Roles and responsibilities of neuroscience nurses in preventing Ventriculostomy related infections in adults: an integrative literature review.

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Abstract

Background: The literature suggests that when nurses are aware of their roles and responsibilities, it may contribute to the improved quality of healthcare services. However, the identified roles and responsibilities of nurses in preventing ventriculostomy-related infections (VRI) are limited in the literature, despite their active participation in the management of external ventricular drainage (EVD).

Method: The CINAHL Complete, Health Source: Nursing and Academic edition, and MEDLINE Complete were accessed simultaneously through the EBSCO database. The database was searched using the key search terms for peer-reviewed, full-text journal articles in English from 2016 onwards. More literature including some seminal articles were retrieved from the Scopus database after searching through the reference lists of relevant articles. The selected articles were appraised for quality and then thematically analysed.

Results: The thematic analysis of the 34 selected articles elucidated seven themes that inform certain nursing roles and responsibilities that could contribute to VRI prevention.

KEYWORDS: Ventriculostomy-related infection, External ventricular drain, Neuroscience Nursing

Introduction

The history of temporary ventriculostomies, otherwise known as EVD dates to the 18th century when Claude-Nicolas Le Cat experimented ventricular puncture with a wick (Srinivasan et al., 2014). Since then, ventriculostomy evolved over time into a common life-saving technique to manage hydrocephalus and intracranial pressure (ICP), in neuro critical care units (Khalaveh et al., 2021). EVDs are flexible catheters surgically placed into the frontal horn of a lateral ventricle (Ducis, Thakrar and Tranmer, 2015; Khalaveh et al., 2021). Whether non-antibiotic coated or antibiotic-impregnated, the choice of catheters depends on the organisation's preference. The distal end of the ventriculostomy drain is connected to a sterile external closed system with multiple access ports, a burette and a collection bag (Khalaveh et al., 2021). EVDs allow the removal of CSF to reduce ICP, enable ICP monitoring, and facilitate the administration of specific medications (Whyte et al., 2O20).

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One of the most common complications of ventriculostomies is VRI, with a published incidence rate of zero to 45% (Flint et al., 2017; Reiter et al., 2023; Lewis et al., 2016); an Australian study reported a VRI incidence rate of 11% (Phan et al., 2016). VRI could be defined as a mandatory presence of either the clinical signs of bacterial meningitis or a positive Cerebro-spinal fluid (CSF) culture in patients with EVD, and at least one of the following parameters: CSF pleocytosis, gram-positive stain, or identical pathogens isolated from both the blood and CSF (Lewis et al., 2016). VRIs are known to increase morbidity, hospital stays and healthcare costs (Reiter et al., 2023). EVD management guidelines vary widely between healthcare organisations. Despite the active participation of nurses in the management of patients with EVD throughout their journey, in literature, discussion on the role of nurses in preventing VRI is limited. The purpose of this paper is to explore and elucidate the roles and responsibilities nurses could play, in preventing VRI. This paper describes the seven themes that emerged from the recent and seminal literature: infection controller, wound care provider, team player, learner, educator, patient advocate, and researcher. Finally, some recommendations for the future are included before the conclusion of this paper.

CINAHL Complete, Health Source: Nursing and Academic edition and MEDLINE Complete were accessed simultaneously through the EBSCO database in the UTAS library. The initial search string used was 'ventriculitis' OR 'ventriculostomy related infection' OR 'external ventricular drain infection' AND 'external ventricular drain*' yielding 547 articles. The same search string was filtered for full-text articles and further extended with the Boolean term 'OR'; 'ventriculostomy' OR 'external ventricular drain management' OR 'external ventricular drain care bundle' OR 'external ventricular care*' OR 'external ventricular drain management protocol', identifying an additional 386 articles. The limiters such as peer-reviewed (168), English (167) and adults (43) were applied to further narrow the search. The date range for the above search was limited to include articles from 2016 onwards to ensure recency. However, after going through the reference lists of the searched articles, seven more journals including two seminal articles were retrieved from SCOPUS to support the derived themes. The inclusion criteria included full-text primary articles, systematic reviews, the English language, and the adult population. The exclusion criteria were the paediatric population, studies irrelevant to nursing, review articles, and non-peer-reviewed articles. The Joanna Briggs Institute (JBI) levels of evidence for effectiveness (Munn, Lockwood and Moola, 2015) was utilised to determine the evidence level of each article. A further quality check was completed using the checklists available on either the Equator network or JBI critical appraisal tools. Results After the quality appraisal, the 34 articles chosen included randomised controlled trial (1), quasi-experimental (10), systematic review (3), observational analytical (13), qualitative studies (4) and evidence-based consensus statement (3). Most of the studies available were retrospective in nature due to the highly specialised nature of the cohort.

