MEDINFO 2007
HISA Ltd Australia
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Automated Surveillance for Catheter-Associated Bloodstream Infections

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Abstract

Traditional manual surveillance for catheter-associated bloodstream infections (CA-BSI) by an infection control specialist is costly and labor intensive. An automated computer-based surveillance system that utilizes existing laboratory, pharmacy, and clinical electronic information offers a more efficient and timely method of surveillance. We applied combinations of simple rules to patients with positive blood cultures in the intensive care unit (ICU) to determine whether automated surveillance is feasible. Compared to traditional manual surveillance, sensitivity and specificity of the best rule combination was 87.1% and 73.8%, respectively. This ruleset consisted of four rules: (1) culture collected > 48 hours after admission; (2) patient had central-venous catheter; (3) organism not a common skin contaminant OR either confirmed by repeat culture within 5 days or treated with vancomycin; and (4) organism not a coagulase-negative Staphylococcus. Monthly trends of infection rates rose and fell appropriately. This is comparable to previously reported results [1]. Additional rules may improve prediction performance.

Keywords:

algorithms, catheterization, Central Venous,
cross infection, Septicemia

Introduction

CA-BSI are a significant cause of patient morbidity and mortality in hospitalized patients. Surveillance of nosocomial bloodstream infections (BSI) is traditionally performed in the ICU by infection control specialists using medical charts, physician summaries, microbiology and pharmacy data. Standardized case definitions, usually those from the United States Centers for Disease Control and Prevention (CDC) National Healthcare Safety Network (NHSN), are used to identify CA-BSI. Yet, traditional manual surveillance is labor intensive and costly. Application of case definitions by infection control specialists requires considerable clinical judgment, and definitions are sometimes inconsistently applied. Electronic surveillance offers the potential for more efficient and timely detection of CA-BSI than traditional manual surveillance. An automated surveillance approach that utilizes existing laboratory, pharmacy, and clinical electronic information could shift infection control specialists' time towards prevention, rather than surveillance. Furthermore, development of an automated surveillance system could potentially extend surveillance outside of the ICU, where there is currently an absence of surveillance efforts at most hospitals. The aims of this study were: (1) to develop an automated computer-based surveillance system with the use of existing laboratory, pharmacy, and clinical electronic information; and (2) to compare traditional manual surveillance to electronic surveillance among ICU patients.

Methods

The study was conducted with patients in the ICU at Barnes-Jewish Hospital, a 1250 bed tertiary-care teaching hospital located in Saint Louis, Missouri. Positive blood cultures collected between July 1, 2005 and June 30, 2006 were evaluated; cultures were excluded if the same organism had been recovered from the blood in the previous 7 days. Infection control specialists reviewed each patient to determine presence or absence of CA-BSI using CDC NHSN definitions [2]. Simple "yes-no" rules and combinations of these rules, similar to those used by Trick et al. [1], were applied to electronic data to determine if a positive blood culture represented a CA-BSI. The rules were:

1. Culture collected > 48 hours after admission
2. Patient had central-venous catheter (CVC)
3. Organism not a common skin contaminant OR either confirmed by repeat culture within 5 days or treated with vancomycin
4. Organism not a coagulase-negative Staphylococcus
5. Organism not grown from wound or urine cultures after positive blood culture
6. Organism not grown from wound or respiratory cultures after positive blood culture
7. Organism not grown from wound, urine, respiratory, sterile other, or non-sterile other cultures after positive blood culture

Secondary culture sites such as wound, urine, respiratory, sterile other, and non-sterile other were considered, as well

as their collection time relative to the positive blood culture (i.e., before, after, or ever). Using infection control as the gold standard, we evaluated the ability of various combinations of rules to determine CA-BSI; sensitivity, specificity, predictive values were calculated. The agreement between infection control surveillance and the rulesets was assessed with the kappa statistic. Monthly rates of CA-BSI per 1,000 patient line-days were calculated for manual and electronic surveillance. Discrepancies of case determination were compared between manual surveillance and the best performing rulesets.

Results

During the study period 771 positive blood cultures from 540 patients were evaluated. Infection control specialists identified 70 (9%) CA-BSIs. The most common organisms were coagulase-negative Staphylococci (45%), Corynebacterium species (6%), *Candida albicans* (5%), *Staphylococcus aureus* (5%), *Enterococcus faecalis* (5%), *Enterococcus faecium* (5%), and *Klebsiella pneumoniae* (3%). Rules did not perform well individually. Performance of the best performing combination of rules is shown in Table 1.

