

CONCISE COMMUNICATION

Study of Cerebrospinal Fluid Shunt–Associated Infections in the First Year Following Placement, by the Canadian Nosocomial Infection Surveillance Program

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In a national surveillance system study, the infection rate following cerebrospinal fluid shunt surgery was 4.1% (95% confidence interval, 3.36%–4.92%). Cases of infection were more common in children than in adults (4.85% vs 3.24%; $P = .04$) and occurred sooner after surgery in children than in adults. A wide variation in compliance with antimicrobial prophylaxis was observed between 21 participating medical centers.

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Placement of cerebrospinal fluid (CSF) shunts is a common treatment for hydrocephalus, an enlargement of the cerebroventricular system that results from failure of CSF drainage.¹ Infection of the shunt may result in shunt malfunction, short- or long-term cognitive impairment, and surgical replacement of the device under general anesthesia, with prolonged hospital stay.^{2,3} Over 40,000 shunts are placed annually in the United States, with an estimated inpatient mortality of 2.7% in the community hospital setting.¹ The National Nosocomial Infections Surveillance System reported pooled mean rates of 4.42–5.36 cases of infection per 1,000 procedures, depending on the risk category.⁴ We began a surveillance program to permit benchmarking in Canada.

METHODS

The Canadian Nosocomial Infection Surveillance Program is a collaborative effort of the Canadian Hospital Epidemiology Committee, which is a subcommittee of the Association of Medical Microbiology and Infectious Disease of Canada, and the Public Health Agency of Canada. Patients of any age admitted for placement of an internalized CSF shunting device or modification of a shunting device were eligible. Patients with transcutaneous or external shunting devices were excluded, as were those who had CSF infection at the time

of surgery. Patients who had eligible shunt surgery from January 15, 2000 to January 15, 2002 were followed up for 12 months or until an infection occurred or the device was removed.

A patient could be enrolled more than once if the device had not previously been infected. A “new” shunt was defined as one in which all hardware was newly inserted. A modification was defined as a procedure in which at least one part of a preexisting shunt remained in the patient. The age for children was defined as 18 years or less. The duration of shunt placement was determined to be from the time of placement or modification until infection, removal, death, or 1 year after placement. The primary outcome measure was the occurrence of nosocomial CSF shunt infection, defined as a positive result yielded by culture of the CSF, within 12 months of the surgery.⁵ This was an observational study; clinicians were not provided direction with regard to CSF sampling or other interventions. Microbiology laboratory records were reviewed regularly by infection control practitioners to ascertain infected patients. Following data extraction on standard forms, nonnominal data were forwarded to the Public Health Agency of Canada for data entry. Where required by local institutions, ethics review board approval was obtained.

Data were analyzed using the software program SAS, version 8.2 (SAS). Unless otherwise specified, 95% confidence intervals (CIs) were constructed; the level of significance was set at .05. No adjustments were made for multiple comparisons. The analysis of proportions consisted of constructing binomial point estimates and exact binomial CIs for each group and of assessing differences between treatments by use of χ^2 tests. The analysis for continuous variables consisted of point estimates and CIs for mean values. P values greater than .05 were listed as nonsignificant. P values less than .001 were listed as $<.001$; other P values were listed as exact values. Relative risk estimates and 95% CIs were used to explore the association between antibiotic use and infection rates for each participating medical center. Comparisons between survival curves of time to infection for adult and pediatric cases were performed using a log-rank test.

RESULTS

During the study period, there were 2,616 shunt procedures performed for a total of 1,844 patients in 21 hospitals from 8 provinces; approximately half (53%) of the procedures were performed for patients aged 18 years or less. Completely new shunts were placed in 608 (44%) of 1,382 procedures performed for pediatric patients and in 769 (62%) of 1,234 procedures performed for adult patients; the remaining procedures were for modifications or replacements. Male patients

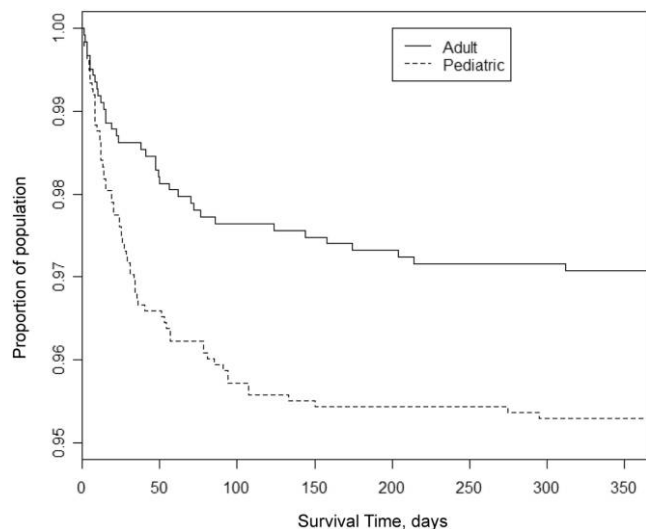


FIGURE 1. Survival curves of the time to infection of the cerebrospinal fluid shunt during the 365 days after shunt insertion, replacement, or modification, by age group. The y-axis shows the proportion of the 2 populations (adult and pediatric) who remained infection free during the year after shunt surgery, starting with 100% of the population (1.0) and showing loss of the cohort to infection over time (Wilcoxon log-rank, 25499; $P = .049$).