Discussion

The quality of healthcare delivery depends on the nurses' awareness and perception of the breadth of their roles and responsibilities. Ignorance or poor understanding of nursing

roles and responsibilities results in low-quality healthcare services (Oldland et al., 2020). Nurses participate in EVD management throughout the EVD trajectory; nevertheless, in literature, their role in the care of patients with EVD is confined to adherence to certain protocols in the bundled EVD care approaches, such as aseptic EVD handling and administration of prophylactic antibiotics (Champey et al., 2018; Talibi et al., 2020; Reiter et al., 2023). Significant variations in the published incidence rate of VRI, ranging between zero and 45%, itself indicate a room for further improvement in EVD management; an increased awareness of roles and responsibilities in the management of patients with EVD among nurses may contribute towards improved quality of care and thus reduced VRIs.

Infection controller

Nurses play a cardinal role in preventing and controlling infections in Australian healthcare settings (Kirby et al., 2020). The present notion is that patients with EVD could develop VRI from endogenous or exogenous pathogens (Mehreen et al., 2022). The exogenous pathogens gain access to the ventricles either by direct inoculation during the intraoperative period (Mehreen et al., 2022); or alternatively by contamination or colonisation of the EVD system whilst in place (Widén et al., 2017). Skin commensals such as staphylococcus, cutibacterium acnes and the microbes in the hospital environment can cause VRI if they gain access to the subarachnoid space (Widén et al., 2017). In an Australian healthcare setting, (n=110), (VRI rate= 11.50%), the main causative agents of VRI found in the study were Staphylococcus epidermis, Coagulase-negative Staphylococcus, Klebsiella pneumoniae, Gram-negative bacilli, Enterococcus faecium and Acinetobacter baumannii (Phan et al., 2016); some of them were the common skin flora while most pathogens comprised of the nosocomial agents including the resistant strains (Kadri et al., 2018). Similarly, in a single centre prospective study (n=214) by Mehreen et al., (2022) while investigating the aetiology, risk factors and VRI rate (19.4%), they found that the causative agents in 76 % of the diagnosed VRI cases were gram-negative bacilli; the bacilli that constituted the predominant environmental pathogens (Kadri et al., 2018). Whilst Mehreen et al.'s research is an international study that unveiled a huge gap in the healthcare standards, with much more nosocomial VRI compared to the Australian settings, both the studies reiterate the importance of continuing hand hygiene and the adherence to the general infection control measures to prevent nosocomial VRIs.

Indeed, the level of infection control before and during an EVD span might affect the VRI rate. Katzir et al. (2019) comparing the VRI rates between the groups that underwent EVD replacements every 5 days (group A) and the group that replaced EVD on clinical indication (group B) found a significant reduction of VRI rate in group B; they suggested that this decrease in VRI rate in group B could be attributed to the reduced number of EVD replacements and thus the reduced chance of direct microbial inoculation during the surgery. Similarly, Holloway et al. (1996) found that the VRI onset was more in the first few days, gradually declining after five days of EVD. The above studies indicate a greater possibility of infection in their setting by directly inoculating microbes during the intraoperative period and highlight the

significance of scalp preparation and surgical asepsis during the EVD placement. The World Health Organisation's guidelines for the prevention of surgical site infection (2018) recommend decreasing skin bioburden and dirt with a shower or wash before the surgical skin preparation. Conversely, the VRI onset later during EVD days might indicate an inferior standard of EVD care. A more recent clinical practice guideline developed in Brazil after a scoping review, research quality analysis using the AGREE II instrument, and Delphi technique recommended the following to prevent VRI; minimum EVD handling and preservation of a closed EVD system, scalp hygiene, surgical wound dressing change only when loose or soiled, aseptic surgical wound care with normal saline, 0.5% alcoholic chlorhexidine and application of transparent dressing, monitoring of the ventriculostomy site for CSF leakage and inflammation, reservoir bag changes using aseptic technique, aseptic CSF sampling from the proximal port only when clinically indicated and so on (Vieira et al., 2022). Nevertheless, the most appropriate access port for CSF sampling remains controversial in the literature for the associated complications including infection, and diagnostic value (Kinast, Paal and Liebchen, 2022; Khalaveh et al., 2023). Regardless, the general and specific infection control practices before, during and after the EVD insertion call for supreme priority in curbing VRI; it is high time for nurses to behold recommended infection control measures and uphold the responsibility as infection controllers in their settings, in the endeavor to prevent VRI.

