ORIGINAL ARTICLE

Use of Central Venous Catheter-Related Bloodstream Infection Prevention Practices by US Hospitals

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OBJECTIVE: **To examine the extent to which US acute care hospitals have adopted recommended practices to prevent central venous catheter-related bloodstream infections (CR-BSIs).**

PARTICIPANTS AND METHODS: **Between March 16, 2005, and August 1, 2005, a survey of infection control coordinators was conducted at a national random sample of nonfederal hospitals with an intensive care unit and more than 50 hospital beds (n=600) and at all Department of Veterans Affairs (VA) medical centers (n=119). Primary outcomes were regular use of 5 specific practices and a composite approach for preventing CR-BSIs.**

RESULTS: **The overall survey response rate was 72% (n=516). A higher percentage of VA compared to non-VA hospitals reported using maximal sterile barrier precautions (84% vs 71%; *P*=.01); chlorhexidine gluconate for insertion site antisepsis (91% vs 69%; *P*<.001); and a composite approach (62% vs 44%; *P*=.003) combining concurrent use of maximal sterile barrier precautions, chlorhexidine gluconate, and avoidance of routine central line changes. Those hospitals having a higher safety culture score, having a certified infection control professional, and participating in an infection prevention collaborative were more likely to use CR-BSI prevention practices.**

CONCLUSION: **Most US hospitals are using maximal sterile barrier precautions and chlorhexidine gluconate, 2 of the most strongly recommended practices to prevent CR-BSIs. However, fewer than half of non-VA US hospitals reported concurrent use of maximal sterile barrier precautions, chlorhexidine gluconate, and avoidance of routine central line changes. Wider use of CR-BSI prevention practices by hospitals could be encouraged by fostering a culture of safety, participating in infection prevention collaboratives, and promoting infection control professional certification.**

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AHA = American Hospital Association; CDC = Centers for Disease Control and Prevention; CI = confidence interval; CR-BSI = catheter-related bloodstream infection; ICP = infection control professional; ICU= intensive care unit; OR = odds ratio; VA = Department of Veterans Affairs

The Centers for Disease Control and Prevention (CDC) estimates that health care–associated infections affect more than 2 million hospitalized patients annually and cost the US health care system more than $6 billion in excess charges.[1-4] Among the leading types of health care–associated infections are those related to the use of central venous catheters.[5-8] Catheter-related bloodstream infections (CR-BSIs) affect more than 200,000 patients per year in the United States.[9,10] In Europe, approximately 12% of health care–associated infections are bloodstream infections.[11] Bloodstream infections are associated with an increased risk of death[12] and with increases in morbidity, length of stay, and health care costs.[6,13-15] Importantly, at least 20% of health care–associated infections and more than 50% of vascular catheter–related infections may be preventable.[16]

Given the importance of prevention, the CDC and the Agency for Healthcare Research and Quality have published evidence-based recommendations for preventing CR-BSIs.[17,18] Strongly recommended practices include proper hand hygiene, use of maximal barrier precautions,[19,20] use of chlorhexidine gluconate for insertion site preparation,[21-23] and avoidance of routine catheter changes. Catheters impregnated with antimicrobial agents are recommended when infection rates are high or when catheters will remain in place for a considerable time.[24-27]

For editorial comment, see page 665

Publication of evidence-based recommendations does not, however, lead directly to clinical change.[28-31] In fact, research shows that only about 55% of patients receive the recommended care.[32] Studies also suggest that certain infection prevention practices are not commonly used, despite evidence that these practices substantially reduce infection risk.[33-39] However, the extent to which CR-BSI prevention practices are used by US hospitals is unknown.

The aim of our study was to determine the extent to which US acute care hospitals have adopted central venous CR-BSI prevention practices and to identify the factors that encouraged their adoption. We studied both the individual

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infection prevention practices recommended by the CDC guidelines and a "composite" approach advocated by organizations such as the Institute for Healthcare Improvement.[40] We were also interested in whether the following factors would be associated with the adoption of infection prevention practices: (1) a centralized administration, as in the Department of Veterans Affairs (VA) health care system; (2) a guideline recommendation for a specific procedure, with strong supporting evidence; and (3) certain hospital characteristics, such as having a hospital epidemiologist.

