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Letters

RESEARCH LETTER

Performance of the TRI-SCORE in a Multicenter Cohort Undergoing Transcatheter Tricuspid Valve Repair and Replacement

The TRI-SCORE has been demonstrated to predict mortality after tricuspid valve surgery,[1] and its performance in transcatheter tricuspid valve repair has been described.[2,3] However, the accuracy of the TRI-SCORE in transcatheter tricuspid valve replacement (TTVR) is unknown. Accordingly, the discrimination and calibration of the TRI-SCORE for the prediction of in-hospital mortality were compared among a contemporary cohort undergoing TTVR, tricuspid edge-to-edge repair (T-TEER), and transcatheter tricuspid valve annuloplasty (TTA).

A total of 457 consecutive patients undergoing transcatheter tricuspid valve intervention (TTVI) were identified from an international, multicenter registry (6 centers in Germany, the United States, and Switzerland) between January 2019 and December 2024 and evaluated using the TRI-SCORE (original 8-variable model). This cohort included 243 T-TEER (53.2%), 131 TTVR (28.7%), and 83 TTA (18.2%) cases. The study included all consecutive patients meeting eligibility criteria from the participating centers during the study period. The primary outcome was in-hospital mortality. Discrimination was assessed using the C-statistic, and calibration plots of observed vs predicted mortality were assessed with the Hosmer-Lemeshow test. Missing data for the TRI-SCORE ranged from 0% to 21.2% (97 of 457) for bilirubin; other key missing rates included signs of right heart failure (4.8% [22 of 457]) and furosemide (3.3% [15 of 457]). All missing TRI-SCORE component values were imputed using a single-imputation random forest algorithm (R package missForest). This imputation strategy aligns with methodology in the original TRI-SCORE development,[1] and a complete case analysis yielded consistent results. Statistical analyses were performed using R version 4.2.2 (R Foundation for Statistical Computing). The study was approved by the local ethics committee and was conducted in accordance with the Declaration of Helsinki. This report was prepared in accordance with the Transparent Reporting of a Multivariable Prediction Model for Individual Prognosis or Diagnosis statement.

Overall, observed in-hospital mortality was 2.63% (12 of 457). The median follow-up duration for the cohort was 173 days (Q1-Q3: 88-530 days). In-hospital mortality occurred in 6 of 243 T-TEER patients (2.5%), 5 of 131 TTVR patients (3.8%), and 2 of 83 TTA patients (2.4%). The TRI-SCORE showed similar discrimination for in-hospital mortality across the entire cohort (C-statistic = 0.72; 95% CI: 0.56-0.88), consistent with its performance in the original surgical derivation.[1] Within the TTVR subgroup (n = 131), the C-statistic was 0.67 (95% CI: 0.35-0.98). However, overall calibration was limited; average predicted mortality was 21.5%, which significantly overestimated the observed rate ($P < 0.001$, Hosmer-Lemeshow test).

The observed/expected mortality ratio for TTVR was 0.196 (95% CI: 0.08-0.47), while the observed/expected ratio for combined T-TEER and TTA was 0.110 (95% CI: 0.06-0.22) ($P = 0.31$ for comparison with TTVR), indicating similar miscalibration across all groups. This mortality overestimation was apparent across the entire risk spectrum. Predicted mortality significantly exceeded observed rates within each TRI-SCORE category (**Figure 1A**). The distribution of patient outcomes contrasts with the high original TRI-SCORE predicted risk probabilities (**Figure 1C**). This miscalibration pattern was consistently observed across all TTVI subgroups, including TTVR, as shown in their calibration curves (**Figure 1D**).

In this contemporary cohort of 457 TTVI patients, the TRI-SCORE demonstrated adequate overall risk discrimination but substantial overestimation of in-hospital mortality (2.63% [12 of 457] observed vs 21.5% [98 of 457] predicted). This miscalibration was consistent across all types of TTVI. This is the first analysis of the TRI-SCORE calibration in a substantial TTVR cohort (**Figure 1D**) and aligns with prior studies examining transcatheter repair.[2-4] This also reflects

