

External Validation of the Cham Score for Ordering of Blood Cultures in Emergency Department Patients with Non-Hospital Acquired Pneumonia

Mark Patterson, ¹*MBBS*, Anne-Maree Kelly, ²*MD, FACEM, FCCP*, Sharon Klim, ²*BN*

Abstract

Introduction: The aim of this study was to externally validate the Cham score for the prediction of bacteraemia in emergency department (ED) patients with non-hospital acquired pneumonia. **Materials and Methods:** This is a secondary analysis of a dataset collected to identify independent predictors of bacteraemia in adult ED patients with non-hospital acquired pneumonia. The primary outcome of interest was the predictive performance (sensitivity, specificity, negative predictive value) of the score with respect to bacteraemia. Secondary outcomes included the performance of the score in patients not known to be intravenous (IV) drug users, the predictive performance of pneumonia severity index (PSI) class IV/V and PSI class IV/V or IV drug use as predictors and the clinical impact of score application on test ordering. Data analysis was by clinical performance and receiver operator characteristic curve analysis. **Results:** A total of 200 patients were studied; 14 true positive blood cultures (7%, 95% CI, 4% to 11%). The Cham score had a sensitivity of 92.9% (95% CI, 64.2% to 99.6%), specificity of 26.3% (95% CI, 20.3% to 33.4%) and negative predictive value (NPV) of 98% (87.0% to 99.9%). Area under the receiver operating characteristic (ROC) curve was 0.71 (95% CI, 0.56 to 0.86). Using PSI class IV/V or known IV drug use as predictors had sensitivity of 92.9% (95% CI, 64.2% to 99.6%), specificity of 51.1% (95% CI, 43.7% to 58.4%) and NPV of 99% (95% CI, 93.5% to 99.9%). **Conclusion:** In retrospective external validation, the Cham score performed better than in derivation with acceptable sensitivity and NPV. Simplified criteria (PSI class IV/V or known IV drug use), as yet not validated, had similar sensitivity and NPV but would avoid blood cultures in a higher proportion of patients.

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Key words: Blood culture, Emergency department, Pneumonia

Introduction

Some guidelines currently promote the taking of blood cultures in patients admitted to hospital with non-hospital acquired pneumonia in order to identify pathogens and guide therapy.^{1,2} Previous studies have reported that the proportion of patients returning a true positive blood culture is between 2.1% and 9%.³⁻¹⁰ False positive cultures have been reported to occur in 2.5% to 3.7% of tests.^{3,7} This low rate of true positive results and significant false positive rate pose a serious challenge to their utility, both on clinical and cost-effectiveness grounds and debate challenging these guidelines is growing.^{7,11,12}

A selective approach has been suggested, with the ordering of cultures being reserved for patients with severe disease.⁵ Another approach, taken by Cham and colleagues,³ is the development of a score to assist in identifying patients

more likely to have a true positive culture. They conducted a case control study of emergency department (ED) patients diagnosed with community acquired pneumonia to identify factors independently associated with positive blood cultures. Using regression analysis, a predictive probability equation with minimum number of culture positive misclassification was developed. Based on the predictive model, a scoring system was devised, with scores predicting which patients would be likely to have a positive or negative blood culture upon presentation at the ED. That scoring system is shown in Table 1. The score ranges from -5 to +5 and a cut-off score ≤ -1 was chosen as the discriminator level. They reported an area under the receiver operating characteristic (ROC) curve of 0.64 (95% CI, 0.58 to 0.70). The model had a sensitivity of 82% and specificity was 38.2% for a positive blood culture.

¹Department of Emergency Medicine, Western Health, Australia

²Joseph Epstein Centre for Emergency Medicine Research, Western Health, Australia

Address for Correspondence: Prof Anne-Maree Kelly, Joseph Epstein Centre for Emergency Medicine Research, Western Health, Sunshine Hospital, Furlong Road, St Albans 3021, Melbourne, Australia.

Email: anne-maree.kelly@wh.org.au

Table 1. The Cham Score and Modified Cham Score

Predictor	Cham Score	Modified Cham Score
PSI class V	3	3
PSI class IV	2	2
Prior antibiotic treatment	– 2	– 2
COPD	– 2	– 2
Smoker	1	1
Cough	– 1	– 1
Malay ethnicity	1	NA
Range	– 5 to +5	– 5 to +4

COPD: Chronic obstructive pulmonary disease; NA: Not applicable;
PSI: Pneumonia severity index

The aim of this study was to externally validate the Cham score for the prediction of bacteraemia in ED patients with non-hospital acquired pneumonia. We hypothesised that the score would have >95% negative predictive value for true positive blood culture.