comprised 51% of the population. The ventriculoperitoneal shunt was, for all age groups, the most common device used (ie, it was used for 2,170 [83%] of the 2,616 procedures). Cystoperitoneal shunts were used more commonly in adults than in children (6.3% vs 3.1%), and lumboperitoneal shunts were also used more commonly in adults than in children (3.5% vs 0.44%). Ventriculoatrial shunts were used overall in 52 (2%) of 2,616 procedures. The most common causes of hydrocephalus (as an indication for shunt insertion) were congenital conditions and hemorrhage; other causes varied with the age of the patient. Of the 1,208 procedures for shunt modification or replacement, 1,029 (85%) were the result of shunt malfunction, 64 (5.3%) were the result of device fracture, and 29 (2.4%) were the result of the need for a longer shunt.

Overall, there were 4.1 cases of infection per 100 procedures (95% CI, 3.36–4.92); there were 107 cases of infection in 2,616 procedures. Shunt infections were more common in children, with 4.85 cases of infection per 100 procedures (95% CI, 3.78–6.12), compared with shunt infections in adults, with 3.24 cases of infection per 100 procedures (95% CI, 2.32–4.39) ($P = .04$). Shunt infections occurred sooner after surgery for children than for adults (mean interval, 84 vs 101 days; Wilcoxon log-rank, 25499; $P = .049$); see Figure 1. Of the 107 isolates recovered from culture of CSF, the most common organisms were cutaneous commensal flora: coagulase-negative *Staphylococcus* (58 isolates [54%]), *Staphylococcus aureus* (21 isolates [20%]), and *Propionibacterium* species (7 isolates [6.5%]). Prophylactic antibiotics were used overall in 1,972 (75%) of 2,616 procedures. Prophylactic an-

tibiotic use is described in the Table. The relative risk of infection for patients who had preoperative antibiotic prophylaxis, compared with the patients who had no antibiotics in the 2 hours prior to surgery, was 0.76 (95% CI, 0.51–1.15).

DISCUSSION

Complications associated with CSF shunt placement are an important health problem throughout the life span of the patient. For children, the highest rates of complications were seen for those aged less than 5 years; for adults, the highest rates were observed for those aged 50–59 years (Figure 2).

Regardless of the age of the patient, commensal skin flora were the most common pathogens, supporting an epidemiologic link to perioperative inoculation. In the case of CSF shunt surgery, as in the case of other clean surgical procedures involving placement of a prosthetic device, skin flora are thought to gain access to the operative site during the perioperative period. Recently, investigators have suggested that the critical period of inoculation may extend into the early postoperative period.⁶ Efforts to prevent CSF shunt-associated infection have focused on skin preparation, aseptic technique, “theatre discipline,” and prophylactic antibiotics.^{7,8} In our study, 644 (25%) of the 2,616 procedures did not involve any prophylaxis, and variation in practice was seen across medical centers. Randomized controlled trials suggest that prophylactic antibiotics may decrease shunt infection rates,⁹ and preoperative antibiotics are considered a standard of care.¹⁰ We found an overall protective effect of prophylaxis (relative risk, 0.77 [95% CI, 0.51–1.15]). It should be noted that the CI for this estimate included the number 1 and that our study was observational and not designed to test the efficacy of antimicrobial prophylaxis. Many variables can influence risk for infection, but antibiotic prophylaxis is a remediable factor for infection. Participating medical centers

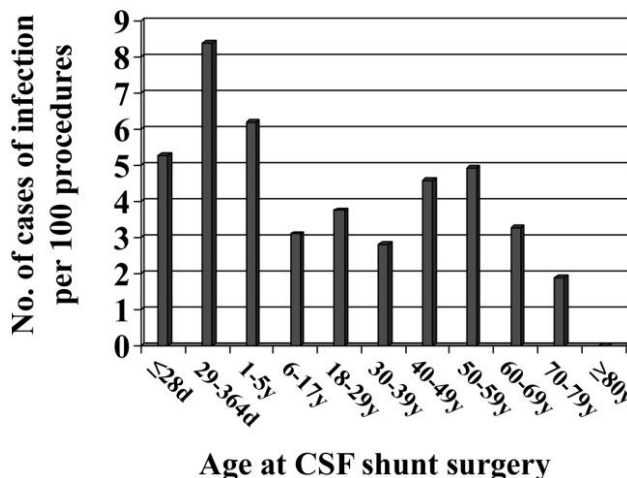


FIGURE 2. Comparison of the rates of healthcare-associated surgical site infection of the cerebrospinal fluid (CSF) shunt within 12 months after device surgery, by age of the patient at surgery.

