dressing and dressing changes, interventions for clogging, changing drainage system, environmental cleaning and other aspects of care. Evidence-based best care practices and standard infection control practices for insertion and maintenance of EVDs to avoid their contamination is to be reinforced.

Key words: External ventricular drain, Care practices, EVD insertion

External ventricular drain (EVD) insertion is the commonly performed procedure in neurosurgery units. This procedure is often done as a life saving procedure in of emergency condition like acute hydrocephalus. Acute hydrocephalus may be caused by underlying disease pathologies like sub arachnoid or interventricular haemorrhage, obstruction to cerebrospinal fluid (CSF) pathways due to tumours, genetic disorders like aqueduct stenosis or Chiari malformation or DandyWalker syndrome, exudates from infections and over production of CSF due to tumours of choroid plexus. If hydrocephalus is left untreated, it may lead to increased intra cranial pressure (ICP) and reduced cerebral tissue perfusion and eventually cerebral herniations. EVD is also inserted for ICP monitoring, administration of intraventricular antibiotics and in some situations, to reduce ICP prior to surgery for tumours of posterior fossa.

The EVD is usually inserted into frontal horn of right lateral ventricle. This procedure is performed as an elective or emergency procedure in the intensive care unit, emergency department or in the operating theatre. EVDs are commonly inserted at Kocher's Point, which is approximately 10 cm posterior to the nasion and 3 cm to the right (or left) of midline, approximately at the mid-pupillary line. However, there are alternative locations, such as the Frazier's point, which is used for a parietal-occipital approach. After a twist drill aperture placement on the calvarium, a sterile catheter is advanced through the dura, and brain parenchyma into the ipsilateral lateral ventricle ideally up to the level of foramen of monro (intraventricular foramen).

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Need of the study

Even though this is a simple procedure, it is associated with potential serious complications like haemorrhage (extra-dural, sub dural or parenchymal), inadvertent placement into brain tissue and infections. Infections include ventriculitis, meningitis or even brain abscess. All the infections associated with EVD placement are termed as ventriculostomy-associated

CSF infections (VAI). The prevalence of EVD–related infection has been reported as low as from 0 to 27 percent. The fact that 44 percent of patients with an external CSF drainage require a permanent shunt at a later time point represents a challenge in case of an ongoing EVD-associated infection. The incidence of EVD-related infection leads to increased hospitalisation days, additional health care cost and added mortality and morbidity. A survey among neurosurgery residents and nurses showed lack of knowledge among them regarding insertion practices and care practices in the intensive care unit to prevent infection and other complications. There is no consensus among surgeons regarding the frequency of sampling, dressing change, monitoring of patients and recording of patient data in connection with EVD in-situ. Some hospitals in the developed countries have their own institutional protocols and guideline in regard. But in developing countries like India, there is no standard of care practices which are widely accepted. Nurses often lack time and resources to access the latest research evidence a or even knowledge to identify the quality research finding from studies to adopt best practices in the care area. The main reasons for the increased incidence of EVD-related infection are lack of routine surveillance, lack of knowledge among staff and residents and lack of standardised protocol. So, a systematic review was designed to collect the evidence-based best practices for EVD insertion maintenance.

Objectives

The aim of this review was to identify the available research evidences for EVD insertion and best nursing care practices to prevent infection and other complications, and to prepare a guideline for EVD insertion and maintenance.

Review of Literature

A recent meta-analysis showed the incidence of VAI as 11.4 per 1000 catheter-days (Ramanan et al, 2015). Elements that predispose patients to EVD–related ventriculo-meningitis include patient-related factors such as systemic infection, depressed cranial facture, and intraventricular haemorrhage. EVDs left in situ for ≥8 days and those sampled more frequently were associated with a higher risk of infection. The other factors include longer indwelling time (6 to 10 days), more frequent sampling, CSF leak, frequent touching of the connectors, tubing and drainage bag and catheter irrigation, presence of blood in CSF, reinsertion and severe systemic illness (Kohli et al, 2018). One study to identify the outcomes of post-neurosurgical ventriculostomy-associated infections showed that the median interval between EVD placement and diagnosis of infection was 3 days. Mean length of stay in VRI patients was 31.85 ± 20.53 days. More than 12 percent patients required ICU care, 15.2 percent expired during hospital stay or within 30 days of discharge and 5 percent were comatose (Bari et al, 2017).

