CONCISE COMMUNICATION

Incidence of Catheter-Related Bloodstream Infection Among Patients With a Needleless, Mechanical Valve–Based Intravenous Connector in an Australian Hematology-Oncology Unit

Kathryn Field, MBBS; Caroline McFarlane, MBBS; Allen C. Cheng, PhD; Andrew J. Hughes, FRACP; Elly Jacobs, MNurs; Kaylene Styles, RN; Jillian Low, RN; Peter Stow, FJFICM; Philip Campbell, FRACP; Eugene Athan, FRACP

There are few Australian data on the incidence of catheter-associated bloodstream infection (BSI) among patients in hematology-oncology units. We found an increase in catheter-associated BSI rates coincident with the introduction of a mechanical valve connector (2.6 infections vs 5.8 infections per 1,000 catheter-days; incidence rate ratio, 2.2; $P = .031$).

Infect Control Hosp Epidemiol 2007; 28:610-613

Catheter-associated bloodstream infection (BSI) is a serious complication of long-term use of intravenous catheters. Although data are difficult to compare because of differences in populations, studies of BSI in hematology-oncology units found rates of 3-14 catheter-associated BSIs per 1,000 catheter-days.[1] In Australia, one survey involving patients with Hickman catheters who were hospitalized in a hematology unit found an infection rate of 50% (9.1 infections per 1,000 catheter-days) over a 22-month period.[2]

There have been recent reports that mechanical valve (MV) intravenous devices may be associated with a higher incidence of catheter-associated BSI than split septum (SS) connectors.[3-7] We initiated an audit of catheter-associated BSI rates in response to a perceived increase in incidence coincident with a change from a SS intravenous connector to a MV connector.

METHODS

Geelong Hospital is a 400-bed regional public hospital in Geelong that services southwestern Victoria, Australia. The hematology-oncology service treats all hematological and solid organ malignancies, including those requiring autologous transplantation but not those requiring allogeneic transplantation. Chemotherapy is administered both in the inpatient and outpatient setting; a mean of 15-20 inpatients are receiving chemotherapy at any one time. Single-lumen and double-lumen Hickman catheters are used for intravenous access when necessary. The Infection Prevention Service provides education for hospital staff, including nurses in the hematology-oncology service, on the insertion and care of catheters.

The study included all patients with Hickman catheters placed during hospitalization in the hematology-oncology service between July 1, 2004, and June 30, 2005. This retrospective analysis was conducted in the latter half of 2005 after observing evidence of an anecdotal increase in the incidence of BSI during a quasi-experimental 12-month period in which 2 different access devices—an SS device and an MV device—were used during separate periods for Hickman catheters. We defined BSI according to Centers for Disease Control and Prevention guidelines[8] and similar Australian guidelines.[9] Bacteremia involving commensal bacteria was defined as isolation of the same species from multiple blood cultures. Clinical notes for all episodes of BSI were reviewed by 2 infectious diseases physicians (A.C. and E.A.) to ensure that the infections satisfied the case definition.

Use of needleless MV intravenous connectors (the Clave connector system and CLC2000 connector system; Abbott Laboratories) (Figure 1) began on November 1, 2004, and

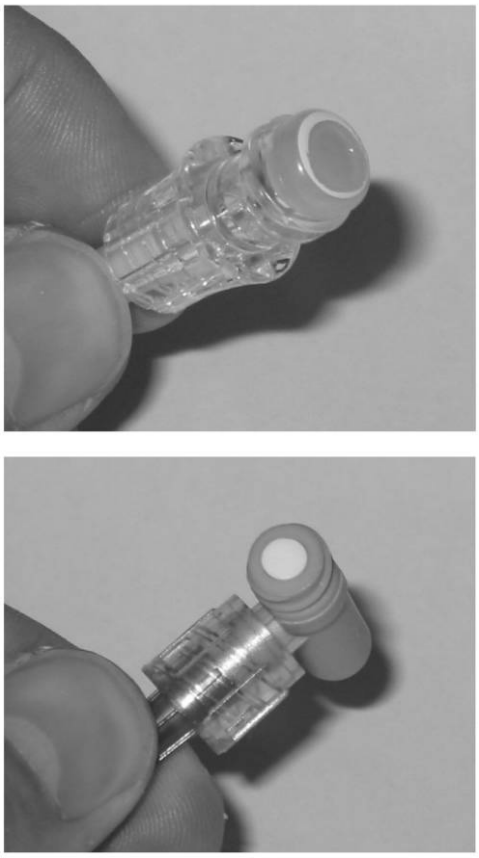

FIGURE 1. Interlink split septum connector (Baxter; *top*) and CLC2000 mechanical valve connector (Abbott Laboratories; *bottom*).

