American Journal of Infection Control 42 (2014) 122-8

Contents lists available at ScienceDirect

American Journal of Infection Control

journal homepage: www.ajicjournal.org

Major article

Sustained low incidence of central venous catheter-related infections over six years in a Swedish hospital with an active central venous catheter team

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Key Words:
Central venous catheter-related bloodstream infection
Intravascular catheter
Nosocomial infection
Statistical process control

Background: There are limited data on the long-term effects of implementing a central venous catheter (CVC) program for prevention of CVC infections. The aims of this study were to evaluate the incidence of CVC colonization, catheter-related infections (CRI), catheter-related bloodstream infections (CRBSI), and their risk factors over a 6-year period in a hospital with an active CVC team.

Methods: We conducted a continuous prospective study aiming to include all CVCs used at our hospital during the years 2004 to 2009, evaluating colonization, CRI, CRBSI, and possible risk factors.

Results: A total of 2,772 CVCs was used during the study period. Data on culture results and catheterization time were available for 2,045 CVCs used in 1,674 patients. The incidences of colonization, CRI, and CRBSI were 7.0, 2.2, and 0.6 per 1,000 CVC-days, respectively. Analysis of quarterly incidences revealed 1 occasion with increasing infection rates. Catheterization time was a risk factor for CRI but not for CRBSI. Other risk factors for CRI were hemodialysis and CVC use in the internal jugular vein compared with the subclavian vein. Hemodialysis was the only risk factor for CRBSI.

Conclusion: We found that a CRI prevention program led by an active CVC team and adhered to by the entire staff at a county hospital is successful in keeping CVC infections at a low rate over a long period of time.

Central venous catheter (CVC)-related bloodstream infections (CRBSI) are common and can cause excessive morbidity and substantial economic costs and be potentially lethal. There are 80,000 CRBSI annually in the United States.[1] Several studies have shown that the implementation of basic hygiene routines can significantly reduce the number of CRBSI.[1-5] Most of these studies, however, have evaluated this effect over relatively short periods of time. There are limited data on the long-term effects after such intervention. Pronovost et al showed that the incidence of CRBSI continues to decrease after the completion of a study on implementing a bundle for CVC insertion and care on intensive care units (ICUs).[2] This finding was supported by another ICU study over a period of 4 years.[4] A continuous decline in the incidence of CRBSI was also reported in a European ICU study of hospitals participating in a surveillance program, with intermittent registration over 5 years.[6]

In 1999, we introduced an educational and follow-up program based on previous recommendations from the Centers for Disease Control and Prevention for basic hygiene routines on insertion, care, and removal of CVCs.[7] Since then, all wards and outpatient departments (OPDs) at our 500-bed hospital have participated in this program. We evaluated the effects of this program in a 16-month study in 2001 and 2002 and found a CRBSI incidence of 0.44/1,000 days.[8]

To analyze the long-term effect of this program, we conducted a continuous prospective 6-year study, from 2004 through 2009,

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Supported by grants from Futurum the Academy for Health-care, Jönköping County Council, Jönköping, Sweden.
Conflicts of interest: None to report.

http://dx.doi.org/10.1016/j.ajic.2013.09.023

studying CVC colonization, catheter-related infection (CRI), CRBSI, and possible risk factors. The study was approved by the Regional Ethics Review Board in Linköping (reference number M203-09).

METHODS AND MATERIALS

Setting

The hospital is a 500-bed, public, county hospital supporting most medical and surgical specialties. The ICU is a 7-bed general ICU with a median patient Acute Physiology and Chronic Health Evaluation II (Apache II) score[9] of 18. Inpatients outside the ICU were treated on various medical and surgical wards. The hospital has no cardiothoracic surgery or neurosurgery and no transplantation activity. Outpatients were treated in a wide range of OPD clinics, including chronic hemodialysis, parenteral nutrition at home, oncology, infectious diseases, and palliative care.

Study design

We performed a prospective, observational, cohort study from 2004 up to and including 2009. All units using CVCs were instructed to perform a tip culture on CVC removal. Our aim was to study all CVCs used at the hospital. However, for various reasons, tip culture was not performed in all patients (missed culture, transfer to other hospital, accidental removal). Hence, we analyzed all cultured CVCs where insertion and removal dates were given. Exclusion criteria were patients with subcutaneous venous ports, peripherally inserted CVCs, and CVCs used in the neonatal setting. The medical records of all patients included were examined by one of the investigators (F.H.) registering diagnosis, insertion date and hospital, vein, type of catheter, Systemic Inflammatory Response Syndrome (SIRS),[10] Apache II score, reasons for removal, antibiotic treatment, microbial cultures, CRI, CRBSI, and mortality. Adherence to the CVC routines was not evaluated.