Materials and Methods

This is a secondary analysis of a dataset collected to identify independent predictors of true positive blood cultures in ED patients with pneumonia.¹³ Participants were a convenience sample of 200 patients with an ED discharge diagnosis of non-hospital acquired pneumonia treated at the ED of a community teaching hospital in Melbourne, Australia between July 2008 and May 2009 and in whom at least one set of blood cultures was taken as part of their initial investigations. ED discharge diagnosis was made by the treating clinician with access to all the clinical and investigative data available at ED discharge. Taking of blood cultures was at the discretion of treating clinicians, however it would be usual practice to collect blood cultures in patients being admitted to hospital for treatment of pneumonia or who exhibit a fever >38°C. Patients were identified from an administrative database. Eligibility criteria included age over 18 years, having a blood culture taken within 6 hours of arrival in ED and availability of record for review. The study hospital has an adult census of 35,000 per year with an admission rate of approximately 35%.

Patients were identified from an administrative database covering the period 1 July 2008 to 30 June 2009. Data were collected by explicit medical records review (MP, SK) on to a specifically designed data form. Eligibility criteria included age over 18 years, having a blood culture taken within 6 hours of arrival in ED and availability of record for review. Data abstractors were trained in data collection from medical records and had predefined definitions for all data elements. As this is an unplanned secondary analysis,

data collectors were unaware of the specific hypothesis.

Data collected included demographics, past medical history of chronic obstructive pulmonary disease (COPD), smoking, immunosuppression, intravenous (IV) drug use or diabetes, antibiotic use prior to ED attendance, biochemistry, haematology and blood culture results, clinical features and ED disposition. Inter-rater reliability was tested on 10% of records. Inter-rater agreement of data collection was 100% for the items: age, gender, white cell count, serum sodium concentration and ED disposition.

During study development, an issue arose with a data element of the Cham score. Malay ethnicity was not clinically relevant in the study population, representing <1% of all patients. We elected to remove 'Malay ethnicity' from the score calculation but retained the score cut-off for recommended ordering of blood cultures (≥ -1). The modified score has a range of –5 to +4. Pneumonia severity index (PSI) and Cham score were calculated retrospectively.

The primary outcome of interest was the clinical performance (sensitivity, specificity, negative predictive value (NPV)) of the score with respect to true positive blood cultures. True positive was defined according to previously published standards.¹⁴ Secondary outcomes included the performance of the score in patients not known to be IV drug users, the predictive performance of PSI class IV/V or PSI class IV/V or IV drug use as predictors and the clinical impact of Cham score application on test ordering. We included the latter analysis because the parent study¹³ had shown a very strong association between IV drug use and positive blood culture (OR 16.7, 95% CI, 2.65 to 105) and this variable had not been collected in the Cham score derivation study.³

Data analysis was by sensitivity, specificity and negative predictive value analyses (with 95% confidence intervals) and ROC curve analysis. As this was a secondary analysis, sample size was not calculated a priori.

Results

Characteristics of the sample are shown in Table 2. There were 14 true positive blood cultures (7%, range, 4% to 11%). Organisms were *Streptococcus pneumoniae* (7), *Streptococcus pyogenes* (2), *Staphylococcus aureus* (2), *Escherichia coli* (1), *Candida albicans* (1) and *Corynebacterium jeikeium* (1).

The Cham score at the ≥ -1 cut-off had a sensitivity of 92.9% (13/14 true positives) (95% CI, 64.2% to 99.6%), specificity of 26.3% (95% CI, 20.3% to 33.4%) and NPV of 98% (87.0% to 99.9%). Area under the ROC curve was 0.71 (95% CI, 0.56 to 0.86) (Fig. 1). For patients not known to be IV drug users, the Cham score at the same cut-off had a sensitivity of 100% (10/10 true positives) (95% CI, 65.5% to 100%), specificity of 26.3% (95% CI, 20.1% to 33.3%)

Table 2. Characteristics of the Study Sample

Variable	Grouping	Number
Gender (male n, %)		118, 59%
Age in years (median, IQR)		72, 60 to 81
Residential care (n, %)		26, 13%
Duration of symptoms (n, %)	>2 days	124, 52%
	<2 days	75, 37.5%
	Unknown	1
Temperature (n, %)	35 to 38.5 °C	59, 29.5%
	<35 or >38.5 °C	141, 70.5%
Past history (n, %)	Diabetes	56, 28%
	COAD	59, 29.5%
	Immunosuppression	4, 2%
	IV drug use	7, 3.5%
	Antibiotics prior to ED	53, 26.5%
PSI group (n, %)	I	16, 8%
	II	47, 23.5%
	III	39, 19.5%
	IV	66, 33%
	V	32, 16%
Respiratory rate (median, IQR)		28, 22 to 32
Pulse rate (median, IQR)		112, 91 to 128
Oxygen saturation (n, %)	≥93%	115, 57.5%
	<93%	79, 39.5%
	Unknown	6, 3%
WCC (n, %)	<4	8, 4%
	4 to 11	80, 40%
	11 to 20	88, 44%
	>20	22, 11%
	Unknown	2, 1%
Final hospital diagnosis (n, %)	Pneumonia	178, 89%
	COAD/ Respiratory failure	16, 8%
	Sepsis	4, 2%
	Other	2, 1%