Table 1 - Performance of combined rules

Rules	# BSIs predicted	Sens %	Spec %	PVP %	PVN %	Kappa
1,2	459	97.1	44.2	14.8	99.4	.118
1,2,3	362	95.7	57.9	18.5	99.3	.186
1,2,3,4	245	87.1	73.8	24.9	98.3	.287
1,2,3,4,5	230	80.0	75.2	24.3	97.4	.272
1,2,3,4,6	208	72.9	77.6	24.5	96.6	.267
1,2,3,4,7	184	62.9	80.0	23.9	95.6	.247

The combination of rules with highest agreement with infection control surveillance (kappa = .287) identified 245 (32%) CA-BSIs. This ruleset, which included rules 1, 2, 3, and 4, had a sensitivity and specificity of 87.1% and 73.8%, respectively. Although the rulesets with rules 1 and 2 as well as rules 1, 2, and 3 had higher sensitivity, this ruleset had higher specificity and better agreement with infection control surveillance. Augmentation of the best ruleset with cultures from secondary sites marginally increased specificity but decreased sensitivity and the kappa statistic. Secondary site cultures collected before positive blood cultures improved rulesets better than those collected after or ever. Manual surveillance detected 2.64 CA-BSI per 1,000 line-days while the best performing ruleset predicted 9.24 CA-BSI per 1,000 line-days. CA-BSI rates are displayed in Figure 1.

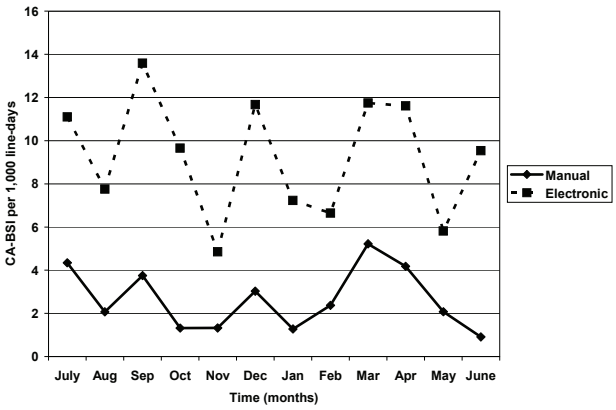

Figure 1 - Performance of rules in determining rates

Of 771 positive blood cultures, 193 (25%) were classified differently by manual versus electronic surveillance methods. Among 70 gold standard CA-BSI, the ruleset failed to classify 9 of these positive blood cultures as CA-BSI; 7 patients had a common skin contaminant, 1 had a community-acquired infection and a common skin contaminant, and 1 had misclassified CVC usage data. Among 701 positive blood cultures not classified as CA-BSI by infection control specialists, the ruleset classified 184 positive blood cultures as CA-BSI; 73 had a secondary organism grown from wound, urine, respiratory, sterile-other, or non-sterile-other sites. Other reasons for misclassification remain to be studied.

Discussion

An automated surveillance system that utilized existing patient data was able to identify CA-BSI with reasonable sensitivity and specificity. Our results are comparable to those reported by Trick et al. [1]. Although sensitivity and specificity need to be improved, trends of infection rates rose and fell appropriately. The high negative predictive value of our rulesets is promising. In the absence of perfect sensitivity, infection control specialists may benefit most from a list of patients without CA-BSI. As with any analyses dependent on electronic data, errors exist. For instance, 1 gold standard CA-BSI was not classified as a CA-BSI by the ruleset due to not having a CVC; yet the patient medical chart recorded CVC usage. In addition, July and August line-day information did not include PICC lines; a sensitivity analysis shows that this did not change CA-BSI rates substantially. Automated surveillance of CA-BSI has several advantages including consistent application of case definitions, reallocation of infection control specialists' time from surveillance to prevention efforts, and extension of surveillance outside of the ICU.

Conclusion

Automated CA-BSI surveillance may be useful for identifying trends for manual investigation. Future work will be to improve on the rulesets and to evaluate alternative methods of analysis, such as logistic or Bayesian prediction models.

Acknowledgement

Supported by BJH Foundation Grant 00426-0805-01

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