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CONCISE COMMUNICATION

Reducing the Incidence of Intraventricular Catheter-Related Ventriculitis in the Neurology-Neurosurgical Intensive Care Unit at a Tertiary Care Center in St Louis, Missouri: An 8-Year Follow-Up Study

Hitoshi Honda, MD; Jeffrey C. Jones, MD; Martha C. Craighead, MBA, RN; Michael N. Diringer, MD; Ralph G. Dacey, MD; David K. Warren, MD, MPH

We reviewed the effect of 3 interventions to reduce the incidence of intraventricular catheter-related ventriculitis, conducted at a tertiary care center in St Louis, Missouri, during an 8-year period. The incidence density of intraventricular catheter-related ventriculitis decreased substantially after the implementation of standardized management of intraventricular catheters.

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Intraventricular catheters are widely used for diagnostic and therapeutic purposes in patients with hydrocephalus and elevated intracranial pressure. Ventriculitis is a recognized complication that results from the use of these catheters. The incidence of intraventricular catheter-related ventriculitis ranges from 0% to 22%, depending on the definition of ventriculitis.¹⁻³ Risk factors for intraventricular catheter-related ventriculitis include prolonged intraventricular catheterization, leakage of cerebrospinal fluid (CSF), intracranial hemorrhage, a recent neurosurgical procedure, the insertion of multiple catheters, and the lack of a strict protocol for drain management.^{1,4,5}

Appropriate management of intraventricular catheters is essential to prevent intraventricular catheter-related ventriculitis. Despite the potential life-threatening consequences of intraventricular catheter-related infections, the optimal management of these devices has not been well investigated.

We chronologically implemented 3 interventions to standardize management of intraventricular catheters in a single neurology-neurosurgical intensive care unit (NNICU) and observed a reduction in the incidence of intraventricular catheter-related ventriculitis during an 8-year period.

METHODS

A before-after study was conducted during the period from January 2001 through December 2008 in the 20-bed NNICU at Barnes-Jewish Hospital, a 1,252-bed, academic, tertiary care center in St Louis, Missouri. During the preintervention period, the physicians who inserted the intraventricular cath-

eters adhered to maximal barrier precautions (ie, the use of cap, mask, sterile gown, and sterile gloves) during the procedure. Catheters could be inserted in patients in the NNICU at the bedside or in the operating room. A transparent, semi-permeable dressing was applied as a cover to the intraventricular catheter insertion site. This dressing was not changed at a regular interval but only when it was soiled or became loose, and then only by neurosurgery staff physicians, residents, or NNICU physicians. The patient's scalp hair was trimmed with a hair clipper prior to intraventricular catheter placement. Povidone-iodine was applied to the insertion site of the intraventricular catheter. Patients who underwent intraventricular catheterization received cefazolin as an antimicrobial prophylaxis prior to the procedure.

During our 8-year study, 3 interventions were subsequently implemented to standardize management of intraventricular catheters. These interventions have continued to be used as a standard protocol after their implementation in our study. The first intervention required that all medical personnel in the patient's room or in the operating room who were not directly involved in the placement of the intraventricular catheter wear a mask and cap while the patient underwent intraventricular catheterization. This intervention was introduced in May 2002. In June 2004, a standardized dressing protocol was implemented (ie, the second intervention). This protocol was adapted from guidelines to prevent intravascular catheter-related bloodstream infections⁶ and consisted of 3 components: (1) use of sterile gauze dressing with adhesive tape to cover the catheter site, (2) changing of the intraventricular catheter site dressing every 48 hours by NNICU nurses who received standard training, and (3) documentation of the date and time of gauze-dressing change. The third intervention was the use of a clindamycin- and rifampin-impregnated intraventricular catheter (Bactiseal; Codman) starting in October 2006.⁷

We defined each period of our study as follows: period 1 was the preintervention period (January 2001–April 2002); period 2 started after additional precautions were initiated for healthcare workers present during catheter insertion (May 2002–May 2004); period 3 started after the implementation of a standardized protocol for dressing an intraventricular catheter site (June 2004–September 2006); and period 4 started after the introduction of the antimicrobial-impregnated catheter (October 2006–December 2008).