In a recent RCT, Walek et al (2021) showed that subcutaneous tunnelling of EVD catheter reduced sampling frequency and use of chlorhexidine or alcohol-based disinfectant reduced the incidence of infection (2%) compared to 6.7 percent in the other group. Use of navigation techniques to place EVD such as computer-guided or CT-guided insertion techniques does not show any significant difference in the accuracy of placement and occurrence of complications compared to free hand approach. It added the additional CT cost and radiation exposure (Nowacki et al, 2018; Eisenring et al, 2020). The study evaluated EVD placement via trephine burr hole with tunnelled catheter and twist drill burr hole with bolt system fixing showed no difference in infection rate, number of attempts and accuracy of placement (Mansoor et al, 2020).

Tunnelling of catheter, use of antibiotic impregnated catheter and periprocedural antibiotic use reduced the incidence of infections in few studies but the difference was not significant on adjusted analysis (Kim et al, 1995; Zhou et al, 2019; Collins et al, 2014). Similarly continuous drainage by Ommaya reservoir reduced the infection rate and blockage but the difference was not statistically significant. CSF leakage, increased manipulation and catheter placement of more than 7-10 days were associated with infection (Jamjoom et al, 2018; Alleyne et al, 2000; Gulsen et al, 2015).

The EVD-related infections are usually caused by low-virulent microorganisms like common skin flora. Nearly all VAI are acquired through external contamination. Initially the EVD colonisation with skin and environmental flora occurs. Microorganisms contiguously spread along the drainage tube to the internal EVD system and the CSF. Culture results are positive in about 77 percent. Coagulase-negative staphylococci 63 percent, Propionibacterium acnes in 15 percent and polymicrobial infections in 21 percent (Eisenring et al, 2020), Coagulase-negative staphylococci 26.0 percent and Acinetobacter baumanniiin 21.0 percent (Mansoor et al, 2020).

Methodology

Systematic review following Preferred Reporting Items for SystematicReviews and Meta-analyses (PRISMA) guidelines for design, conduct and reporting was carried out to collate evidence-based practices in external ventricular drain insertion and maintenance. This review was registered in PROSPERO (prospective registry of systematic review and meta analysis). The data base searched were google scholar and PubMed. The search key words were 'External ventriculostomy drainage' and 'ventricular drain'. The search strategy was confirmed by another author to make sure of reproducibility. In the care areas where evidences

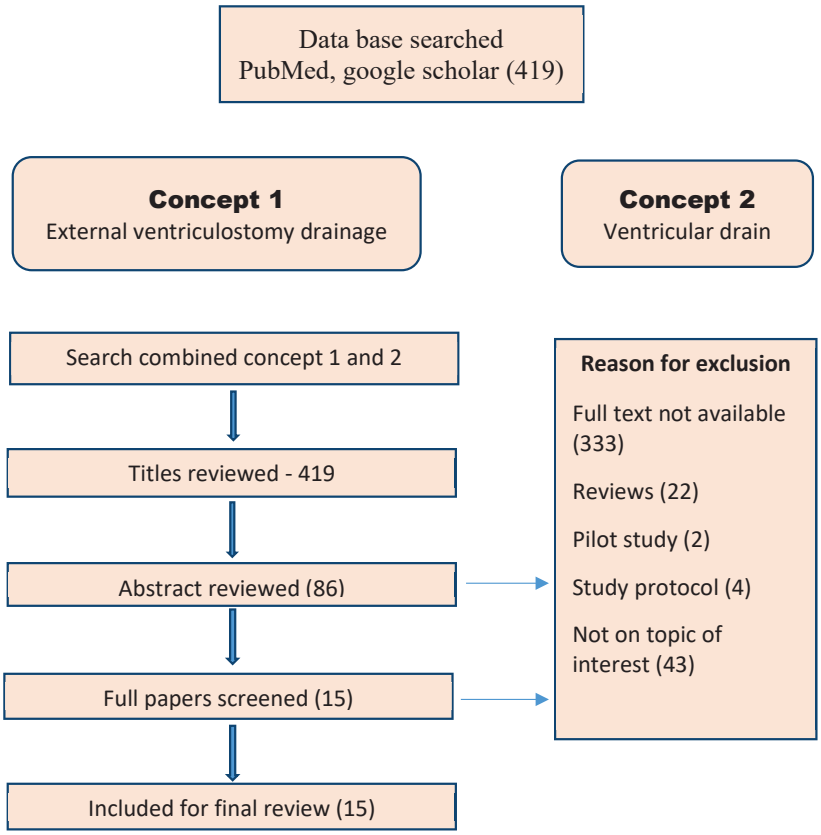

Figure 1: PRISMA Flow chart.

are limited, our experiences and practices were also incorporated into this review to put forward the best practices for EVD insertion and maintenance to prevent infections and other complications.