PARTICIPANTS AND METHODS

Data Collection

Between March 16, 2005, and August 1, 2005, questionnaires were mailed to infection control coordinators at 719 hospitals across the United States.[41] If the hospital employed more than 1 infection control professional (ICP), the one who supervised the other ICPs was asked to complete the survey. The 2005 American Hospital Association (AHA) database (fiscal year 2003 data) was used both to identify nonfederal, general medical, and surgical hospitals with more than 50 beds and with intensive care unit (ICU) beds and to stratify those hospitals by the number of beds (50-250 beds and >251 beds). A random sample of 300 hospitals was selected from each stratum, for a total sample of 600 hospitals. We then expanded the sample with a 100% over-sample of all VA medical centers with operating acute care beds (n=119).

Supplementary data were obtained from the AHA Database and the 2003 Area Resource File.[42] Institutional review board approval was obtained from the VA Ann Arbor Healthcare System.

Study Measures

Main outcomes for this analysis were dichotomous variables indicating regular use of a specific practice for preventing CR-BSIs. The outcome variables were derived from survey questions about the use of recommended CR-BSI prevention practices for adult acute care patients. The recommended practices included maximal sterile barrier precautions (full gown, sterile gloves, large sterile patient drape), chlorhexidine gluconate for insertion site antisepsis, and antimicrobial central venous catheters (eg, coated with chlorhexidine/silver sulfadiazine). We also asked about one procedure that the guidelines recommend against, the routine changing of central catheters even with no suspicion of infection, and one for which they make no recommendation because of limited evidence, the use of a chlorhexidine-impregnated antimicrobial dressing (Biopatch, Johnson & Johnson, Somerville, NJ). Respondents rated the frequency of use for each practice on a scale from 1 to 5 (1 being never and 5 always). For the analysis, we constructed a binary variable (0/1). Ratings of 4 or 5, indicating that the practice is used always or almost always, were defined as "regular use" and coded as 1, whereas ratings of 1, 2, or 3 were coded as 0. A multicomponent measure indicating regular use of maximal sterile barrier precautions and chlorhexidine gluconate and avoidance of routine central venous catheter changes was also created for our "composite" analysis.

Based on an adoption of innovation framework described previously,[43] the primary independent variables included general hospital characteristics, infection control program features, and the use of other practices to prevent CR-BSIs. One characteristic of interest was whether the facility was a VA medical center. Department of Veterans Affairs hospitals belong to a health care system with a centralized administration, which can more easily institute wide-scale policies and purchasing decisions. Moreover, the VA system has undergone a significant quality transformation over the past decade with an emphasis on patient safety.[44,45]

The available expertise and hospital culture at the participating institutions were assessed. Hospitals specified in the AHA database as being approved to train residents were considered to have an academic affiliation. Responses to the questionnaires were used to determine whether institutions had hospitalists or participated in collaboratives. When responses to the hospitalist question were missing, the AHA database was used to make that determination. The safety culture measure was based on the level of agreement from 1 (strongly agree) to 5 (strongly disagree) with the following statements: (1) "Leadership is driving us to be a safety-centered institution" and (2) "I would feel safe being treated here as a patient."[46] Responses to both statements were combined into a single measure ranging from 2 to 10 and reverse scored so that higher scores indicated greater safety-centeredness.

The survey also included questions regarding the infection control program, including whether the facility had a hospital epidemiologist and whether the "lead" ICP was certified in infection control and epidemiology. In the analysis we adjusted for the number of intensive care unit beds, registered nurse staffing (full-time equivalent registered nurses/adjusted average daily census), level of facility support for evidence-based practice,[47] county population, and metropolitan location.