Wound care provider

The nurse's role as a wound care provider is inevitable in the healthcare sector; meticulous surgical wound care by nurses in patients with EVD is a widely accepted strategy in the literature for preventing VRI (Flint et al., 2017; Reiter et al., 2023). On the contrary, Ducis, Thskrar and Tranmer (2016) proved in their single-centre study that a low VRI rate could also be achieved with no application of protective EVD dressing, if EVD is aseptically inserted and minimally manipulated post-operatively; the VRI rate achieved in Ducis et al. (2016) study was 5.1% (95 % CI= 2.6-9 %, P= 0.002) which is similar to the results from many other studies that trialled different other strategies such as various types of dressings (Roethlisberger et al., 2018; Angulo et al., 2019), antibiotic-impregnated catheters, bundled EVD care approaches (Hong et al., 2021) and so on. This emanates the suspicion that this surprisingly low infection rate in Ducis et al. (2016) study could be the impact of confounding factors, the variations in VRI diagnostic criteria and lower CSF surveillance rates. On the other hand, several authors before and after Ducis et al. (2016) such as Bookland, Sukul and Connolly (2014), Angulo et al. (2019), Hong et al. (2021) and so on strongly suggested that wound care and occlusive EVD dressings are some of the consistent interventions to decrease rather than increasing VRI. Therefore, as a caregiver, meticulous aseptic EVD wound care and the application of occlusive dressings by bedside nurses could be a good practice to pursue currently; this argument is in support of the neurocritical care evidence-based consensus statement (Fried et al., 2016).

Team player

The interdisciplinary approach in the prevention of VRI is gaining more acceptance these days as evident in many bundled EVD

care approaches (BECA). Several studies have demonstrated a lower VRI rate since the implementation of BECA using an interdisciplinary approach (Champey et al., 2018; Talibi et al., 2020; Reiter et al., 2023). A meta-analysis reporting 5242 EVD outcomes revealed that when continuous prophylactic antibiotics or antibiotic-impregnated EVDs were trialled as monotherapy, the VRI rates ranged between three and nine per cent (Sheppard et al., 2020). Surprisingly, Reiter et al. (2023), in their recent single centre pre-test (n= 133) and post-test (n=134) study implementing a BECA, yielded a statistically significant VRI rate of zero (p=0.0006, 95% CI = 0.00521, 0.0186); in their study, they actively involved the nursing staff and the result was sustained over a period of 20 months (Reiter et al., 2023). On implementing a similar interdisciplinary BECA, Hong et al. (2021) reported their pre-test (n=141) and post-test (n=208) research results from over 10 years, to demonstrate a VRI rate improvement from 29.1 % to 4.8% (p=0.0001). Previously, a similar significant reduction in the VRI from 27 % to 10 %, (p=0.001) was also noted in the Talibi et al. (2020) study, reporting interdisciplinary BECA that involved nurses. Whilst there is little agreement on which intervention in the bundle is more effective (Hong et al., 2021) their success demonstrates the importance of partnership between the healthcare team members, and the inevitable role the nurses can play in preventing VRI.

Learner

The mission targeting to curb VRI may be impossible when the nurses are ignorant of the common risk factors (RF) of VRI, and the evidence-based risk mitigation strategies. Murthy et al. (2016) reported older age, intraventricular haemorrhage, longer hospital stays and concurrent systemic infections as RF of VRI. Khalaveh et al. (2021) found increased CSF sampling frequency as the only RF for VRI in their research while RFs in Mehreen et al. (2022) study were the longer EVD placement duration and the increased frequency of CSF sampling. Hong et al. (2021) proposed CSF leakage from the ventriculostomy site as a major cause of VRI. Flint et al. (2013) implied any disconnection of the closed EVD system such as ventriculostomy drainage bag changes, CSF sampling from the EVD, opening of three-way cork and medication administration through EVD as RF for VRI.

