

Validation of a Screening Tool to Assist in the Early Identification of Bloodstream Infections in Older Patients



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ABSTRACT

Background: Delayed diagnosis of blood stream infection (BSI) occurs in >20% of older patients. A validated BSI screening tool (ST) to identify older patients with a high probability of BSI may improve early diagnosis and management.

Objective: The objective was to validate a BSI-ST in older patients.

Methods: Inpatients ≥65 years old admitted between March 12, 2010-December 2, 2013 were eligible. A retrospective chart review of a matched cohort of older patients with and without documented BSI was completed. Data analysis was done for all patients ≥ 65 years old. Bacteremia pre-test probability, sensitivity, specificity, accuracy, false positive and negative rates of bacteremia; and positive and negative predictive value, post-test probability, and likelihood ratios were determined.

Results: The BSI-ST was validated in 486 patients (Cases = 294; Controls = 192). Of 25942 patients ≥65 years old admitted during the study, 510 had BSI, corresponding to a period prevalence (PP) of BSI in older patients of 2.0%. At the 2.0% BSI PP, the negative predictive value is 99.5% with a 0.5% probability of missing a BSI in an older patient.

Conclusion: The BSI-ST has excellent predictive capability for identifying older patients in whom a blood culture should be obtained, with a positive predictive value of 91% and false positive rate of only 11%. Although the false negative rate was 23%, a negative test in a patient with a BSI would occur in only 0.5% of patients at the institutional PP of BSI in older patients. Therefore, the retrospective validation of the BSI screening tool supports its implementation and pragmatic prospective evaluation.

BACKGROUND

- Delayed diagnosis of blood stream infection (BSI) occurs in >20% of older patients
- A validated BSI screening tool (ST) to identify older patients (≥ 65 years old) with high probability of BSI may improve early diagnosis and management
- Our group developed a BSI-ST using a retrospective study design in 130 older patients (N=130; Cases = 73 and Controls = 57) (Learn Cohort)

Binary Logistic Regression Model Developed:

- $\ln(\text{odds of BSI}) = -150.299 + 3.751(\text{Maximum Temperature}) + 0.654(\text{Neutrophils}) + 0.452(\Delta \text{ Level of Consciousness, Yes=1, No=0}) + 0.307(\text{Blood Urea Nitrogen}) + 0.154(\text{Glucose}) + 0.038(\text{Albumin}) + 0.005(\text{Alanine Transaminase})$
- $\text{Probability of BSI} = \text{Odds of BSI} / (1 + \text{Odds of BSI})$

- The tool's performance in the Learn Cohort was excellent:

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BACKGROUND

Results Learn Cohort (Previously Presented)	(N=130; Cases=73, Controls=57)
Pre-Test Probability of Bacteremia (%)	56
Sensitivity (%)	94
Specificity (%)	95
Accuracy (%)	95
Positive Predictive Value and Post-Test Probability (%)	96
Negative Predictive Value	93
Negative Post-Test Probability (%)	7
Positive Likelihood Ratio	18
Negative Likelihood Ratio	0.06
False Positive Rate (%)	5
False Negative Rate (%)	6

OBJECTIVE

- To validate the previously developed BSI-ST in a large cohort of older patients (≥ 65 years old) (Test Cohort)

METHODS

Study Design:

- Retrospective matched cohort study in patients ≥ 65 years old
- Patients at Sunnybrook Health Sciences Centre (SHSC) between March 12, 2010 and December 2, 2013 with BSI (Bacteremic Test Cohort or Cases) were matched to patients who never had a positive culture (any site) and did not receive any antimicrobials during hospital stay (Controls)

Inclusion:

- Patients ≥ 65 years old with BSI who had not been included in the development of the BSI-ST (Cases) were matched to Controls who had not been included in the development of the BSI-ST (Figure 1)

Definitions

- Bacteremic patients were those with a positive blood culture who received antimicrobial treatment
- Patients with blood isolates of possible contaminants were excluded (e.g. *Coagulase negative Staphylococci*, *Corynebacterium spp*, *Propionibacterium spp*, and *Bacillus spp* (other than *B. anthracis*)).
- If patients had multiple positive blood cultures during a given hospital stay, data was only collected in relation to their first positive blood culture