It was decided to include the studies done in humans and assess the effect of different insertion practices, care practices, and described the EVD-related outcome. Studies done to identify the benefits of EVD insertion on different medical and surgical conditions were excluded.

The data were extracted from studies and summarised in the pre-defined data extraction form. The data on study design, sample size, author details, year of publication, the care areas discussed were identified and summarised in the data extraction form. Narrative review was performed by systematically analysing the available research evidences.

Results

This study was conducted in 2022, initial search was completed in August and exhaustive literature review was completed in September.

On initial search 419 studies were obtained. The results were filtered using the criteria; studies reported in English with full free text available. On modified search 86 studies were obtained out of which 22 were excluded because they were review papers. Two pilot studies and 4 study protocols were removed from final review. A vast majority of the studies (43) were removed because in these studies though there was discussion about EVD, the thrust was not on insertion or care practices or maintenance. For the final review 15 studies were included in which free full text was available in English and were published in last five years. The PRISMA flow diagram is given in Figure 1.

Risk of bias for randomised controlled trials (RCT) was assessed using predefined Cochrane risk of bias tool. Observational studies were assessed for risk of random and systematic bias. These were considered of high quality if they met the criteria for all the assessment domains (selection, performance, attrition, reporting and confounders). Five studies are having fair risk of bias (Ramanan et al, 2015; Nowacki et al, 2018). All the other studies are having high risk of bias (Eisenring et al, 2020; Mansoor et al, 2020; Kim et al, 1995; Zhou et al, 2019; Collins et al, 2014; Jamjoom et al, 2018; Alleyne et al, 2000; Gulsen et al, 2015; Thompson et al, 2018; Singh et al, 2018). The list of included studies are given in Table 1.

The key practice areas are summarised under insertion practices and maintenance practices. The key areas of best maintenance practices include placing and fixing of drainage system, monitoring drainage of CSF and documentation, maintenance of closed drainage system, CSF sampling, dressing and dressing changes, interventions for clogging, changing drainage system, environmental cleaning and other aspects of care.

Insertion Practices

EVD are inserted in operating theatre, intensive care unit or in emergency ward strictly following the aseptic techniques. There is no difference in the rate of infection same irrespective of the place or qualification and experience of surgeon. Neurosurgeon and the assistant should perform surgical hand washing for 3-5 minutes. Maximal barrier precautions should be taken with full body drape and surgical gown for surgeon and assistants. Initially surgeon will mark the site of EVD insertion. Shaving of scalp is not recommended; close clipping of the hair around the insertion site can be done if needed. Check the access site skin condition and hygiene. Prepare site with 10 percent betadine or 2 percent chlorhexidine. The catheter is inserted through a twist drill burr hole in a free hand approach. The accuracy of placement, attempt number and rate of complications are independent of computer-guided or CT-guided insertion (Nowacki et al, 2018; Eisenring et al, 2020). Similarly, no difference in the infection and complication rates whether procedure is done through drill burr

Table1: Summary of the included studies

Sl. No	Author	Design	Sample size	Practice areas
1	Ramanan et al[1]	Meta analysis	35 studies	Catheter days
2	Kohli et al[2]	Retrospective review	190 EVD	Location and person who did procedure, EVD days and causative organism
3	Bari et al[3]	Retrospective review	256 patients	Outcome, catheter days
4	Walek et al[4]	12 Years longitudinal study	1000 EVD days	Sampling frequency, subcutaneous tunnelling, skin preparation
5	Nowacki et al[5]	RCT	35 patients	Technique of insertion
6	Eisenring et al[6]	RCT	20 EVDs	Technique of insertion
7	Mansoor et al[7]	RCT	273 patients, 61 bolt, 211 standard EVD	Technique of insertion, fixing, dressing, tunnelling
8	Kim et al[8]	RCT	66 procedures	Drainage status, EVD days
9	Zhou et al[9]	RCT	120 patients	Securing of EVD
10	Collins et at[10]	Survey	181 EVDs	Outcome of long tunnelled catheter
11	Jamjoom et al[11]	Cohort	495 EVDs	Type of catheter, frequency of sampling, EVD days
12	Alleyne et al[12]	Retrospective review	308 patients	Periprocedural antibiotic use
13	Gulsen et al[13]	Retrospective	25 patients	Frequency of change of catheter, dressing and system
14	Thompson et al[14]	Matched case control study	83 cases 249 controls	Sampling frequency, EVD days
15	Singh et al[15]	Survey	793 drainage days	Reservoir drainage

