LVAD RVF: The real reason current risk scores miss the mark

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Advanced heart failure patients often rely on left ventricular assist devices (LVADs) to extend survival and improve quality of life. But the promise of these devices is frequently complicated by right ventricular failure (RVF), a serious post-operative event that significantly increases morbidity and mortality. Clinicians have long sought reliable tools to predict which patients will develop RVF, hoping to mitigate this risk through better patient selection or pre-emptive interventions.

A recent single-center retrospective study, published in Angiology, evaluated the performance of several established RVF risk scores. The analysis found that while the European Registry for Patients with Mechanical Circulatory Support (EUROMACS) score offered the highest predictive value, the overall discrimination of all tested scores remained modest, highlighting a persistent gap in our ability to accurately forecast this critical complication.1

KEY TAKEAWAYS

- The Pivot: Existing risk scores for post-LVAD right ventricular failure demonstrate only modest predictive accuracy, failing to reliably identify patients at highest risk.
- The Data: The EUROMACS score achieved the highest predictive value for RVF (C-statistic 0.670; P<.001), but this still indicates limited discrimination.
- The Action: Clinicians should exercise caution when relying solely on current RVF risk scores for patient selection or pre-operative planning, as their predictive power is insufficient for definitive decision-making.

Left ventricular assist devices have transformed the management of end-stage heart failure, offering a bridge to transplant or destination therapy for patients who have exhausted other medical options. These mechanical pumps support the failing left ventricle, restoring systemic circulation and improving organ perfusion. However, the physiological changes induced by LVAD implantation can impose significant stress on the right ventricle, which must then pump against a higher afterload due to increased left ventricular output. This delicate balance means that right ventricular failure remains a formidable challenge, occurring in up to 40% of patients post-implantation.1

The study, conducted by Mortada I, Mhanna M, and Gollapally Krishna SR, retrospectively analysed data from 326 continuous-flow LVAD recipients at a single center between March 2009 and May 2024. Of these, 205 patients met the inclusion criteria for the analysis. The investigators defined right ventricular failure as the need for inotropic support or the implantation of a right ventricular assist device (RVAD) post-LVAD. This definition is clinically relevant, capturing the most severe manifestations requiring intervention. The primary objective was to compare the predictive performance

of several established RVF risk scores: Michigan, Penn/Fitzpatrick, EUROMACS, and CRITT (Central venous pressure, severe Right ventricular dysfunction, preoperative Intubation, severe Tricuspid regurgitation, Tachycardia).1

Evaluating the Predictive Power of Established Scores

The investigators employed receiver operating characteristic (ROC) analysis, logistic regression, and internal validation to assess each score's ability to predict post-LVAD RVF. Among the 205 patients included in the final analysis, 81 (39.5%) developed post-LVAD right ventricular failure. This incidence rate aligns with previously reported figures, underscoring the persistent clinical burden of this complication. The Michigan score, developed at the University of Michigan, incorporates variables such as pre-operative creatinine, bilirubin, and albumin. The Penn/Fitzpatrick score, from the University of Pennsylvania, considers factors like right atrial pressure, pulmonary capillary wedge pressure, and tricuspid regurgitation severity. The EUROMACS score, derived from a large European registry, integrates a broader set of clinical and hemodynamic parameters. Finally, the CRITT score focuses on five specific risk factors: central venous pressure, severe right ventricular dysfunction, preoperative intubation, severe tricuspid regurgitation, and tachycardia.1

The EUROMACS score demonstrated the highest predictive value for RVF, achieving a C-statistic of 0.670 (P<.001). A C-statistic, or area under the ROC curve, measures the discriminatory ability of a model, with 0.5 indicating no better than random chance and 1.0 indicating perfect prediction. A value of 0.670 suggests that while the EUROMACS score has some predictive capability, it is far from perfect. It correctly discriminates between patients who will and will not develop RVF approximately 67% of the time.1

The CRITT score followed closely, with a C-statistic of 0.653 (P<.001). The Penn/Fitzpatrick score showed a C-statistic of 0.616 (P=.004), and the Michigan score registered the lowest predictive value among the group, with a C-statistic of 0.606 (P=.005). These numbers collectively indicate that while all scores showed statistically significant predictive ability, their clinical utility for definitively identifying high-risk patients remains limited. Youden-optimized cutoffs were derived for each score to provide practical thresholds for sensitivity, specificity, positive predictive value, and negative predictive value, but these metrics also reflected the modest overall discrimination.1

