QUALITY IMPROVEMENT REPORT

Reduction of bloodstream infections associated with catheters in paediatric intensive care unit: stepwise approach

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Context

Hospital acquired infections or nosocomial infections are an important problem in safe and effective health care. The Centers for Disease Control and Prevention (CDC) estimates that each year in the United States there are about 1.7 million nosocomial infections in hospitals and 99 000 associated deaths. The estimated incidence is 4.5 nosocomial infections per 100 admissions, with direct costs (at 2004 prices) ranging from \$10 500 (£5300, €8000 at 2006 rates) per case (for bloodstream, urinary tract, or respiratory infections in immunocompetent patients) to \$111 000 (£57 000, €85 000) per case for antibiotic resistant infections in the bloodstream in patients with transplants.¹ With these numbers, conservative estimates of the total direct costs of nosocomial infections are above \$17bn. The reduction of such infections forms an important component of efforts to improve healthcare safety in the US.

This problem is not unique to one country; the British National Audit Office estimated that the incidence of nosocomial infections in Europe ranges from 4% to 10% of all hospital admissions.² In the United Kingdom, they further estimated in 2000 that nosocomial infections contributed to 5000 deaths each year at an annual cost of £1bn to the NHS.^{2,3}

Nosocomial infections are more likely to occur in patients with compromised immune systems because

of their age, disease, nutritional status, and external factors such as the presence of central venous lines, bladder catheters, or endotracheal tubes. Patients in intensive care units therefore have infection rates that are three times higher than those seen in patients in other hospital locations.⁴

Children are especially vulnerable.⁵ Additional factors include the involvement of multidisciplinary teams, the lack of physical barriers between bed spaces, and multiple attempts often required for placing monitoring devices, which further increase the chances of developing nosocomial infections.⁶

Bloodstream infections associated with catheters are the most commonly reported nosocomial infection in paediatric intensive care.⁶ The risk of infection and the associated mortality increases significantly according to the site of the catheter (for instance, femoral or subclavian),^{7,8} age, immune status, and paediatric risk of mortality (PRISM) score.⁹ Other factors that increase the risk of infection include presence of multiple catheters (venous and arterial) and transport of patients to other parts of the hospital.¹⁰ Mortality, increased length of stay in intensive care, and substantial additional financial costs have been reported.¹¹ Evidence exists for measures such as universal barrier precautions at the time of catheter insertion, chlorhexidine

Abstract

Problem Bloodstream infections associated with catheters were the most common nosocomial infections in one paediatric intensive care unit in 1994-7, with rates well above the national average.

Design Clinical data were collected prospectively to assess the rates of infection from 1994 onwards. The high rates in 1994-7 led to the stepwise introduction of interventions over a five year period. At quarterly intervals, prospective data continued to be collected during this period and an additional three year follow-up period.

Setting A 292 bed tertiary care children's hospital.

Key measures for improvement We aimed to reduce our infection rates to below the national mean rates for similar units by 2000 (a 25% reduction). Strategies for change A stepwise introduction of interventions designed to reduce infection rates, including maximal barrier precautions, transition

to antibiotic impregnated central venous catheters, annual handwashing campaigns, and changing the skin disinfectant from povidone-iodine to chlorhexidine.

Effects of change Significant decreases in rates of infection occurred over the intervention period. These were sustained over the three year follow-up. Annual rates decreased from 9.7/1000 days with a central venous catheter in 1997 to 3.0/1000 days in 2005, which translates to a relative risk reduction of 75% (95% confidence interval 35% to 126%), an absolute risk reduction of 6% (2% to 10%), and a number needed to treat of 16 (10 to 35).

Lessons learnt A stepwise introduction of interventions leading to a greater than threefold reduction in nosocomial infections can be implemented successfully. This requires a multidisciplinary team, support from hospital leadership, ongoing data collection, shared data interpretation, and introduction of evidence based interventions.

skin disinfection, and use of catheters impregnated with an antimicrobial, but their implementation has not been explored.^{12 13} Reduction of catheter infection in intensive care can lead to decreases in morbidity and mortality in children and decreased costs for the family and society.

Outline of the problem

The national nosocomial infection surveillance (NNIS) system is a national voluntary tracking system resulting from a cooperative, non-financial relationship between more than 300 hospitals and the Centers for Disease Control and Prevention for tracking hospital acquired infection (www.cdc.gov/ncidod/dhqp/nnis.html). In June 1998 they published a pooled mean rate of bloodstream infection associated with a central venous catheter of 8.0 infections per 1000 days with a catheter in the paediatric intensive care unit (median rate of 7.1 infections/1000 days).¹⁴ In 1994-7 the rate in our 19 bed multidisciplinary unit was well above the national average. A multidisciplinary group of paediatric clinicians—including the director of infection control, critical care nurses, infectious diseases specialists, and critical care medicine physicians—formulated a strategy to decrease such infections in the unit. The hospital's medical director served as a senior leader and advocate for this project.