TABLE. Infection Rates and Use of Antimicrobial Prophylaxis in Patients Undergoing Cerebrospinal Fluid Shunt Surgery in Hospitals in the Canadian Nosocomial Infection Surveillance Program, 2000–2003

Hospital	No. of procedures	No. (%) of procedures that used antibiotic prophylaxis	Infection rate	Prophylactic antibiotic used, % of patients					RR ^a (95% CI)
				1G CSP	VM	CLOX	RIF	Other	
A	99	88 (88.9)	9.1	56.6	29.3	2.0	1.0	12.1	1.0 (0.14–7.26)
B	220	203 (92.3)	3.2	80.0	5.9	0	0.0	8.2	0.50 (0.06–3.94)
C	96	84 (87.5)	3.1	80.2	4.2	2.1	0.0	6.3	0.29 (0.03–2.92)
D	199	190 (95.5)	5.5	95.0	1.5	1.0	0.0	1.5	0.47 (0.07–3.31)
E	117	81 (69.2)	5.1	59.8	12.0	0.0	0.0	11.1	0.89 (0.17–4.63)
F	71	43 (60.6)	8.5	52.1	2.8	1.4	0.0	4.2	3.26 (0.40–26.42)
G	70	41 (58.6)	1.4	47.1	10.0	1.4	0.0	1.4	
H	147	83 (56.5)	4.8	29.3	21.1	2.0	2.0	20.4	1.03 (0.24–4.43)
I	140	103 (73.6)	2.1	50.0	21.4	0.0	0.0	0.7	
J	116	50 (43.1)	2.6	37.9	11.2	<1.0	0.0	9.5	
K	53	29 (54.7)	1.9	47.2	9.4	0.0	0.0	0.0	
L	98	57 (58.2)	2.0	64.3	10.2	3.1	0.0	13.3	
M	204	175 (85.8)	2.0	71.6	6.9	1.5	0.0	12.3	0.50 (0.05–4.62)
N	45	19 (42.2)	11.1	24.4	6.7	6.7	6.7	4.4	0.34 (0.04–2.82)
O	90	35 (38.9)	3.3	22.2	3.3	10	0.0	4.4	
P	382	334 (87.4)	5.2	69.9	6.0	8.4	0.3	8.4	1.29 (0.31–5.40)
Q	209	185 (88.5)	2.4	81.8	3.8	1.0	0.0	2.9	0.52 (0.06–4.45)
R	75	50 (66.7)	8.0	44.0	10.7	2.7	2.7	18.7	1.00 (0.20–5.09)
S	53	31 (58.5)	5.7	7.5	1.9	45.3	0.0	3.8	1.42 (0.14–14.70)
T	59	56 (94.9)	0	88.1	6.8	3.4	8.5	3.4	
U	73	35 (47.9)	2.7	39.7	4.1	4.1	1.4	2.7	1.09 (0.07–16.71)
Total	2,616	1,972 (75.4)	4.1	61.8	8.7	3.6	0.6	7.6	0.77 (0.51–1.15)

NOTE. Some patients received more than 1 antibiotic. CI, confidence interval; CLOX, cloxacillin; CSP, cephalosporin; RIF, rifampin; RR, relative risk; VM, vancomycin; 1G, first-generation.

^a With vs without antibiotic prophylaxis.

can use compliance data from this program to improve performance.

The higher rates of infection for children, and the potential long-term sequelae of infection on the developing brain, argue for stratification of CSF shunt-associated infections by age. The pooled all-ages Canadian infection rate is similar to that reported by the National Nosocomial Infections Surveillance System, but we found that rates for children and adults are significantly different. We recommend that surveillance of CSF shunt-associated infections be stratified by age. We will be continuing age-stratified surveillance for this important clean surgery with prosthetic device placement, and we expect over time to develop benchmark rates for use in infection prevention and control and in quality improvement programs.

MEMBERS OF THE CANADIAN NOSOCOMIAL INFECTION SURVEILLANCE PROGRAM

The members of the Canadian Nosocomial Infection Surveillance Program who participated in the surveillance project for CSF shunt-associated infections are as follows: Dr. E.

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