Statistical Analyses

To produce estimates that reflect the full population of VA and non-VA acute care hospitals with 50 or more hospital beds and an ICU, we analyzed the data using sample weights based on the probabilities of selection within each stratum

TABLE 1. **Department of Veterans Affairs (VA) and Non-VA Hospital and Community Characteristics and Use of Central Venous Catheter-Related Infection Prevention Practices***

Characteristic	VA hospitals (n=119)†	Non-VA hospitals (n=2671)†	*P* value
Mean No. of intensive care unit beds (95% CI)	17.3 (15.1-19.5)	19.3 (18.1-20.5)	.13
Approved for resident training	75	24	<.001
Have hospitalists	64	55	.14
Participate in collaborative	31	42	.07
Mean safety culture score (range 2-10) (95% CI)	7.5 (7.2-7.8)	8.0 (7.8-8.1)	.001
Have hospital epidemiologist	50	39	.05
Have ICP certified in infection control	75	57	.002
Mean evidence-based practice support score (range 2-10) (95% CI)	6.7 (6.3-7.0)	6.8 (6.6-6.9)	.66
Mean registered nurse staffing (FTE registered nurse/adjusted average daily census) (95% CI)	1.7 (1.5-1.9)	1.2 (1.1-1.2)	<.001
Located in metropolitan area	89	72	.001
Mean county population in 10,000s	92.2 (53.8-125.6)	68.2 (54.7-81.8)	.19

*Values are percentages unless indicated otherwise. CI = confidence interval; FTE = full-time equivalent; ICP = infection control professional.

†Weighted sample size reflecting the total population of hospitals represented by the respondent sample. For the non-VA sample, the population represented is general medical and surgical hospitals with more than 50 beds and with ICU beds.

and the survey commands for descriptive statistics and regression models found in Stata 9 (StataCorp, College Station, Tex). We conducted bivariate analyses comparing VA and non-VA hospitals and in our descriptive table present the weighted proportions and Pearson χ^2 results for dichotomous variables and the weighted means, 95% confidence interval (CI) ranges, and adjusted Wald test results for continuous variables. We also constructed weighted logistic regression models to examine which of our primary independent variables were associated with the use of each practice of interest. In doing so, we adjusted for other variables of interest as aforementioned (eg, VA, ICP certification), as well as facility and community factors (eg, number of ICU beds, registered nurse staffing, evidence-based practice support score, total population, metropolitan location). Regression results are reported using odds ratio (OR) values and 95% CI ranges. Reported *P* values are 2-tailed, with $P<.05$ considered statistically significant.

RESULTS

The overall survey response rate was 72% (n=516), with 80% (n=95) of VA and 70% (n=421) of non-VA hospitals responding. Table 1 provides a comparison of the VA and non-VA hospitals across a number of characteristics. While the average number of ICU beds, evidence-based practice support score, use of hospitalists, and participation in an infection-related collaborative were similar for both, VA hospitals had a higher registered nurse staffing ratio, were more likely to be located in a metropolitan area and to be approved to train residents (75% vs 24%; $P<.001$), and to have a supervisory ICP certified in infection control (75% vs 57%; $P=.002$) and a hospital epidemiologist than non-VA hospitals. However, non-VA hospitals scored higher than VA facilities on the culture of safety measure (8.0 vs 7.5; $P=.001$).

Use of CR-BSI Prevention Practices at VA vs Non-VA Hospitals

Percentages for the use of specific practices to prevent CR-BSIs by VA and non-VA hospitals are shown in Figure 1. A higher percentage of VA hospitals vs non-VA hospitals reported using maximal sterile barrier precautions (84% vs 71%; $P=.01$) and chlorhexidine gluconate for insertion site antisepsis (91% vs 69%; $P<.001$), both of which are recommended practices. No significant differences were noted between VA and non-VA facilities in the use of antimicrobial central venous catheters, avoidance of routine central line changes, or use of an antimicrobial dressing with chlorhexidine (a practice for which there is no guideline recommendation). However, use of a composite approach was significantly higher for VA than for non-VA hospitals (62% vs 44%; $P=.003$). Our logistic regression results (Table 2) also show that, even after adjustment, a statistically significant positive association exists between VA hospitals and 2 practices of interest. Specifically, VA hospitals were nearly 5 times as likely to use chlorhexidine gluconate and twice as likely to use a composite approach than non-VA hospitals.