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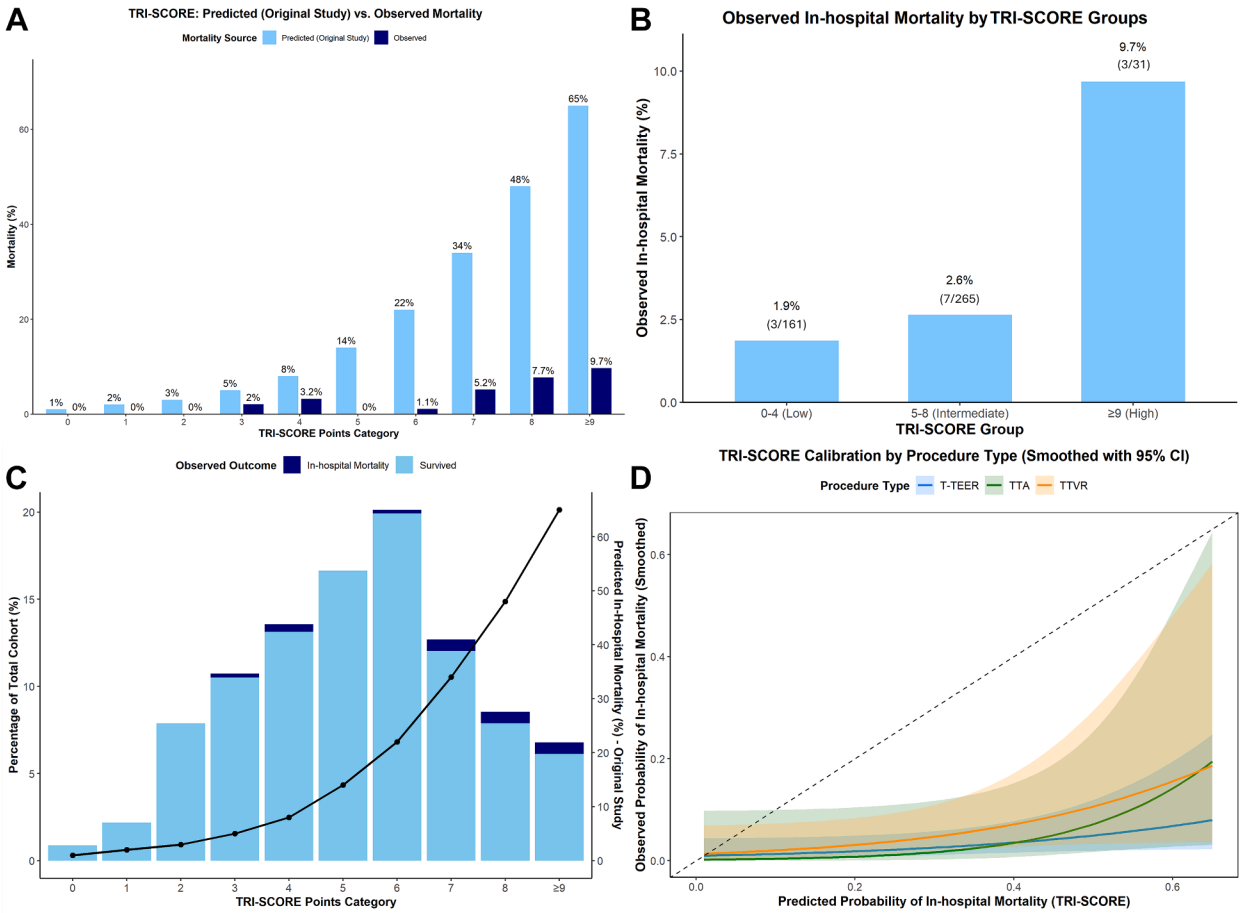
FIGURE 1 **TRI-SCORE Performance and Calibration in a Contemporary Transcatheter Tricuspid Valve Intervention Cohort**



(A) Predicted in-hospital mortality (original TRI-SCORE study) vs observed in-hospital mortality (present cohort) by TRI-SCORE. (B) Observed in-hospital mortality (percentage) by custom TRI-SCORE groups (0-4, 5-8, and ≥9 points). (C) Stacked bars of observed outcomes (percentage of total cohort) by TRI-SCORE category, with original TRI-SCORE-predicted mortality probability overlaid (solid line, right y-axis). (D) Smoothed calibration plots for TRI-SCORE (observed vs predicted probability of in-hospital mortality) with 95% CIs, stratified by transcatheter tricuspid valve intervention procedure type. TTA = transcatheter tricuspid annuloplasty; T-TEER = transcatheter edge-to-edge repair; TTVR = transcatheter tricuspid valve replacement.

fundamental differences from the original surgical derivation cohort,[1] such as the markedly lower observed mortality in contemporary TTVI despite high baseline patient risk.

The TRI-SCORE aids in relative risk ranking (Figure 1B), but the absolute probabilities of in-hospital mortality reflected in the surgically derived original cohort are unreliable for TTVI. This overestimation could misguide clinical decisions regarding patient selection for TTVI or complicate shared decision making. Recalibrated risk scores specific for TTVI, including distinct considerations for TTVR, are needed.

Limitations of our analysis include the retrospective nature of our international multicenter analysis and its focus on in-hospital mortality. Additionally, our single-imputation approach did not account for the statistical uncertainty of missing data.

In conclusion, the TRI-SCORE can risk stratify those undergoing TTVI, including TTVR. However, there is significant and similar miscalibration of absolute risk in TTVR and other TTVI procedures, underscoring the need for tailored assessment tools.

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The authors attest they are in compliance with human studies committees and animal welfare regulations of the authors' institutions and Food and Drug Administration guidelines, including patient consent where appropriate. For more information, visit the Author Center.

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