COAD: Chronic obstructive airways disease; IQR: Interquartile range; PSI: Pneumonia severity index; WCC: White cell count x 10⁹/litre

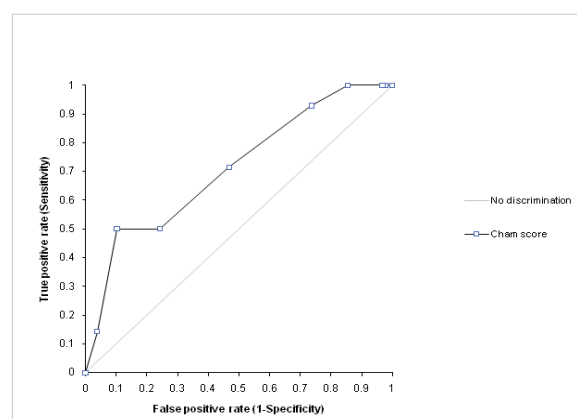


Fig. 1. Receiver operator characteristic curve for the Cham score as a predictor of positive blood culture.

and NPV of 100% (90.8% to 100%). Area under the ROC curve was 0.77 (95% CI, 0.63 to 0.92). Use of the Cham score to guide blood culture ordering would have avoided 50 tests (25%) in the overall cohort and 48 (24.9%) in the cohort not known to be IV drug users.

Using PSI class IV/V alone as a predictor of positive blood culture had a sensitivity of 71.4% (10/14 true positive) (95% CI, 42% to 90.4%), specificity of 52.7% (95% CI, 45.2% to 60%) and NPV of 96.1% (95% CI, 89.7% to 98.7%). Using PSI class IV/V or known IV drug use as predictors had sensitivity of 92.9% (13/14 true positives) (95% CI, 64.2% to 99.6%), specificity of 51.1% (95% CI, 43.7% to 58.4%) and NPV of 99% (95% CI, 93.5% to 99.9%). Application of this criterion would have avoided 96 tests (48%).

Discussion

Our results confirm that blood cultures for community acquired pneumonia have a low yield of true positives (7%). This is consistent with data from other centres showing bacteraemia rates of 2% to 9%.^{3,10} This low rate of positive results coupled with previously published data that results rarely impact therapy or outcome^{4,6,7,8,10} seriously challenge the practice of routine blood cultures for patients presenting with community acquired pneumonia and support calls for a more selective approach.

In this retrospective external validation, the Cham score had higher sensitivity than in derivation (92.9% vs 82%) but with lower specificity (26.3% vs 38%). The predictive performance was also better (area under the curve (AUC) 0.71 vs 0.64). We found that 25% of cultures might have been avoided if the rule had been applied, compared with 38% predicted in the derivation set. The score performed even better when the subset of patients known to be IV drug users were excluded. This likely reflects the impact of this

predictor on the finding of bacteraemia in our original study.

We also found that using the criteria PSI class IV/V or known IV drug use as predictors had similar sensitivity (92.9%), higher specificity (51.1%) and high NPV (99%). Application of these criteria is estimated to avoid 48% of tests. This approach would be simpler as it has fewer elements and no score to calculate. It has not however been prospectively validated.

One element of the Cham score was not relevant to the Australian context (Malay ethnicity) which impacted score calculation but does not appear to have had an adverse influence on score predictive performance. In our local context, we have shown that IV drug use is a powerful predictor of bacteraemia (OR 17.7).¹³ This was not identified as a predictor in Cham's original study, possibly due to a very low rate of IV drug use in Singapore. These data are a reminder that some predictors of bacteraemia may relate to local context and this should be taken into account in setting local practice guidelines.

This study has some limitations that should be considered when interpreting the results. This is a secondary analysis of an existing dataset that was not collected for the purpose to which it has been applied. Data on the inter-rater reliability of Cham score items was not collected as this was not the primary objective of the research. To do so retrospectively is not feasible within available resources. It utilises a convenience sample based on availability of medical records during the study period, so results should not be viewed as definitive. We have no reason to suspect any systematic bias in record availability. The data were collected by explicit medical record review so is subject to data omissions in the records accessed. Data were collected at a single site in Australia, so it may not be generalisable to other settings.

Conclusion

In retrospective external validation, the Cham score performed better than in derivation with acceptable sensitivity and NPV. Simplified criteria (PSI class IV/V or known IV drug use), as yet not validated, had similar sensitivity and NPV but would avoid blood cultures in a higher proportion of patients.

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