Recommended Practices

Among the most strongly recommended practices (Table 2), use of maximal sterile barrier precautions had a statistically significant, positive association with having an ap-

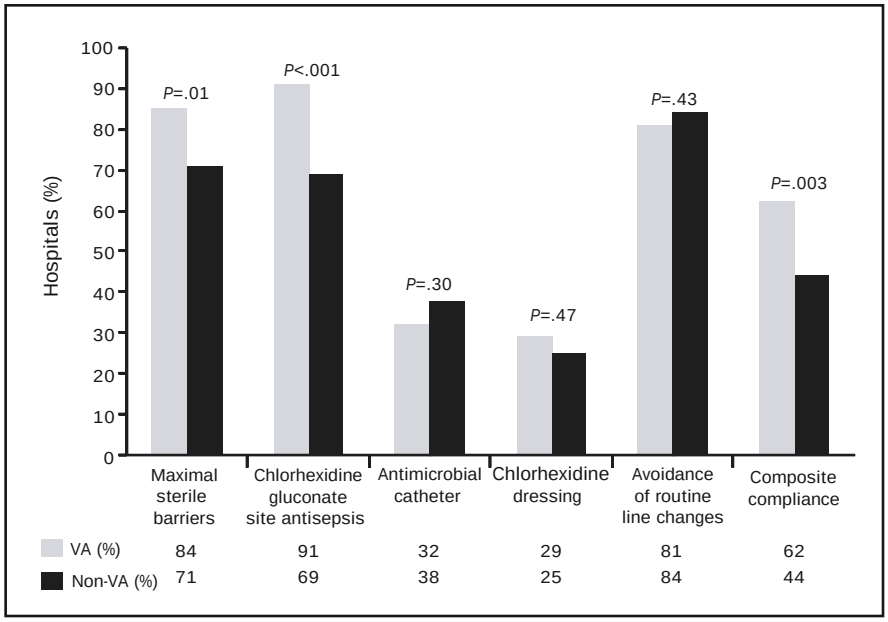

FIGURE 1. Percentage of Veterans Affairs (VA) and non-VA hospitals reporting regular use of central venous catheter-related infection prevention practices. Regular use (coded as 1) is defined as receiving a rating of 4 or 5 on a scale from 1 to 5 (with 1 being never and 5 always), indicating the practice is used always or almost always.

proved residency program (OR, 3.1; 95% CI, 1.7-5.8), scoring higher on the safety culture scale (OR, 1.3; 95% CI, 1.1-1.7), and participating in a collaborative (OR, 1.8; 95% CI, 1.0-3.1). Use of chlorhexidine gluconate for site antisepsis also had a significant, positive association with the safety culture score (OR, 1.4; 95% CI, 1.1-1.8). Several factors, including participation in a collaborative, a higher safety culture score, and ICP certification in infection con-

TABLE 2. **Adjusted Odds Ratio (OR) for Regular Use of Practice* Logistic Regression Results (Weighted)†**

	Maximal sterile barrier precautions‡		Chlorhexidine gluconate for site antisepsis‡		Antimicrobial central venous catheter‡		Chlorhexidine dressing§		Avoid routine line changes‡		Composite approach‖	
	OR	95% CI	OR	95% CI	OR	95% CI	OR	95% CI	OR	95% CI	OR	95% CI
Approved for resident training	3.1	1.7-5.8	1.9	0.8- 4.4	0.9	0.5-1.6	0.8	0.4-1.6	2.1	0.9-4.5	2.9	1.6-5.2
Have hospitalists	1.4	0.8-2.5	1.6	0.8-3.1	1.6	0.9-2.0	0.7	0.4-1.4	0.7	0.4-1.5	1.5	0.9-2.6
Participate in collaborative	1.8	1.0-3.2	1.0	0.5-1.8	1.1	0.7-2.9	1.0	0.6-1.8	1.8	0.9-3.7	1.7	1.0-2.7
Safety culture score	1.3	1.1-1.7	1.4	1.1-1.8	1.1	0.9-1.4	0.7	0.6-0.9	1.1	0.8-1.5	1.4	1.1-1.8
Have hospital epidemiologist	1.3	0.8-2.3	1.5	0.8 -2.7	0.5	0.3-0.9	1.1	0.6-2.0	1.1	0.5-2.1	1.4	0.9-2.3
Have infection control professional certified in infection control	1.1	0.6-2.2	1.8	0.9-3.5	2.6	1.4-4.8	1.1	0.6-2.2	2.2	1.1-4.5	2.3	1.3-4.1
Use maximal sterile barrier precautions	…	…	1.7	0.9-3.4	1.3	0.7-2.3	2.0	1.0-3.9	0.4	0.2-0.9	…	…
Use chlorhexidine gluconate for site antisepsis	1.7	0.9-3.4	…	…	2.5	1.3-5.0	2.4	1.2-5.0	1.0	0.5-2.3	…	…
Use antimicrobial central venous catheter	1.4	0.8-2.5	2.5	1.3-5.0	…	…	1.0	0.6-1.8	1.2	0.6-2.4	1.7	1.0-2.7
Use chlorhexidine dressing	1.9	1.0-3.8	2.4	1.1-5.4	1.0	0.6-1.8	…	…	0.4	0.2-0.7	1.5	0.9-2.7
Avoid routine line changes	0.4	0.1-0.9	0.9	0.4-2.1	1.2	0.6-2.4	0.4	0.2-0.7	…	…	…	…
Department of Veterans Affairs	1.2	0.5-2.6	4.8	1.6-15.0	0.8	0.4-1.5	0.7	0.3-1.4	0.9	0.3-2.3	2.1	1.0-4.2