Key measures for improvement

Our goal was to reduce bloodstream infection associated with a catheter by 25% within 24 months in children in intensive care.

Strategy for change

After a thorough literature search and meetings with all stakeholders, the multidisciplinary team implemented a stepwise programme of evidence based measures to reduce bloodstream infection associated with a catheter.

Maximal barrier precautions for all central venous catheters, November 1998—Based on guidelines from the Centers for Disease Control and Prevention,¹⁵ all physicians in the unit were asked to use the maximum barrier precautions during insertion of the catheter. This process included a complete surgical scrub and the use of a sterile gown, sterile gloves, and mask for the physician, masks for bedside nurses and other personnel, and skin disinfection and sterile drapes for the patient. We used a dedicated trolley with supplies for insertion or other invasive procedures that was moved to the patient's bedside and restocked by unit technicians.

Catheters impregnated with antibiotic, July 1999—As part of a preventive strategy to reduce infection, we recommended the use of catheters impregnated with antimicrobials as cost effective and clinically effective.¹⁶ All multilumen catheters less than 25 cm long were impregnated with minocycline and rifampicin (rifampin).

Annual handwashing campaigns, March 2000—The Institute of Medicine (IOM) report showed that poor

compliance with hand disinfection was associated with nosocomial infections. A performance improvement team developed a programme to increase compliance with routine handwashing. It was called "Friction Rubs Out Germs" and had a frog as a symbol and the message "I washed my hands . . . did you?" In addition, posters, hospital television video, before and after tests of knowledge, and articles in employee and medical staff newsletters emphasised the importance of hand disinfection including the use of alcohol gels and foams.

Design of physical barriers between patients' beds in new unit, occupied April 2003—Our new unit mostly had private rooms instead of open bays. The previous 19 bed unit was in about 930 m² with 10 hand washing and 10 alcohol foam stations. The new 26 bed unit had 22 private rooms in about 1860 m², with 50 handwashing stations and 49 alcohol gel stations.

Chlorhexidine skin disinfectant, May 2003—The 2002 Centers for Disease Control and Prevention guidelines recommended the use of 2% chlorhexidine for skin disinfection and formed the basis for a change in our unit. Our medical staff used 2% chlorhexidine in 70% isopropyl alcohol in all age groups and reported no adverse local skin reactions.

Data collection

In this 292 bed paediatric facility, the infection control division has collected information on nosocomial catheter bloodstream infections since 1994. Infection control personnel make daily rounds in the intensive care unit and gather information on date of placement of the device, type of catheter placed, antibiotic versus non-antibiotic catheter, and duration of placement. They also collect information about positive results on blood cultures from the microbiology department.

We use Raad and Hanna's definitions for bloodstream infections associated with catheters.¹⁷ We identify positive results in blood cultures by standard microbiological techniques and determined clinical relevance in consultation with the intensive care and infectious disease physicians. This information is entered on a database maintained by the programme. Quarterly reports are generated and sent to the medical and nursing leadership of the unit and the hospital.

Analysis and interpretation

The figure illustrates the effect of our ongoing efforts to decrease infection in our unit. A decrease occurred even though there was an increase in the number of catheters placed each year (242 in 1998 and 481 in 2005, a 98% increase) and an increase in the number of admissions to the unit (admissions increased by 17% and patient days increased by 21%) (table). The incidence of bloodstream infection decreased significantly over the study period ($P < 0.001$) with a relative risk reduction of 75% between the start and the end of the study period (95% confidence interval 35% to 126%). The absolute risk reduction was 6% (2% to 10%) and the number needed to treat was 16 (10 to 35). In 1999 we introduced catheters impregnated with antibiotic

Trend over time (1994-2005) in bloodstream infection associated with catheters in paediatric intensive care unit compared with national mean: November 1998—introduction of maximal barrier precautions; July 1999—introduction of catheters impregnated with antibiotic; March 2000—annual handwashing campaigns; April 2003—move to new unit with private rooms; May 2003—introduction of skin disinfection with chlorhexidine

(rifampicin and minocycline). Over seven years (1999-2005), we have examined 2126 catheters. The infection rate with impregnated catheters was 4.2/1000 days with a central venous catheter compared with 6.4/1000 days with catheters without impregnation. We did not see any increased antibiotic resistance with use of this catheter. During the first five years of use, Gram positive organisms accounted for 33% of isolates in the group with impregnated catheters and 32% in the catheters that were not impregnated. There were no differences in rates of methicillin resistant staphylococci between each group.

