Automated Surveillance for Catheter-Associated Bloodstream Infections

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Introduction

- Catheter-associated bloodstream infections (CA-BSI) are a significant cause of patient morbidity and mortality
  - Adds approximately 20 days to hospital length-of-stay[1]
  - Increases costs by $35,000 to $56,000[2,3]
  - Attributable mortality of up to 35%[1]
- Traditional surveillance for CA-BSI
  - Performed by Infection Control Specialists
  - Apply United States Centers for Disease Control & Prevention (CDC) National Healthcare Safety Network (NHSN) case definitions
  - Use medical charts, physician summaries, lab & pharmacy data
  - Limitations
    - Time consuming & costly
    - Often limited to Intensive Care Units (ICUs)
    - Inconsistent application of case definitions

1 Pittet D, et al. *JAMA* 1994;271:1598–601.

2 Rello J, et al. *Am J Respir Crit Care Med* 2000;162:1027–1030

3 Dimick JB, et al. *Arch Surg* 2001;136:229–234.

Methods I

- Specific Aims
  - To develop automated surveillance system for CA-BSI by integration of existing electronically available data
    - Microbiology positive cultures
    - Pharmacy information
    - Laboratory data
    - Vital signs
    - Central venous catheter (CVC) usage
  - Compare automated surveillance to manual chart review (gold standard) with sensitivity, specificity, predictive values, kappa

- Study Population
  - Barnes-Jewish Hospital, a 1250 bed, tertiary-care teaching hospital affiliated with Washington University School of Medicine in St. Louis, Missouri
  - ICU patients with a positive blood culture between July 1, 2005 and June 30, 2006 (1 year)
  - Cultures were excluded if same organism recovered from blood in previous 7 days

Methods II

- Manual Surveillance
  - Infection Control Specialists identify patients with positive blood cultures from hospital informatics database
  - Review of medical charts, physician summaries, microbiology & pharmacy data
  - Application of CDC NHSN case definitions to determine CA-BSI

- Automated (Electronic) Surveillance
  - Patients with positive blood cultures identified from hospital informatics database
  - Additional electronically available data on these patients pulled by standardized query into an analysis dataset
  - Simple yes/no rules and combinations of rules applied to electronic data to determine presence or absence of CA-BSI

Simple Rules (Yes/No)

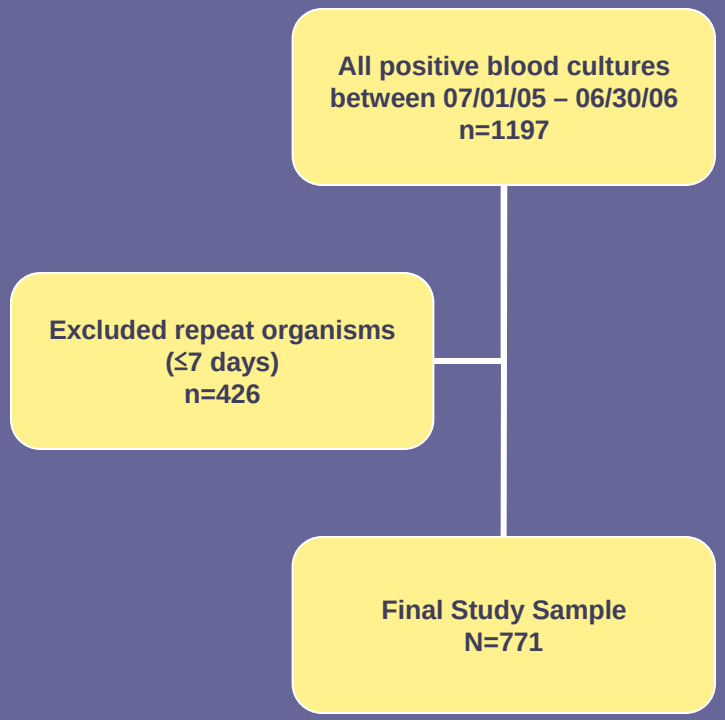
1. Blood culture >48 hrs after hospital admission*
2. Patient had CVC ≤48 hrs before blood culture*
3. At least one of the following:*
    a. Blood culture positive for non-common skin contaminant pathogen
    b. Blood culture positive for common skin contaminant
        - Confirmed within 5 days