*Regular use (coded 1) was defined as receiving a rating of 4 or 5 on a scale from 1 to 5 (with 1 being never and 5 being always), indicating the practice is used always or almost always. Results also adjusted for number of intensive care unit beds, registered nurse staffing (full-time equivalent registered nurse/adjusted average daily census), Evidence-Based Practice support score, total population, metropolitan location.
†CI = confidence interval.
‡Guideline-recommended practice.
§Limited evidence and no guideline recommendation.
‖Use of maximal sterile barrier precautions and chlorhexidine gluconate for site antisepsis and avoidance of routine central line changes.

trol were also positively associated with use of a composite approach. In contrast, use of a chlorhexidine dressing, for which there is no recommendation, was negatively associated with a higher score on the safety culture scale (OR, 0.7; 95% CI, 0.6-0.9).

Other Hospital Characteristics

Those hospitals having a supervisory ICP certified in infection control were more likely to use antimicrobial central venous catheters (OR, 2.6; 95% CI, 1.4-4.8) and avoid routine central catheter changes (OR, 2.2; 95% CI, 1.1-4.5). None of the practices of interest showed an association with the use of hospitalists, and only the use of antimicrobial central venous catheters showed an association with having a hospital epidemiologist.

DISCUSSION

Evidence-based guidelines and recommendations have been published on how to reduce the risk of CR-BSIs, but often changes in practice lag behind guideline dissemination. In this case, however, our results suggest that a substantial proportion of US hospitals are following guideline recommendations and using 2 of the most strongly advocated practices: maximal sterile barrier precautions and chlorhexidine gluconate for insertion site antisepsis. Antimicrobial catheters are used by a smaller but still sizable proportion of hospitals. Despite these generally positive results, many hospitals have not yet implemented certain key practices, and some have not instituted even those measures widely recommended to prevent CR-BSIs.

If effective strategies are to be developed for the implementation of these infection prevention practices nationwide, the factors associated with their use must be identified. Our results suggest that VA hospitals are leaders in the use of several important practices to prevent CR-BSIs, including a composite approach, perhaps because of their centralized administrative structure and the significant quality transformation that occurred within the VA health care system over the past decade.[48] For instance, centralized purchasing functions may help explain why VA affiliation appears to be especially relevant for the use of chlorhexidine gluconate for insertion site antisepsis. Specifically, chlorhexidine is procured through a Blanket Purchase Agreement/Blanket Ordering Agreement as part of the Veterans Health Administration National Standardization Program, designed to facilitate favorable product pricing through volume purchasing and to encourage the use of preferred products in the care of veterans system-wide (VHA Handbook 1761.1).