Interestingly, Bookland, Sukul and Connolly (2014) and Champey et al. (2019) reported violation of EVD care protocols and knowledge deficits as RFs for VRI. In Australia, the National Safety and Quality Health Standards Framework (Australian Commission on Safety and Quality in Healthcare (ACSQHC), 2017) guides organisations to engage in safety and quality improvement activities; the organisations are required to develop policies and guidelines considering the RFs in their settings and underpinning the recent evidence (ACSQHC, 2017); the employees are vested with the responsibility to familiarise and abide by the updated guidelines to ensure excellent and standardised care (ACSQHC, 2017). Therefore, the organisational guidelines about EVD care could be recommended as the primary quick reference guides in the clinical settings for both novice and experienced clinicians in Australia to keep abreast with the relevant knowledge to prevent VRI.

The evidence-training gap among the healthcare workers managing EVD is a risk factor that can lead to complications (Silva et al. 2020). For instance, if the nurses' sampling technique is outdated and sub-standard, it may cause two main problems. Firstly, the false positive CSF culture related to the sample contamination could pose a challenge to the diagnosis of true VRI (Lenski et al., 2019); this is particularly true when CSF pleocytosis cannot be differentiated as in intra-ventricular haemorrhage (Champey et al., 2018; Widén et al., 2017). Secondly, poor sampling techniques can inoculate microbes into the EVD system and cause VRI (Talibi et al., 2020). Talibi et al. (2020) in their prospective study (n=275) implemented a BECA that focused on improving EVD access and manipulation techniques. Whilst the average number of EVD access remained stable during the study period, the VRI rate declined significantly ($p<0.001$) from 27% to 10 % which could partly be attributed to the Hawthorne effect (Talibi et al., 2020); nevertheless, it implies the effectiveness of a superior sampling technique implemented with the BECA (Talibi et al., 2020). Therefore, it is plausible to argue that nurses managing EVD must pursue lifelong learning (Silva et al., 2020) and acquire specialised knowledge and skills, for preventing VRI (Champey et al., 2018).

Educator

Many studies have acknowledged the significance of training nursing staff in EVD care as a strategy for preventing VRI (Champey et al., 2018; Silva et al., 2020). Dasgupta et al. (2018) investigated the effects of simulation-based training (SBT) on precision in the EVD insertion and handling techniques; senior nurses were a part of the team delivering the workshops to the neurosurgeons and nurses (Dasgupta et al., 2018); although the results were statistically insignificant, possibly related to the smaller baseline VRI rate and effect size, a 50% reduction in the VRI was observed after the SBT intervention (Dasgupta et al., 2018). Later, Reiter et al. (2023) used SBT to enable the implementation of their BECA that yielded a VRI rate of zero; albeit the credit for the absolute reduction of VRI to zero cannot be completely attributed to the SBT, it can be viewed as a promising cardinal strategy that nurse educators can adopt to enable prevent VRI.

The training and assessment on EVD care, at regular intervals, could be a beneficial strategy to keep the neuro-nurses abreast with the relevant knowledge and skills. Silva et al. (2020) conducted a Quasi-experimental pre- and post-test study on 38 nurses to determine their knowledge retention upon EVD training. This research demonstrated that the knowledge retention from the EVD training was reduced significantly after 3 months, which is indicated by the statistics in Phase 1 ($M=4$, $SD= 1.3$, $P = 0.004$) and Phase 3 ($M=5$, $SD= 1.4$, $P= 0.20$). Furthermore, they found that the nurses retained practice based EVD related knowledge more than the theoretical component between the test at week 1 and 3 months ($P= 0.014$) (Silva et al., 2020); this implies the scope of the nurse educator role, and the necessity for providing regular skill training, practice opportunities and conducting the competency assessments in EVD care to prevent VRI.

Patient advocate

Nurses are ideally placed in the position to play the role of patient advocate (PA) due to their round-the-clock presence and their