          OR
        - Patient received vancomycin
4. Blood culture positive for organism other than coagulase-negative staphylococci*
5. No wound cultures before**
    – i.e., no wound culture positive for same organism before positive blood culture collection
6. No urine cultures before**
7. No respiratory cultures before**
8. No sterile other cultures before**
9. No non-sterile other cultures before**

*Similar to rules reported by Trick et al. *Emerg Infect Dis*. 2004;10:1612-1620.

**Cultures from secondary sites were also evaluated if collection was (1) after or (2) before or after blood culture collection

Results I



- Study Population
  - 771 positive blood cultures
  - 540 patients
  - 70 (9%) CA-BSI by manual review
  - 701 (91%) without CA-BSI
- Positive Blood Cultures
  - Coagulase-neg Staphylococci (45%)
  - Corynebacterium species (6%)
  - *Candida albicans* (5%)
  - *Staphylococcus aureus* (5%)
  - *Enterococcus faecalis* (5%)
  - *Enterococcus faecium* (5%)
  - *Klebsiella pneumoniae* (3%)
  - Other (26%)

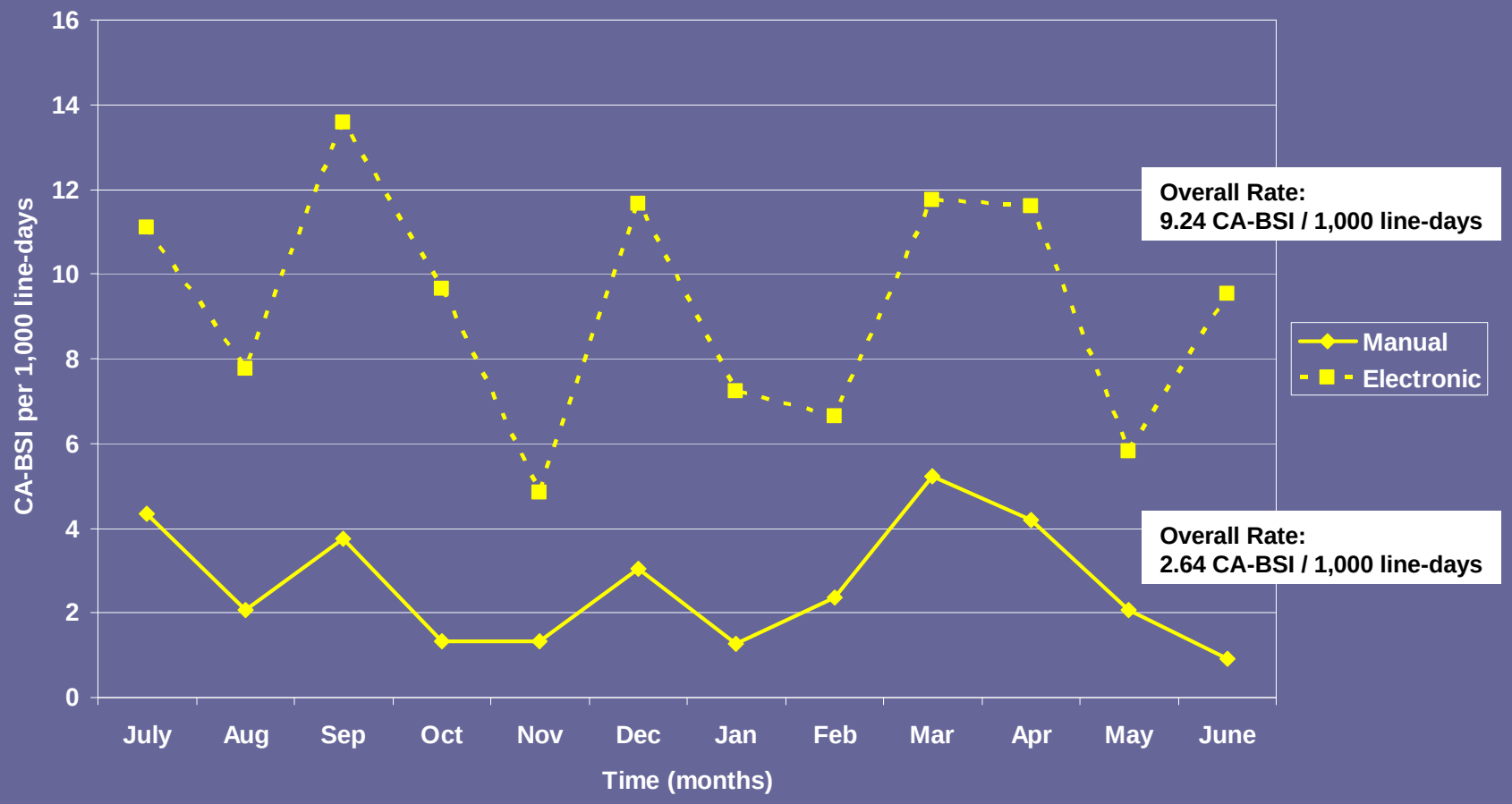
Table 1. Performance of Rulesets

Ruleset	# CA-BSI Confirmed by Rules N (%)	Sensitivity %	Specificity %	PPV %	NPV %	Kappa *
1,2	459 (59.5)	97.1	44.2	14.8	99.4	.118
1,2,3	362 (47.0)	95.7	57.9	18.5	99.3	.186
1,2,3,4	245 (31.8)	87.1	73.8	24.9	98.3	.287
1,2,3,4,5,6	230 (29.8)	80.0	75.2	24.3	97.4	.272
1,2,3,4,5,7	208 (27.0)	72.9	77.6	24.5	96.6	.267
1,2,3,4,5,6,7,8,9	184 (23.9)	62.9	80.0	23.9	95.6	.247

* $0 \leq$ Kappa ≤ 0.4 denotes *marginal* reproducibility

* Secondary site cultures collected before blood cultures improved rulesets better than those collected after or ever

Figure 1. CA-BSI Surveillance Rates