TABLE. Demographic and Clinical Characteristics of Patients With Hickman Catheters Inserted Between July 1, 2004, and June 30, 2005, in the Hematology-Oncology Unit at Geelong Hospital (Geelong, Australia)

Variable	Overall	SS connector periods	MV connector period
Hickman catheter type, no. of patients			
Any	98	83	62
Double lumen	34	28	21
Single lumen	64	55	41
Condition, no. of patients			
Acute leukemia	20	18	14
Other hematological conditions	26	21	15
Solid tumor	52	44	33
No. of catheter-days	8,007	4,539	3,468
No. of catheter-associated nosocomial BSIs	32	12	20
BSI incidence, cases per 1,000 catheter-days	…	2.6	5.8
Organism recovered, no. of isolates[a]			
Staphylococcus aureus	2	1	1
Coagulase-negative staphylococci	16	2	14
Streptococcus species	1	1	0
Enterococcus species	2	0	2
Stenotrophomonas maltophilia	2	2	0
Pseudomonas aeruginosa	2	2	0
Enterobacter cloacae	5	2	3
Other gram-negative bacilli	8	5	3
Candida parapsilosis	1	1	0

NOTE. A total of 47 patients had catheters in place during the entire study period. Split septum (SS) connectors were used between July 1, 2004, and October 31, 2004, and between April 1, 2005, and June 30, 2005. Mechanical valve (MV) connectors were used between November 1, 2004, and March 31, 2005. BSI, bloodstream infection.

[a] Data include organisms associated with polymicrobial bacteremia in 6 of the 32 episodes of catheter-associated BSI.

ended on March 31, 2005. Before and subsequent to this period, an SS intravenous connector (Interlink; Baxter) was used. The incidence rate ratio (IRR) of BSI and the number of catheter-days were calculated for the time in which the MV device was used (hereafter, the MV period) and the time in which the SS device was used (hereafter, the SS period). Apart from changes in connectors, there were no alterations in staffing levels, line types or supplier, intravenous fluids, catheter insertion policy and method, barrier precautions, nursing education or educational campaigns, blood culture policy and procedures, or dressings and other equipment used. Nursing staff were all trained by clinical nurse educators or oncology clinical nurse specialists, and additionally, each connector supplier provided a representative to give necessary education about the use and care of their device. Only trained oncology nurses were permitted to access central catheters. Blood was obtained for culture from patients if they were febrile (temperature, >38°C) or had clinical signs of infection (eg, rigors and/or hemodynamic instability); in the absence of these signs, routine cultures were not performed for neutropenic patients.

Confidence intervals (CIs) for IRRs were calculated assuming the Poisson distribution. Comparison of the time to first BSI onset in each group was performed using the log rank test. Statistical tests were conducted using Stata SE, version 9.0 (Stata).

RESULTS

During the study period (July 1, 2004, through June 30, 2005), 98 patients had Hickman catheters placed. Of these patients, 20 had acute leukemia, 26 had other hematological conditions, and 52 had solid organ tumors. The median age of the patients was 60 years, and 53% were male. Only BSI in patients with single-lumen or double-lumen Hickman catheters was analyzed; BSI in patients with ports or peripherally inserted central catheters was not assessed.

There were 32 confirmed catheter-associated BSIs (20 during the MV period and 12 during the SS period) in 25 patients. These were all considered to be nosocomially acquired, on review of the patients' clinical history. There were 62 patients with catheters in situ during the MV period, for a total of 3,468 catheter-days, and 83 patients with catheters in situ during the SS period, for a total of 4,539 catheter-days (Table). Six patients developed more than 1 episode of bacteremia, but the catheters were salvaged rather than removed; subsequent BSI was due to different organisms. There were 19 infections in patients with acute leukemia, 6 in patients with

other hematological malignancies, and 5 in patients with solid organ malignancies. The median interval between the day of Hickman catheter insertion to the first BSI was 54 days (range, 8-345 days; interquartile range, 22-111 days). The median time to the first BSI was 65 days in patients who developed infections during the SS period and 44 days in patients who developed infections during the MV period. This difference was not statistically significant ($P = .17$, by the log rank test). The weekly incidence of BSI during the study period is detailed in Figure 2.

