A Cox-proportional Hazards Model for Predicting Nosocomial Bloodstream Infections From the Clinical Electronic Medical Record


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ABSTRACT:

Previous studies identifying risk factors for nosocomial bloodstream infections (BSI) have relied on labor-intensive chart review. The electronic medical record (EMR) can provide real-time data for profiling patients at risk for BSI. We used our hospital EMR to study risk factors for nosocomial BSI from 2001-2002. Using Cox definitions for BSI, we pulled a number of variables from the EMR data repository including demographics, medications, nutritional status, presence of diabetes (DM), skin/wound status, and use of ventilator, urinary catheter, or central/arterial/PICC catheter. We developed a Cox Proportional Hazards model with half the cohort (14,977 controls and 123 BSI cases). Final variables chosen by clinical relevance, significance on univariate analysis and by step-wise automated selection to include confounders. The model contained: use of antibiotics (HR 4.6), central venous catheter for 6-8 days (HR 1.8), central venous catheter for greater or equal to 7 days (HR 1.3), tunnelled central venous port (HR 9.3) and DM (HR 2.1). Variables from multivariate analysis were used for the predictive index: points were derived from the respective HR of the Cox model. A cutoff value that maximized sensitivity (75%) and specificity (89%) had a positive predictive value (PPV) of .05. This model was validated on the second half of the cohort (122 BSI, 14,977 ‘non-cases’) with resultant sensitivity of 69%, specificity of 88% and PPV of 0.05 (no significant differences in the sensitivity, specificity and PPV).

Conclusion: We successfully used a hospital-based EMR in developing a Cox Proportional Hazards model for nosocomial BSI. This model was used to derive a predictive index. At a cutoff point providing a sensitivity of 75% and specificity of 89% for finding patients who develop nosocomial BSI, the index had a PPV 0.05.

Background:

The electronic medical record (EMR) provides an opportunity to labor-intensive studies. Conventional chart review is labor-intensive and may not allow for intervention to prevent development of BSI in susceptible patients.

Methods:

Variables extracted from EMR:
- Demographics
- Medication
- Immunosuppression + DM
- Nutritional status
- Ventilator use
- Urinary Catheter
- Skin/wound status
- Mental status
- CVC/PICC/Arterial Cath.

Cox Proportional Hazards Model derived from ½ cohort

Predictive model and scoring system derived from Cox proportional hazards model

Predictive model validated on other ½ cohort

Model tested for internal validity

BSI Definition:

CDC Criteria:

**Newly positive blood culture within 48 hours post admission**

**Capture 1st episode of nosocomial BSI**

Exclude:

- Patients with positive blood cultures within the first 48 hours

- Patients with same organism bacteremia pre and post 48 hours

- Coagulase negative staphylococci

Validation Model

Variables chosen by clinical relevance, significance on univariate analysis and by SAS step-wise selection

-Catheter GE 7D non-significance likely due to lack of power but retained due to pathophysiologic plausibility

Multivariate Model from Test Cohort

Variable Hazard Ratio P value

Antimicrobial 4.6 <.0001

CVC for < 1-6 days 1.8 0.0178

CVC for > 7 days 1.3 0.3297

Tunnelled 9.3 <.0001

CVC for > 7 days 1.3 0.3297

Diabetes Mellitus 2.1 0.0002

Multivariate HR: TCVP>Antibiotics>DM>
Catheter 0-6> catheter GE 7D

Results:

<table>
<thead>
<tr>
<th>Score</th>
<th>With Event</th>
<th>Without Event</th>
<th>Cutoff if (P &lt; 0.05)</th>
<th>PV +</th>
<th>Sensitivity</th>
<th>Specificity</th>
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Conclusion:

- Study goal was to use the EMR to identify patients at high risk for nosocomial BSI using automated systems
- Data was successfully extracted for 245 NBSI and 29,954 non-BSI patients
- This cohort was randomly divided in half in order to develop a predictive model for NBSI
- The predictive model was internally validated on the second half of the cohort.
- The model is preliminary and must be prospectively validated

Validation Cohort

245 distinct NBSI cases

+29,954 ‘non cases’

Catheter 0-6> catheter GE 7D

End Point= NBSI: Score ranges from 0 - 17. Positive Trend in PV + with increasing score. 5 Point cut-off to maximize sensitivity and specificity.

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Chi-Square Test: Internal Validity

Parameter Test Statistic P Value

PPV 0.6425 0.422

Sensitivity 0.9504 0.3296

Specificity 0.4382 0.5080

Statistical comparison between the predictive model and the validation cohort reveals NO statistically significant differences in Sensitivity, Specificity, or PPV.

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EMR Screen Reprint: Invasive Catheters

Model tested for internal validity

Clinical data repository

Analytical Model