All patients who underwent intraventricular catheterization were included in our study. Patients were excluded if they were less than 18 years of age; if they had a preexisting diagnosis of meningitis, subdural empyema, and/or internalized ventricular shunt infection; or if they had a positive culture result from a CSF sample 5 or more days after intraventricular catheter removal.⁸ Intraventricular catheter-related ventri-

TABLE 1. Incidence of Intraventricular Catheter-Related Ventriculitis in a Neurology-Neurosurgical Intensive Care Unit at a Tertiary Care Center in St Louis, Missouri, by Study Period

Study period	No. of catheter-days	Mean device utilization rate, per month	Incidence density	Incidence ratio vs period 1 (95% CI)
Period 1	1,125	0.17	3.56	...
Period 2	1,826	0.17	3.29	0.92 (0.26–3.27)
Period 3	3,690	0.30	2.17	0.61 (0.18–2.02)
Period 4	3,457	0.23	0.87	0.24 (0.05–1.09)

NOTE. Period 1 was the preintervention period (January 2001–April 2002); period 2 started after additional precautions were initiated for healthcare workers present during catheter insertion (May 2002–May 2004); period 3 started after the implementation of a standardized protocol for dressing an intraventricular catheter site (June 2004–September 2006); and period 4 started after the introduction of the antimicrobial-impregnated catheter (October 2006–December 2008). The incidence density of intraventricular catheter-related ventriculitis was defined as the number of infections per 1,000 catheter-days. CI, confidence interval.

culitis was defined as the growth of a pathogen from a CSF culture at least 48 hours after intraventricular catheter insertion.⁸ If common skin flora were isolated from the CSF culture (eg, coagulase-negative staphylococci or *Corynebacterium*, *Bacillus*, *Micrococcus*, or *Propionibacterium* species), then one of the following criteria also had to be met for the patient to receive a diagnosis of intraventricular catheter-related ventriculitis: a positive Gram stain result from the original CSF sample, consistent with the organism cultured; a decreased CSF glucose level (ie, less than 25 mg/dL); an increased CSF protein level (ie, greater than 50 mg/dL); or CSF neutrophilic pleocytosis (ie, white blood cell count greater than 10 cells/mm³).⁸

The primary outcome was the incidence density of intraventricular catheter-related ventriculitis, which was defined as the number of infections per 1,000 catheter-days. The monthly

device utilization rates were defined as the number of catheter-days per total number of patient-days per month. Patients who did not meet the aforementioned criteria were excluded from these calculations. The incidence ratios and 95% confidence intervals were calculated by use of SPSS, version 15.0 (SPSS), and Epi Info, version 3.5.1 (Centers for Disease Control and Prevention). Our study was approved by the Washington University Human Research Protection Office.

RESULTS

During the 8-year study period, a total of 953 patients underwent intraventricular catheterization. Of these 953 patients, 42 (4.4%) were excluded from our study because they either were less than 18 years of age (4 patients), had ven-