Of the 39 isolates recovered, 22 (56.4%) were gram-positive cocci, 15 (38.5%) were gram-negative rods, and 1 (2.6%) was *Candida parapsilosis*. Much of the increase in the incidence of BSI was accounted for by an increase in the number of infections due to coagulase-negative staphylococci: 14 patients during the MV period were infected with these pathogens, compared with 2 patients during the SS period. All coagulase-negative staphylococci were different species and/or had different antibiotic susceptibility patterns except for 2 pairs that were isolated from separate patients. Molecular typing of these isolates was not conducted. Polymicrobial bacteremia was documented in 6 of 32 episodes of BSI. Further delineation of the isolated organisms appears in the Table.

The incidence of catheter-associated BSI during the MV period was 5.8 infections per 1,000 catheter-days, compared with 2.6 infections per 1,000 catheter-days during the SS period (IRR, 2.2 [95% CI, 1.0-4.9]; $P = .031$). The IRRs were similar for patients with acute leukemia (IRR, 1.6 [95% CI, 0.57-4.5]; 16.2 infections per 1,000 catheter-days during the MV period vs 10.3 infections per 1,000 catheter-days during the SS period), patients with other hematological conditions (IRR, 2.5 [95% CI, 0.35-27.3]; 5.0 vs 2.0 infections per 1,000 catheter-days), and patients with solid organ malignancies (IRR, 3.2 [95% CI, 0.53-34.0]; 2.5 vs 0.71 infections per 1,000 catheter-days). Similarly, IRRs were higher during the MV period, compared with the SS period, for patients with double-lumen catheters (IRR, 2.7 [95% CI, 1.1-7.4]; 17.6 vs 6.5 infections per 1,000 catheter-days) and patients with single-lumen catheters (IRR, 1.3 [95% CI, 0.24-6.8]; 1.5 vs 1.2 infections per 1,000 catheter-days).

At the time of writing, the hematology-oncology unit continues to audit Hickman catheter infections. In the latter half of 2005 (July 1 through December 31), a period in which use of the SS device continued, the incidence of BSI was 2.3 infections per 1,000 catheter-days, which is similar to the BSI incidence among patients during the SS period. We have not noted any further case clusters.

DISCUSSION

In this study, we observed a significant increase in the incidence of catheter-associated BSI coincident with the introduction of a MV intravenous connector. The increased incidence was consistent across patient subgroups and central catheter types and remained increased despite awareness among and continuing education of staff. We considered other confounding factors, such as flushing techniques or other ancillary equipment, that might have contributed to the increased incidence, but a limited ability to detect other confounders is a limitation of this study design. If the nurses' unfamiliarity with the access devices had contributed, one would expect an initial increase in the BSI incidence after introduction of the MV device, followed by a decrease in the incidence as nurses became more familiar with the device; in fact, rates increased rather than decreased during the MV period (Figure 2).

The increase in the incidence of catheter-associated BSI continued until use of the SS device resumed. Although some SS connectors were retained after the change in policy (that is, not all patients had MV connectors changed to SS connectors immediately), no catheter-associated BSIs were recorded during the first week after the change to the MV connector, and 3 catheter-associated BSIs were recorded during the first week after the change back to the SS connector; thus, the true attributable IRR may be higher than that documented.

Our findings are consistent with those from earlier reports on BSI in various patient populations, including patients in the ICU, patients in acute care facilities, and patients in long-term acute care facilities. In a hospital in Melbourne, Australia, a significant increase in the incidence of BSI (from 6.8 to 15.5 cases per 1,000 catheter-days) was documented.[3] Similar results were reported in a healthcare center in the United States, where an increase from 5.4 to 17.3 BSIs per 1,000 catheter-days was associated with a change from SS to MV connectors.[6]

We speculate that risk of colonization of the connector device may be higher for MV devices because of the potential

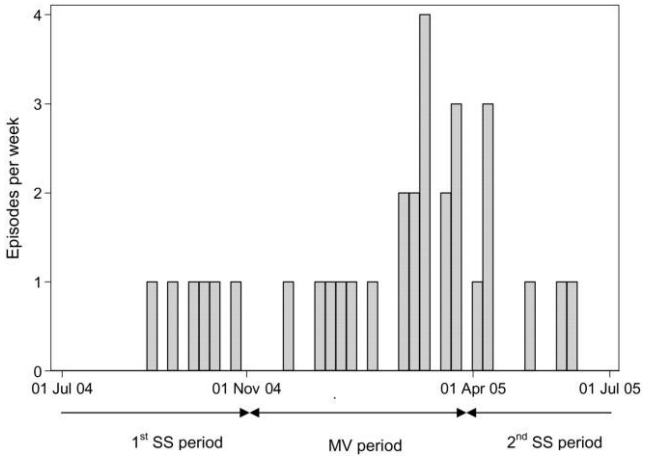

FIGURE 2. Weekly incidence of catheter-associated bloodstream infection between July 1, 2004, and June 30, 2005, in the hematology-oncology unit at Geelong Hospital (Geelong, Australia). MV period, period during which mechanical valve connectors were used; SS period, period during which split septum connectors were used.