Effects of change

The successful stepwise implementation of various measures to decrease nosocomial bloodstream infections resulted in a steady and sustained decline in the rates of bloodstream infection associated with catheter use in our unit since 1998 (figure). Our annual handwashing campaigns increased compliance with hand disinfection before contact with patients in our unit from 47% in March 2000 to 82% in March 2005. Similarly, an observational survey by the infection control division found 98% compliance with use of maximum barrier precautions during insertion of catheters in 2005.

In 1998-2005, if our infection rate had stayed at the national mean, we would have had an additional 39

cases of bloodstream infection. As the estimated mortality attributable to each episode is 12-25%,¹³ this would have been equivalent to about 5-10 deaths during this time period.

This success in the paediatric intensive care unit has been translated into use of similar strategies in other units in the same hospital. The cardiothoracic unit has seen a fall in rates of catheter associated bloodstream infection from 8.4/1000 days in 2001 to 3.6/1000 days in 2005, representing a decline of 63%.

Lessons learnt

Using a stepwise approach, we were able to successfully lower the rates of catheter associated bloodstream infection in a paediatric intensive care unit. Our multidisciplinary group identified the problem, created a data collection system to measure baseline performance and ongoing improvement, and created a data reporting system that allowed all stakeholders to understand the extent of the problem and gauge the effects of changes in practice. We also introduced effective evidence based strategies to combat the problem and provided continued education for all staff members. The outcomes task force report from the Society of Critical Care Medicine published in January 2006 outlines a similar stepwise approach for clinicians interested in successfully implementing a quality improvement project.¹⁸ The Pittsburgh Regional Healthcare Initiative used a similar approach regionally in 66 intensive care units (including three paediatric units) and saw a decline in catheter associated bloodstream infection of 68% over four years.¹⁹

Intensive and continued educational efforts by team members to educate unit staff together with the implementation of each new step, as well as renewed educational efforts when increases in infection rates were noted in particular time periods, are an important component of our success to date. Specifically, the infection control staff report quarterly data to the nursing and medical directors of the unit. Since 2004, all new employees in the unit are taught about this prevention project. At annual evaluation, all employees are required to perform validation of skills on aspects of catheter care such as insertion, weekly changes of dressings, and accessing lines while maintaining aseptic techniques. In 2005, our unit staff participated in the design of a web based learning module with

Incidence of bloodstream infections in children in intensive care unit over study period (1998-2005)

Year	Total No of admissions	No of central venous catheters inserted	Total No of days with catheter	No of infections	% of catheters infected	Infection rate/1000 catheter days
1998	989	242	2325	20	8.2	8.6
1999	903	215	1896	11	5.1	5.8
2000	939	200	2312	13	6.5	5.6
2001	962	261	2120	12	4.6	5.7
2002	1043	273	2123	13	4.8	6.1
2003	1031	343	3850	15	4.3	3.8
2004	1168	353	4402	8	2.2	1.8
2005	1161	481	3047	10	2.0	3

*In 2001-5, five patients had two episodes of bloodstream infection from same catheter. This was not recorded for the years before this period.

KEY LEARNING POINTS

- A stepwise introduction of evidence based interventions is effective in reducing catheter associated blood stream infections
- A multidisciplinary team is needed to set up a data collection system to establish baseline prevalence of such infections and ongoing surveillance
- The data need to be shared with all stakeholders so that the extent of the prevalence is known and efforts to reduce it are easier to gauge
- Intensive and sustained education of all staff is needed for continued success in trying to reduce these infections

Child Health Corporation of America (CHCA) on prevention of catheter bloodstream infections in the intensive care unit. This programme is required for registered nurses, advanced practice nurses, and resident physicians in the unit and has led to increased awareness among physicians, nurses, and other staff members about both nosocomial infections and the necessity to review and maintain central venous catheters or other devices as an integral part of daily rounds. We believe that implementation of similar strategies to reduce such infections in other intensive care units can lead to substantial reductions in mortality and morbidity in this vulnerable group of patients.

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Hardest job in the world

A medic friend of mine made a passing comment that I was lucky to "be at home"—having had a baby three months ago and now on maternity leave. It infuriated me at how naive it is to think we mothers are on a permanent holiday.

Imagine being on call 24 hours a day, seven days a week, 52 weeks a year, with no protected bleep-free time, no feedback from the patient about how you

are doing, no one to ask for help, no team for support, skipping meals because of the workload, vomit on your shirt but no time to change clothes, no healthcare assistants or nurses to clean up the urine and faeces. I could go on and on.

So when will motherhood be recognised as being the hardest job in the world?

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