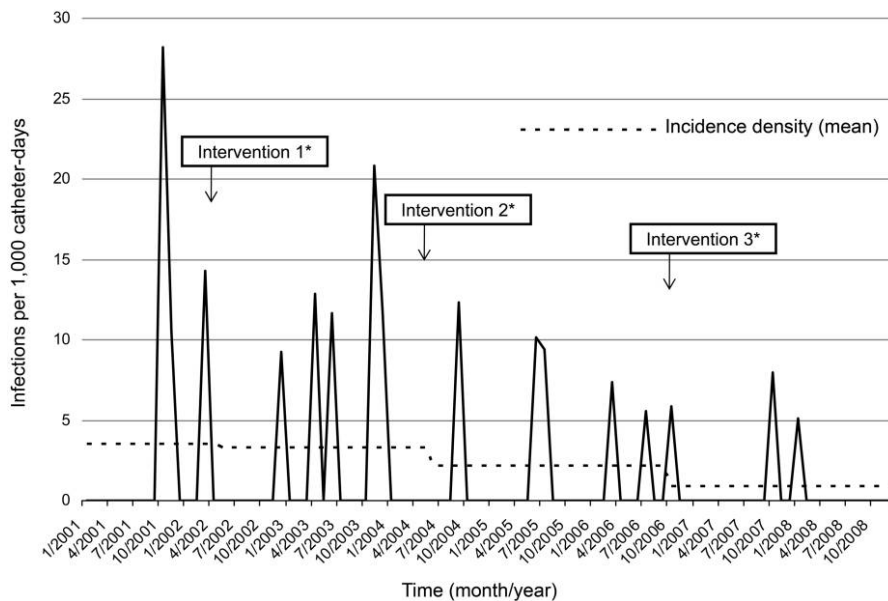


FIGURE 1. Incidence density (which was defined as the number of infections per 1,000 catheter-days) of intraventricular catheter-related ventriculitis in a neurology-neurosurgical intensive care unit at a tertiary care center in St Louis, Missouri. *See Methods for the description of interventions.

triculitis due to an internalized ventricular shunt infection (14 patients), or received a diagnosis of preexisting meningitis or subdural empyema (24 patients), thus leaving 911 patients for our study (resulting in a total of 10,098 catheter-days).

Nontraumatic intracranial hemorrhage was the most common indication for intraventricular catheterization (657 [72.1%] of 911 patients). The number of catheter-days during each intervention period is shown in Table 1 and Figure 1. The mean monthly device utilization rate per period ranged from 0.17 to 0.30 (Table 1). The overall incidence of intraventricular catheter-related ventriculitis was 2.3% (21 of 911 patients). Of the 21 patients with intraventricular catheter-related ventriculitis, 14 patients (66.6%) had intraventricular catheter-related ventriculitis due to gram-positive bacteria—with the most common being coagulase-negative staphylococci (9 patients) and *Enterococcus faecalis* (3 patients)—and 7 patients (33.3%) had intraventricular catheter-related ventriculitis due to gram-negative bacteria—with the most common being from the Enterobacteriaceae family (*Klebsiella pneumoniae* [3 patients], *Enterobacter* species [2 patients], and *Escherichia coli* [1 patient]). The incidence density for each period is shown in Table 1. The incidence density was highest during the preintervention period (ie, 3.56 infections per 1,000 catheter-days). Compared with the initial 16-month preintervention period, the last 27 months of our study had a 76% reduction in the incidence of intraventricular catheter-related ventriculitis ($P = .066$).

DISCUSSION

The incidence of intraventricular catheter-related ventriculitis decreased by more than three-quarters after the implementation of multiple interventions, although, because of our small sample size, this reduction did not reach statistical significance. However, our findings suggest that the standardized management of intraventricular catheters and the use of antimicrobial-impregnated catheters led to a decrease in the incidence of intraventricular catheter-related ventriculitis. We hypothesize that the implementation of a standardized protocol for dressing an intraventricular catheter site, adapted from guidelines to prevent intravascular catheter-related bloodstream infections,⁶ was a key component in reducing the risk of intraventricular catheter-related ventriculitis. A previous study showed that strict adherence to infection prevention measures during dressing changes of intraventricular catheter sites terminated an outbreak of *Pseudomonas aeruginosa* ventriculitis in a neurosurgical intensive care unit.⁹ Similar to central venous catheters, intraventricular catheters are inserted into a sterile anatomical space and are used to obtain CSF samples. Bacterial colonization and local inoculation around the intraventricular catheter site likely predisposes a patient to intraventricular catheter-related ventriculitis. Thus, the aseptic insertion and care of an intraventricular catheter are essential to preventing infection. Our study also supports the use of antimicrobial-impregnated

intraventricular catheters as a potential means to reduce the incidence of ventriculitis. A small, randomized, controlled trial demonstrated that the use of antimicrobial-impregnated external ventricular drain catheters reduced the colonization rate by 50%, compared with the use of nonimpregnated catheters.¹⁰

Ideal management of intraventricular catheters is evolving. In our study, the baseline characteristics of the patients, the frequency of manipulation of the intraventricular catheter, prophylactic antimicrobial use, adherence to maximal barrier precautions, and the “washout” period for each intervention were not assessed. However, a multidisciplinary approach and the use of methods similar to those applied to the prevention of intravascular catheter-related infections appear to hold the promise of preventing intraventricular device-related infections in critically ill patients and warrant further study.

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