hole or trephine burr hole (Mansoor et al, 2020). The catheter is preferably tunnelled a few centimetres under the scalp before entering the skull. Tunnelling the catheter reduce infection rates and CSF leak (Walek et al, 2021; Kim et al, 1995; Zhou et al, 2019; Collins et al, 2014). Studies on different catheter type such as antibiotic impregnated, silver-coated or plain catheter does not show any difference in infection rate (Jamjoom et al, 2018). Infection rate is not dependent of the catheter type. Prolonged use of prophylactic antibiotic use during the period of EVD in-situ is not recommended. Periprocedural prophylaxis may be considered. Antibiotic prophylaxis can be given for emergency procedure (Gulsen et al, 2015).

Monitoring CSF Drainage and Recording

Outside the skull, the catheter is connected to a drainage system via a three-way stop cock, consisting of a collection chamber hanging from an intravenous (IV) pole attached to the bed, a pressure scale and a drainage bag. Stopcocks between the collection chamber and drainage bag allow control of the entry of CSF and its drainage. Visible clear fluid on or around the entry sitemust be reported to the neurosurgeon. Assess and record the colour of CSF. It should be colourless, cloudiness or debris in previously clear CSF indicates infection. The exit site needs to be observed for redness, inflammation, oozing of blood or leakage of CSF. Assess the readiness of patient for EVD removal. Check temperature every four hours. Check blood counts and other parameters of infection. The dwelling time of more than 8-10 days is associated with infection (Alleyne et al, 2015; Thompson et al, 2018; Singh et al, 2020). So, it is recommended to reduce the dwelling time to less than 7 days. Consider for early internalisation if the patient is suspected to be dependent on CSF drainage.

EVD maintenance practices: The desired height of EVD placement is determined by the neurosurgeon. Usually, the drip chamber is placed at a desired height so that CSF will be drained when the intraventricular pressure exceeds the set height. The reference point is tragus of the ear lobe in supine position and between the eyebrows in lateral position. Relevel the system after changing position of the patient. Drainage of CSF may be continuous or intermittent. In continuous drainage CSF will be drained at a fixed rate set by the surgeon. In intermittent drainage either a fixed amount per hour is drained or drained as and when indicated based on patients' clinical status or ICP values. Once the desired level of height and drainage status is determined, it becomes essentially the responsibility of nurses to maintain the closed drainage system. Strict aseptic techniques should be followed while handling EVD. Minimal manipulation is recommended. Always maintain closed drainage system. Observe frequently for disconnection. Frequent manipulation is associated with EVD-related infection (Singh et al, 2020). Continuous drainage with Ommaya reservoir is associated with less infection rate and blockage (Dey et al, 2012). Maintain the collection system in an upright position to prevent back flow. Block EVD while changing position or transportation after consulting the neurosurgeon.

Measurement of ICP: The ventricular catheter can be transduced to measure the intracranial pressure. While zeroing, the transduced should come at the

level of foramen Munro which is at the level of tragus of the ear lobe in supine position and between the eyebrows in lateral position. The drainage should be stopped while reading ICP. Transducer should be levelled after every position change to avoid false reading.

Sampling: The EVD collection system is usually accessed by the neurosurgeon. Frequent sampling is associated with EVD-related infection routine daily sampling is not recommended. Sampling-on the day of insertion and on 5th day or when infection is suspected. Full barrier precautions and full patient drape should be insisted. Clean the access hub with alcohol swab and wait till it is dry. Collect minimum of 1.0 ml (around 10 drops) CSF in sterile CSF tube. Never aspirate CSF from an EVD, allow drops to drip out. Replace with new sterile cap. Turn the EVD on and ensure that the drain is oscillating / draining. Remove gloves and perform hand hygiene. Label and send specimens. Document procedure.

Dressing and dressing changes: The EVD catheter is inserted into the anterior horn of the ventricle by drilling a small hole in the skull (burr hole) and incising the meninges. The skin incision is then sutured, the catheter is sutured to the scalp and the wound covered with a sterile occlusive dressing (Walek et al 2021) or cotton dressing. Dressings of the EVD site need to be observed hourly, and documented to ensure a leak has not occurred. CSF leak is around the site and wet dressing increases patients' risk for infection (Kohli et al, 2018; Zhou et al, 2019; Singh et al, 2020). Dressing has to be changed once it gets wet, soiled or displaced. Keep scalp clean and dry. Routine changing of occlusive dressing can be done 7th day under full aseptic precautions.