Our findings also show that hospitals are more likely to adopt practices that have been strongly recommended by published evidence-based guidelines. Since we used separate models to examine each practice, level of evidence was not directly assessed. However, the 2 most commonly used practices, maximal sterile barrier precautions and chlorhexidine gluconate for insertion site antisepsis, are Category IA recommendations, ie, those ranking highest for strength of evidence, and therefore are strongly recommended by the CDC's Healthcare Infection Control Practices Advisory Committee.[18] In contrast, despite evidence of their effectiveness,[26] antimicrobial vascular catheters are used by only about one third of hospitals, with non-VA more likely than VA hospitals to adopt this practice. This low adoption rate could be related to the incremental cost of the coated catheter,[12,27] or it could reflect the tendency at many hospitals to follow the CDC guidelines, which recommend trying other strategies to reduce CR-BSI rates first (eg, maximal sterile barrier precautions).

Surprisingly, a chlorhexidine-impregnated dressing is used by at least 25% of hospitals although it is not recommended by any of the published guidelines and its efficacy is not strongly supported by currently published evidence.[49,50] Nonetheless, the popularity of these dressings is growing, perhaps because of targeted marketing strategies or the influence of key leaders in the field.

An association was found between the use of several CR-BSI prevention practices and a higher safety culture score. Generally defined, culture is a unifying theme within an organization that is manifested through common attitudes, values, and practices.[46,51] In the past several years, the promotion of a culture of safety has become increasingly recognized as a promising strategy to improve patient safety.[4,46,51] Indeed, an annual assessment of safety culture is part of the 2007 Joint Commission for Accreditation of Healthcare Organizations patient safety goals.[46] Fostering a culture of safety[51] might facilitate the adoption of practices related to infection prevention. We are therefore somewhat puzzled by the lower culture of safety score for VA compared to non-VA hospitals. While this finding could in part be a statistical artifact, given the nearly overlapping CIs, it suggests that additional work is needed to better understand how this concept is defined both within and across hospitals.

Other characteristics associated with the use of practices to prevent CR-BSIs were certification of ICPs in infection control and participation in an infection prevention collaborative. Infection control professionals obtain certification by passing a comprehensive examination developed by the Certification Board of Infection Control and Epidemiology, which is accredited by the National Commission for Certifying Agencies.[52] The certification program promotes continuing mastery and knowledge of current practices required for infection control and prevention. Certified ICPs may be better prepared to interpret the evidence

and promote key infection prevention practices within their organization. Hospitals could promote ICP certification by providing the time and resources needed to attain this additional level of education and expertise.

Collaborative initiatives to reduce infections are a relatively new concept and, as defined in this study, range from participation in the National Nosocomial Infections Surveillance System to the 100,000 Lives Campaign of the Institute for Healthcare Improvement.[2,40] Our results suggest that these initiatives may facilitate the use of important infection prevention practices. Further development of collaborative methods could promote the implementation of infection prevention and other patient safety practices.

Our study shows a greater use of practices to prevent CR-BSIs than previous studies. A survey by Warren et al[33] of 25 ICUs at 10 hospitals showed that a written policy specifying the use of maximal sterile barrier precautions and chlorhexidine for skin preparation had been developed at only 28% and 8% of the hospitals, respectively. Similarly, a survey by Rubinson et al[34,35] of US intensivists found that 28% reported using full maximal barrier precautions and approximately 17% used central venous catheters impregnated or coated with antimicrobial agents. Although partly attributable to respondent and measurement issues, the higher rate of adoption of these practices noted in our study likely reflects current practice and the increasing use of these prevention techniques over time.

Our study has several limitations. First, our measure of regular use of a practice is a global assessment and does not identify whether the practice is adequately implemented. Second, the potential for response bias exists, with some respondents providing what they perceive to be the preferred answer. However, efforts were made to minimize this type of response by ensuring the anonymity of the respondent. Third, the infection control coordinator may not be the most knowledgeable respondent for some of the practices, and it would be ideal to verify use of such practices with others at the facility, such as an ICU nurse manager.

CONCLUSION

Our results have important implications for enhancing the safety of hospitalized patients.[53,54] Although many US acute care hospitals are following guidelines and using specific recommended practices for preventing CR-BSIs, fewer than half of non-VA US hospitals are concurrently using the 3 practices widely recommended to prevent CR-BSIs. To improve adoption of key CR-BSI prevention practices, hospitals can begin by fostering a culture of safety, encouraging ICP certification in infection control, and participating in an infection prevention collaborative. However, additional strategies for promoting proven infection prevention practices in hospitals will need to be identified if the goal of a safer health care environment is to be achieved.

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