intimacy with the patients (Cole, Mummery and Peck, 2022). The nursing code of conduct requires nurses to be the PA and act to safeguard against any healthcare-related harm and empower patients to be partners in their care (Cole et al., 2022; Nursing and Midwifery Board of Australia, 2018). Unfortunately, many patients with EVD are sedated or in a deteriorated neurological state (Champey et al., 2018); impacting their physical and cognitive status and requiring significant nursing support. Skill-related contemporary evidence-based knowledge is one of the antecedents that nurses must possess to effectively execute PA roles (Abbasinia, Ahmadi and Kazemnejad, 2020). For instance, routine CSF sampling is a controversial practice in literature for the procedure itself can predispose patients to VRI (Talibi et al., 2020). However, in a multi-centre retrospective research (n= 462), studying whether daily CSF sampling could benefit prevent VRI, they found VRI rate (1.4%) in the intervention group was much lower (95% CI, 0-2.9) compared to the control group which was 9.2 % (95 % CI 4.2-14.2, P<0.01) (Champey et al., 2018); this study reported that they could identify instances of colonisation earlier and intervene to prevent progression to VRI (Champey et al., 2018). On the other hand, Widén et al. (2017) in their retrospective observational analytical study, (n=191) found frequent CSF sampling as one of the causes of VRI. Given the same procedure of CSF sampling increased the VRI rate in Widén, et al.'s (2017) research, and reduced it in Talibiet al.'s (2020) study, it is dubious whether the poor handling technique has had any role in causing VRI, which warrants further investigation. Despite the uncertainties, the current good practice recommendation based on the available low-quality evidence is to reserve CSF sampling for only when clinically indicated (Fried et al., 2016). Therefore, the nurses must execute their PA role,and identify, and halt any non-adherence to the local hospital protocols and aseptic practices (Talibi et al., 2020). Furthermore, the nurses must be empowered to rationalise and question the requirement of unwarranted EVD manipulations and CSF samplings (Talibi et al., 2020) in the best interest of their patients.

Yet another way to engage in the PA role is to participate in antimicrobial stewardship (AMS). AMS is a collaborative practice aimed to optimise antimicrobial use and thereby retard the emergence of drug-resistant microbial strains (Kirby et al., 2020). The engagement of bedside nurses in AMS is a potent yet underused opportunity whilst antimicrobial resistance is a huge worldwide threat (Danielis et al., 2022). The findings from a multi-centre qualitative study in Australia agree that the nurse's role in AMS is limited by constraints such as knowledge deficits and hierarchical relational issues within the hospital systems (Kirby et al., 2020). The body of evidence suggests that prophylactic antibiotic use to prevent VRI is prevalent (Hong et al., 2021; Sheppard et al., 2020) despite the low evidence and poor consensus on the duration of antibiotics and their efficacy (Rienecker et al., 2023). Interestingly, in the Mehreen et al. (2022) study, 76 % of the causative agents for VRI were multidrug-resistant gram-negative bacilli; this serves as a dire reminder to impose judicious use of antibiotics and AMS in controlling the emergence of superbugs. It is high time to recognise and empower nurses at the bedside who are better positioned to ensure correct drug dosing, identify and report any devi-

ations from the therapeutic guidelines, and report adverse incidents (Kirby et al., 2020); through clarifying, prompting, reminding, and questioning the medical decisions (Kirby et al., 2020) to prevent the emergence of drug-resistant VRIs (Talibi et al., 2020).

Researcher

The number of neuroscience nursing-specific research and researchers is low (Hinkle et al., 2022) causing a huge gap in the literature. Scarcity in the VRI-related nursing research papers was clear when the Boolean limiter 'AND' was applied to yield only 3 relevant papers during the literature search for this paper. Moreover, some studies investigating certain promising interventions to prevent VRI did not attain statistical significance; for example, Angulo et al.'s (2019) research on the effect of betadine gel dressing or Roethlisberger et al.'s (2018) chlorhexidine patch dressing in preventing VRI were underpowered and needed more rigorous research. Neuroscience nursing-specific research and researchers are vital to expand the body of knowledge and evidence and thereby improve patient outcomes (Hinkle et al., 2022) and guide future research directions.

Conclusion

The identified roles and responsibilities of nurses in preventing VRI are limited in the literature despite their active participation in EVD care. Literature suggests that an awareness of the nurses' roles and responsibilities may contribute to the improved quality of healthcare services. This review of literature enabled the author to identify and inform more nursing roles and responsibilities pertinent to preventing VRI, such as infection controller, wound care provider, team player, learner, educator, patient advocate, and researcher. The practice of managing EVD differ widely between organisations. Nevertheless, if an awareness of the roles and responsibilities in preventing VRI among nurses could be created through policies and procedures or education, it may contribute to curbing VRI. It is also high time to encourage neuroscience nurses to expand their role as researchers to produce quality evidence to support preventing VRI, to determine future research directions and to improve patient outcomes.

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