CVC team, insertion, and care

Since 1999, the hospital has had a CVC team, consisting of 2 anesthesiologists and 1 ICU nurse. This team is responsible for all written documents concerning CVC insertion, care, and removal. Written instructions are repeatedly distributed to every unit and are also available on the hospital intranet for all staff handling patients with CVCs. All CVCs are inserted by anesthesiologists, who regardless of previous experience are trained under supervision to perform CVC insertion according to instructions. ICU nurses are trained at the start of their appointment and thereafter every other year so as to ensure high adherence to the CVC care routines. Ward and OPD nurses manage the daily care of CVCs outside the ICU. These nurses are supervised by specially trained department nurses, who constitute a hospital network that relies on the CVC team. Furthermore, the CVC team, or the anesthesiologist on call, are available around the clock for handling CVC problems.

Tip cultures of all removed CVCs are used as surveillance and follow-up of the infection prevention program. Since 2006, we have monthly assessments of adherence to basic hygiene rules throughout the hospital, as part of a general quality program.

The catheters were inserted by an anesthesiologist with maximal sterile precautions (cap, mask, gown, gloves, and large drape) using the Seldinger technique. The multilumen CVCs inserted in our ICU were all chlorhexidine/silver sulfadiazine catheters. No other CVCs were antimicrobiologic. The insertion site was treated with a solution of 0.5% chlorhexidine (wt/vol) in 70% alcohol (SCHA) and allowed to dry for 1 to 2 minutes prior to insertion. No prophylactic antibiotics were given. All catheters were secured with monofilament sutures, and the site was dressed with a semipermeable dressing (Tegaderm HP; 3M Healthcare, St. Paul, MN). CVC insertion was documented in the patient's records after completion of the procedure and registered on a computer. Tunneled CVC sutures were removed, and no semipermeable dressing was used when the subcutaneous cuff had firmly healed. Every third day (every seventh day for OPD patients), dressing, stopcocks, and injection membranes were changed, and the insertion site was treated with SCHA. Heparin flushing and locks were not routinely used, except for patient on hemodialysis outside the ICU. The catheters were flushed after every infusion with 10 mL of saline, 4 times, to prevent occlusion. Resting CVCs (>24 hours) were not routinely flushed. Lipid solutions were administered via a separate lumen when a multilumen catheter was used. All CVCs were supposed to be cultured on removal.

Microbiology

The catheters were removed after site treatment with SCHA that was allowed to dry. The distal 5 cm of the CVC tip was cut off and deposited in a sterile container and cultured using a semiquantitative standardized roll plate method.[11] The tip culture result was considered positive if 1 or more colony-forming units (CFU) were found. The CVC tips were cultured within 18 hours after removal. Blood cultures were performed when clinically indicated by sampling blood from another vessel. The bottles were incubated $\leq$ 6 days using an automated blood culture system (BAc/ALERT; bioMériuex, Inc, Durham, NC). Isolates were identified using standard methods at the local microbiology laboratory. Antibiotic susceptibility tests were performed according to Swedish standards (www.srga.org; January 1, 2007).

Definitions

CVC colonization was defined as a positive tip culture with $\geq$ 1 CFU regardless of clinical symptoms.[8] The reason for this was to evaluate whether tip culture alone could be a surrogate marker for CRI or CRBSI. We also used a second, commonly employed, definition of colonization ($\geq$15 CFU).[11] CRI was defined as a positive tip culture from a patient having at least 2 SIRS symptoms at CVC removal, and no other known source of infection, independently of blood culture results.[8,10,12] CRBSI was defined as isolation of microorganisms from the tip culture and a blood culture drawn from another vessel (within 48 hours prior or after CVC removal) that were indistinguishable.[12] Isolates were regarded as indistinguishable if they shared the same phenotype and antibiogram. Duration of catheterization was defined as the number of days from insertion to removal of the CVC. All catheters that were used to some extent in the ICU were regarded as ICU catheters.

Statistical analysis

Associations and differences among groups were assessed using χ^2 test, Student *t* test, or Mann-Whitney test as appropriate. The correlations between different incidences were evaluated with Spearman rank correlation test. Variations of variables over time were analyzed using linear regression analysis (LR). Univariate logistic regression analyses were performed to estimate the risk for colonization, CRI, and CRBSI. Multiple logistic regression models, controlling for catheterization time with following stepwise introduction of significant risk factors, were performed. All analyses were conducted using a statistical software package (version 19.0 for Windows; IBM SPSS, Armonk, NY).

Variations in incidence over time were analyzed with statistical process control (SPC) methods.[13] Seldom occurring events (CRI and