difficulty in sterilizing the gap between the valve and the hub; one simulation study has suggested that an antiseptic-barrier cap may reduce the transmission of surface bacteria into the line.[10] Our findings, consistent with those from emerging reports elsewhere,[3-7] suggest that colonization of MV connectors may be associated with increased rates of catheter-associated BSI.

ACKNOWLEDGMENTS

We thank Glenys Harrington (Alfred Hospital, Melbourne, Australia) for providing information about relevant abstracts and other unpublished data.

Potential conflicts of interest. All authors report no conflicts of interest relevant to this article.

From the Departments of Clinical Hematology and Medical Oncology (K.F., C.M., E.J., P.C.), Infectious Diseases (A.C., A.H., K.S., J.L., E.A.), and Intensive Care (P.S.), Geelong Hospital, Barwon Health, Geelong, Victoria, Australia.

Address reprint requests to Eugene Athan, FRACP, Geelong Hospital, Barwon Health, Ryrie Street, Geelong VIC 3220, Australia (Eugene@barwonhealth.org.au).

Received May 29, 2006; accepted August 22, 2006; electronically published April 12, 2007.

 0899-823X/2007/2805-0019$15.00. DOI: 10.1086/516660

REFERENCES

1. Press O, Ramsay P, Larson E, Fefer A, Hickman R. Hickman catheter infections in patients with malignancies. *Medicine* 1984; 63:189-200.
2. Soo RA, Gosbell IB, Gallo JH, et al. Hickman catheter complications in a haematology unit, 1996-98. *Intern Med J* 2002; 32:100-103.
3. Harrington G, et al. An increase in central line associated bloodstream infections rate over a 3-year period in a 35-bed Australian intensive care unit. In: Program and abstracts of the Victorian Infection Control Professionals Association Conference; November 23-25, 2005; Melbourne, Australia. Abstract 118.
4. Jarvis W, Sheretz R, Perl T, Bradley K, Giannetta E. Increased central venous catheter-associated bloodstream infection rates temporally associated with changing from a split-septum to a leur-access mechanical valve device: a nationwide outbreak? In: Program and abstracts of the 32nd Annual Educational Conference and International Meeting of the Association for Professionals in Infection Control and Epidemiology; June 20-23, 2005; Baltimore.
5. Maragakis LL, Bradley KL, Song X, et al. Increased catheter-related bloodstream infection rates after the introduction of a new mechanical valve intravenous access port. *Infect Control Hosp Epidemiol* 2006; 27:67-70.
6. Karchmer TB, Cook E, Palavecino E, Ohl C, Sherertz R. Needleless valve ports may be associated with a high rate of catheter-related bloodstream infection. In: Program and abstracts of the 15th Annual Scientific Meeting of the Society For Healthcare Epidemiology of America; April 9-12, 2005; Los Angeles. Abstract 307.
7. Salgado CD, et al. Significant increased rate of catheter-related bloodstream infections (CRBSI) associated with use of a needleless valve (VN) system in a long-term acute care (LTAC) hospital. In: Program and abstracts of the 16th Annual Scientific Meeting of The Society for healthcare Epidemiology Of America; March 18-21, 2006; Chicago. Abstract 144.
8. O'Grady NP, Alexander M, Dellinger EP, et al. Guidelines for the prevention of intravascular catheter-related infections, 2002. Centers for Disease Control and Prevention (CDC), Hospital Infection Control Practices Advisory Committee. *MMWR Recomm Rep* 2002; 1(RR-10):1-26.
9. VICNISS Hospital Acquired Infection Surveillance Coordinating Centre. *Surveillance Manual.* Version 5. Melbourne, Australia: VICNISS; 2004.
10. Menyhay SZ, Maki DG. Disinfection of needleless catheter connectors. *Infect Control Hosp Epidemiol* 2006; 27:23-28.