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Original Article

# Utility of a blood culture time to positivity-incorporated scoring model in predicting vascular infections in adults with nontyphoid *Salmonella* bacteremia

**Jr-Jiun Lin** [a], **Tzu-Hua Weng** [a], **Wen-Pin Tseng** [a], **Shang-Yu Chen** [a], **Chia-Ming Fu** [a], **Hui-Wen Lin** [b], **Chun-Hsing Liao** [b], **Tai-Fen Lee** [c], **Po-Ren Hsueh** [d], **Shey-Ying Chen** [a,*]

[a] *Department of Emergency Medicine, National Taiwan University Hospital, National Taiwan University College of Medicine, Taipei, Taiwan*
[b] *Department of Internal Medicine, Far Eastern Memorial Hospital, Taipei, Taiwan*
[c] *Department of Laboratory Medicine, National Taiwan University Hospital, Taipei, Taiwan*
[d] *Department of Laboratory Medicine and Internal Medicine, National Taiwan University Hospital, National Taiwan University College of Medicine, Taipei, Taiwan*

**Abstract** *Background*: Vascular infections (VI) are potentially catastrophic complications of nontyphoid *Salmonella* (NTS). We aimed to develop a scoring model incorporating information from blood culture time to positivity (TTP-NTSVI) and compared the prediction capability for VI among adults with NTS bacteremia between TTP-NTSVI and a previously published score (Chen-NTSVI).
*Methods*: This retrospective cohort study enrolled 217 adults with NTS bacteremia ≥ 50 years old. We developed a TTP-NTSVI score by multiple logistic regression modeling to identify independent predictors for imaging-confirmed VI and assigned a point value weighting by the corresponding natural logarithm of the odds ratio for each model predictor. Chen-NTSVI score includes hypertension, male sex, serogroup C1, coronary arterial disease (CAD) as positive predictors, and malignancy and immunosuppressive therapy as negative predictors. The prediction capability of the two scores was compared by area under the receiver operating characteristic curve (AUC).

* Corresponding author. Department of Emergency Medicine, National Taiwan University Hospital, College of Medicine, National Taiwan University, No 7 Chung-Shan South Road, Taipei, Taiwan.
E-mail address: erdrcsy@ntu.edu.tw (S.-Y. Chen).

*Results:* The mean age was 68.3 ± 11.2 years-old. Serogroup D was the predominant isolate (155/217, 71.4%). Seventeen (7.8%) patients had VI. Four independent predictors for VI were identified: male sex (24.9 [2.59–239.60]; 6) (odds ratio [95% confidence interval]; assigned score point), peripheral arterial occlusive disease (9.41 [2.21–40.02]; 4), CAD (4.0 [1.16–13.86]; 3), and TTP <10 h (4.67 [1.42–15.39]; 3). Youden's index showed best cutoff value of ≧7 with 70.6% sensitivity and 82.5% specificity. TTP-NTSVI score had higher AUC than Chen-NTSVI (0.851 vs 0.741, *P* = 0.039).

*Conclusion:* While the previously reported scoring model performed well, a TTP-incorporated scoring model was associated with improved capability in predicting NTSVI.

## Introduction

Non-typhoid salmonellae (NTS) are vital foodborne pathogens and cause a broad spectrum of human diseases ranging from self-limited gastroenteritis, primary bacteremia to life-threatening extra-intestinal complications including vascular or necrotizing soft tissue infection.[1–4] Among various extra-intestinal manifestations, vascular infection is especially challenging for first-line clinicians because of the difficulty in early detection and the narrow intervention window before rupture of infected aorta.[1,5–7] The overall mortality rate for NTS vascular infections was over 90% for patients with just medical treatment and approximately 40% for those with combined surgical and medical therapies.[5,6] Due to the high mortality risk from NTS-associated vascular complications, earlier diagnosis and prompt surgical intervention are crucial for the best treatment outcome for patients with NTS vascular infection.

Confirmation of endovascular infection relies on computed tomography (CT) or magnetic resonance (MR) imaging.[8,9] Because of the high prevalence of vascular infection among elderly patients with NTS bacteremia, it was suggested that patients > 50 years old with NTS bacteremia should undergo surveillance imaging tests, including CT to exclude the probability of concurrent endovascular infections.[10–14] However, evidence regarding universal surveillance imaging for all NTS bacteremia patients aged >50 years old to exclude the diagnosis of vascular infection remains inconclusive. This is an especially serious concern for communities with lower NTS vascular infection prevalence or limited medical resources. A decision rule that will facilitate risk stratification of vascular infection is therefore helpful for the timely and cost effective treatment of patients with NTS bacteremia. Chen and colleagues proposed a scoring model with the aim to predict the occurrence of NTS-related vascular infection (Chen-NTSVI score).[6] The Chen-NTSVI score identified hypertension, male sex, serogroup C1 NTS, and coronary artery disease (CAD) as positive predictors, and malignancy and immunosuppressive therapy as negative predictors for NTS-related vascular infection (Table 1). While the Chen-NTSVI score showed high sensitivity (95.0%) with an acceptable specificity (45.3%) at the cut-off value of +1, this model has never been validated independently. Furthermore, decline of serogroup C, particularly of the *Salmonella enterica* serovar *Choleraesuis* isolate, has been observed in Taiwan, possibly due to strict antibiotic usage regulation and the adoption of vaccination policies in hog farms.[15] The different microbiology pattern in NTS bacteremia between different communities may challenge the usefulness of a scoring model using a specific bacterial species as a model predictor.

Blood culture time to positivity (TTP) of a detected microorganism is defined as the time elapsed from inoculation to the detection of bacterial growth in a culture flask. Because TTP presumably reflects the bacterial inoculum size from cultured blood, it represents a quantitative surrogate parameter of bacteremia severity.[16,17] A previous study suggested that shorter TTP is associated with a higher likelihood of the presence of endovascular infection

**Table 1**   Independent predictors of Nontyphoid *Salmonella* Vascular Infection Score developed by Chen's research group (Chen-NTSVI Score).[6]

| Risk factor | [a]OR (95% CI) | *P* value | Chen-NTSVI score | |
|---|---|---|---|---|
| | | | Model 1 | Model 2 |
| Hypertension | 6.09 (2.93–12.66) | <0.0001 | +6 | +1 |
| Male sex | 4.13 (1.95–8.72) | <0.0001 | +4 | +1 |
| Serogroup C1 | 4.03 (1.91–8.51) | <0.0001 | +4 | +1 |
| Coronary arterial disease | 2.50 (1.14–5.49) | 0.02 | +3 | +1 |
| Malignancy | 0.38 (0.15–1.00) | 0.05 | −3 | −1 |
| Immunosuppressive therapy | 0.20 (0.05–0.90) | 0.04 | −5 | −1 |

a OR = adjusted odds ratio; CI = confidence interval.