RESULTS

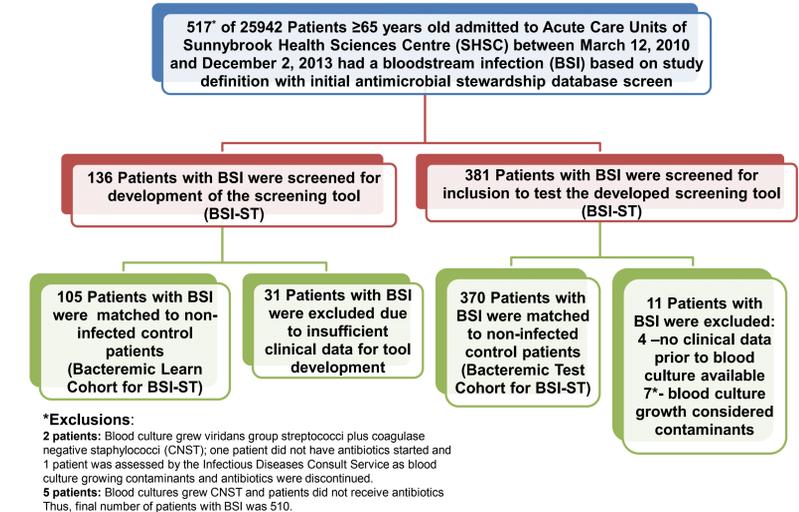


Figure 1. Patient Inclusion for Bloodstream Infection Learn and Test Cohorts

Best Model: Binary Logistic Regression Equation with a Threshold for Decision of Bacteremia Identified from Receiver Operating Curve as Probability of Bacteremia >0.5
 (i.e. If the Probability of Bacteremia from the Logistic Regression Equation >0.5, then Conclude the Patient Has Bacteremia)

Only Patients with a complete data set for the significant independent variables in the Regression Equation Included
 N= 486 patients (Infection = 294; Control = 192)

Bloodstream Infection Screening Tool Result	Bacteremia	Gold Standard (Positive blood culture)		Positive Predictive Value (PPV) = 91%	Positive post-test probability = 91%
		Bacteremia	No Bacteremia		
Bacteremia	TP = 225	FP = 21			
No Bacteremia	FN = 69	TN = 171		Negative Predictive Value (NPV) = 71%	Negative post-test probability = 29%
Independent of pre-test probability – are Intrinsic Characteristics of the screening tool		Sensitivity = 77%	Specificity = 89%	Accuracy = 81%	
Depend on pre-test probability		Pre-test Probability (Prevalence) = 60% (i.e. 294/486)	Likelihood ratio positive test = 7 Likelihood ratio negative test = 0.26	False Positive Rate = 11% False Negative Rate = 23%	

$\ln(\text{odds of infection}) = -150.299 + 3.751(\text{Tmax}) + 0.654(\text{PMN}) + 0.452(\Delta \text{LOC}) + 0.307(\text{BUN}) + 0.154(\text{Glucose}) + 0.038(\text{ALB}) + 0.005(\text{ALT})$

Figure 2. Test Cohort Results Using Only Patients with Complete Bloodstream Infection Screening Tool Data

CONCLUSION

- BSI-ST has high sensitivity, specificity, accuracy and predictive capability for identifying older patients in whom a blood culture should be obtained (Figure 2)
- Although the false negative rate was 23%, a negative test in a patient with a BSI would occur in only 0.5% of patients at the institutional BSI period prevalence of 2.0% in older patients
- Therefore, the retrospective validation of the BSI screening tool supports its implementation and pragmatic prospective evaluation
- The BSI-ST may serve to support (not replace) clinical judgement

Next steps: Pragmatic prospective evaluation in patients ≥ 65 years old in whom a BSI or an infection related diagnosis may be on the differential

Disclosure:

No author has anything to disclose concerning personal or financial relationships with commercial entities that may have a direct or indirect interest in the subject matter of this presentation.