Clogging/block: Regularly check the catheter for oscillation. Absence of oscillation indicates that it is blocked by clotted blood or tissue debris. Manipulations are strongly discouraged, and rinsing of the catheter is forbidden. If cellular debris is suspected, irrigation of tubings using a small volume (less than 2 ml) of sterile isotonic saline is used to restore flow under strict sterile conditions. Distal port away from the patient is flushed.

Care of drainage system: Empty the drainage bag only when three-fourth is full. The entire system needs to be changed using sterile technique every 7 days. Early changing is needed in case of clogging or presence of blood. In the setting of infection, the colonised EVD catheter may be removed and replaced with a new catheter, preferentially at a new site (Woodward & Catheryne, 2010). The urine drainage bag of the patient, if present, should be placed as far from the EVD collection bag site, preferably on the opposite side of the patient cot to prevent inadvertent handling.

Environmental cleaning: To avoid contamination, thorough environmental cleaning is recommended. Neutral detergent or disinfectant is used to clean the bed, railings, bed side equipment and the IV pole in which EVD bag is attached. Avoid cleaning methods that produce mists or aerosols or disperse dust. Clean surfaces, medical devices and other areas as per recommendations on a daily basis.

Other aspects of care: Form monitoring compliance to best practice guidelines, provide ongoing training and competency assessment. Perform infection control rounds. Monitor rates of infection.

Nursing care and transportation of patients with EVD: Drainage should be turned off at the collection chamber before any intervention involving patient movement, such as suctioning, walking, physiotherapy and repositioning in bed – all of which can increase intraventricular pressure. As soon as the intervention is finished, the stopcock should be turned on again towards the drainage system. Maintain regular bowel habits using stool softeners as straining at stools increase intraventricular pressure and cause over drainage. Drainage should not be turned off for longer than needed, as this can cause the catheter to block. When the patient is being transferred, the EVD system must remain in an upright position and not be left lying flat on the bed, as this will impair drainage (Wondafrash & Tirsit, 2021).

Removal of EVD: Once the patient condition is stabilised, the EVD need to be removed. The EVD is clamped or the drainage frequency will be reduced by the neurosurgeon. The EVD removal planning need to be documented. Observe for signs and symptoms of increased ICP, CSF leak at dressing site and ensure the dressing is dry and intact. Once it is determined to remove EVD, the procedure is done by the neurosurgeon in a sterile manner with appropriate pain relief medications. After removal the patient and the wound site need to be observed. Monitor for CSF leak and signs and symptoms of increased ICP in patient. Keep the dressing dry and intact.

Discussion

The present review was undertaken to develop an evidence-based practice guideline for insertion and maintenance to EVD to prevent infection and other complications. There are evidences or high quality evidences are lacking in certain care areas. So further studies need to be done in this area to generate more evidences. But, from the available evidences we could develop a clinically relevant practice recommendation.

There is no routine surveillance of EVD-related infections in majority of the hospitals and the international or national agencies for infection control did not give any practice guidelines for prevention of EVD-related infections similar to guideline to prevent ventilator-associated pneumonia or central line-asso-

ciated blood stream infections. There is lack of training among nurses and neurosurgery residents regarding the best practices for EVD insertion and maintenance.

The studies included in this review are mainly done by neurosurgeons who evaluated the outcome of EVD in specific group of patients. From the outcome and associated factors, best practices were identified. There is no study by nurses evaluating the effect of specific intervention on EVD-related outcome to suggest best practices. We suggest more clinical studies specifically evaluating the effect of different care practices to identify the best way to care EVD.

Recommendations and Nursing Implications

This evidence-based care practice for EVD insertion and maintenance can be used as a reference to educate the nurses working in clinical area and student nurses especially speciality nurses to improve their knowledge and understanding on EVD-related care for better bedside nursing care. This practice recommendation can be adopted in the clinical areas and a surveillance can be done to identify the improvement in care practices. EVDs can be transduced and ICP can be continuously monitored. Further studies can be done to identify the effect of various nursing and other interventions on ICP. Surveillance of EVD-related infections should be included along with the routine surveillance hospital acquired health care events like VAP or CLABSI.

Conclusion

Rates of incidence of EVD-related infections are high and dramatically affect patient's hospital course. Evidence-based best care practices and standard infection control practices for insertion and maintenance of EVDs to avoid their contamination is to be reinforced.

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