Results II

- Of 771 positive blood cultures, 193 (25%) were classified differently by manual versus electronic surveillance methods
  - Among 70 gold standard CA-BSI, the ruleset with rules 1,2,3 and 4 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
    - 1 had misclassified CVC usage data
  - Among 701 positive blood cultures not classified as CA-BSI by infection control specialists, the ruleset with rules 1,2,3 and 4 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

- Advantages
  - Consistent application of case definitions
  - Reallocation of infection control specialists' time from surveillance to prevention efforts
  - Potential extension of surveillance to non-ICU wards
  - High negative predictive value of rulesets provides infection control specialists with a list of patients that do not have CA-BSI
- Limitations
  - Errors in electronic data
    - Not all CVC usage captured by electronic data (e.g., 1 gold-standard CA-BSI with CVC usage recorded in medical chart was not classified as having a CVC in electronic data)
  - Line-day data lacks PICC line information for 2 out of 12 months
    - Sensitivity analysis: Adding PICC line information to CVC line data increased line-usage by 3.9%, on average. This did not substantially change CA-BSI rates.

Conclusions

- An automated surveillance system that utilized existing patient data was able to identify CA-BSI with reasonable sensitivity and specificity.
- Although sensitivity and specificity need to be improved, trends of infection rates rose and fell appropriately.
- Automated CA-BSI surveillance may be useful for identifying trends for manual investigation.

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