The Persistent Challenge of Right Ventricular Failure

The mechanism behind post-LVAD RVF is complex and multifactorial. The sudden reduction in left ventricular preload and afterload by the LVAD can lead to a shift of the interventricular septum to the left, altering right ventricular geometry and increasing its workload. Pre-existing right ventricular dysfunction, pulmonary hypertension, and tricuspid regurgitation are significant contributors. But the interplay of these factors, combined with surgical stress and post-operative fluid shifts, makes precise prediction difficult. The current study underscores that even with established risk scores, our ability to accurately stratify patients for RVF risk remains a work in progress.1

The secondary exploratory endpoint of the study was mortality analysis. While the paper does not detail specific mortality rates associated with each score or RVF incidence, it notes that RVF increases morbidity and mortality. This aligns with the broader understanding in the field: RVF is not merely a complication but a significant driver of adverse outcomes, including prolonged hospital stays, increased rehospitalization rates, and reduced long-term survival. The inability of current scores to robustly predict RVF therefore translates directly into an inability to effectively mitigate these downstream mortality risks.1

The study's single-center, retrospective design is an obvious caveat. Data from a single institution, even over a long period,

may not be generalizable to the broader LVAD population across different surgical centers and patient demographics. Retrospective analyses are also inherently limited by the quality and completeness of historical data, potentially introducing selection bias or confounding factors that were not fully captured. The definition of RVF, while clinically sound, can also vary slightly between studies, making direct comparisons challenging.1

Still, the consistent finding of modest discrimination across multiple established scores is telling. It suggests that the problem lies not just in the specific variables chosen for one score, but perhaps in the overall approach to risk stratification. The investigators themselves concluded that the discrimination of existing RVF scores remained modest. They specifically highlighted the need to refine models with contemporary hemodynamic and echocardiographic metrics. This implies that current scores may not fully capture the dynamic physiological changes that occur around LVAD implantation, or they may be missing key predictive variables that have emerged with advancements in imaging and monitoring technologies. For instance, advanced echocardiographic parameters like right ventricular global longitudinal strain or 3D echocardiography volumes could offer more nuanced insights into RV function than traditional 2D measurements.1

The call for rigorous external validation is also critical. Internal validation, as performed in this study, assesses a model's performance on new data from the same population used to develop the model. External validation, conversely, tests the model on an entirely independent dataset from a different population or institution. This is the gold standard for determining a score's generalizability and true clinical utility. Without it, even a moderately performing score might prove unreliable in a different clinical setting. The Oxford Handbook of Cardiology provides a concise overview of such risk stratification tools in contemporary practice, but the limitations highlighted here suggest a need for updated approaches.1

The implications for clinical practice are clear: while these scores can offer some guidance, they should not be the sole determinant for patient selection or pre-operative risk assessment. Clinicians must integrate these scores with a comprehensive clinical evaluation, including detailed hemodynamic assessment, advanced cardiac imaging, and expert multidisciplinary discussion. The current data suggest that relying too heavily on these scores could lead to both under- and over-estimation of RVF risk, potentially impacting patient outcomes. The next generation of risk prediction models will need to incorporate more sophisticated data points and undergo more stringent validation processes to truly improve patient care.1

CLINICAL IMPLICATIONS

The persistent inability of current risk scores to accurately predict right ventricular failure after LVAD implantation presents a significant challenge for clinicians. A C-statistic of 0.670 for the best-performing EUROMACS score is simply not good enough for definitive clinical decision-making. This means that despite our best efforts, a substantial proportion of patients at risk for RVF are still being missed, or conversely, patients who might tolerate an LVAD well are being unnecessarily excluded.

For surgeons and cardiologists, this necessitates a continued reliance on comprehensive clinical judgment, rather than algorithmic shortcuts. Pre-operative assessment must remain holistic, integrating all available hemodynamic, echocardiographic, and clinical data, alongside the imperfect scores. The data suggest that current models are not capturing the full complexity of RV physiology and its response to LVAD support.

> The industry developing these devices also faces a clear mandate: invest in research that refines predictive analytics. Integrating real-time hemodynamic data, advanced imaging, and perhaps even genetic markers into new models could yield more robust tools. Without better prediction, the morbidity and mortality associated with RVF will continue to temper the otherwise transformative benefits of LVAD therapy.
> Patients, meanwhile, must understand that while LVADs offer a lifeline, the journey is not without significant, and often unpredictable, risks. The current evidence means that even with careful selection, the risk of RVF remains a substantial concern, underscoring the need for vigilant post-operative monitoring and rapid intervention.

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REFERENCES

1. 1. Mortada I, Mhanna M, Gollapally Krishna SR. Performance of Risk Scores in Predicting Right Ventricular Failure After LVAD Implantation. Angiology. 2026.

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