The pitfalls of transcatheter tricuspid valve repair: what we have learned in our last decade of experience

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Once considered the "forgotten valve", the tricuspid valve has moved to the forefront of structural heart disease management. The development of transcatheter tricuspid valve interventions (TTVIs) has generated substantial enthusiasm, supported by promising registries and, more recently, randomized data. The TRILUMINATE Pivotal trial demonstrated that transcatheter edge-to-edge repair improves symptoms, functional status, and quality of life compared with medical therapy (1), while transcatheter replacement systems such as Evoque (2) and Lux (3) have achieved high procedural success and encouraging one-year outcomes. Real-world registries further confirm feasibility and safety across heterogeneous anatomies, albeit with variable clinical benefit (4). Despite more than a decade of clinical advances in this field, certain pitfalls remain. Unlike transcatheter therapies for the aortic or mitral valve, tricuspid repair is still evolving in the context of a heterogeneous patient population, challenging anatomy, and an incomplete understanding of long-term outcomes. Recurring pitfalls—relating to patient selection, imaging, device applicability, durability of benefit, and systems of care—continue to shape the field and demand careful reflection if we want to translate feasibility into durable population-level impact.

Late referral and suboptimal patient selection

The most consistent limitation of transcatheter tricuspid valve replacement (TTVR) remains the timing of intervention. Patients are often referred in advanced stages of right heart failure, with severe symptoms, hepatic or renal dysfunction, and poor overall prognosis. In this context, procedural success rarely translates into a meaningful survival benefit. While surgical dogma historically discouraged isolated tricuspid operations, transcatheter approaches provide an opportunity for earlier referral. Validated risk stratification tools, such as the TRI-SCORE (5), should not be viewed solely as predictors of procedural risk, but also as instruments to guide timing of referral and to identify patients in whom intervention is unlikely to meaningfully modify prognosis. In advanced stages of right heart failure—characterized by severe end-organ dysfunction, marked right ventricular remodeling, and limited physiological reserve—procedural success may translate into little or no clinical benefit, raising the issue of futility.

Contemporary screening cohorts have shown that a substantial proportion of patients evaluated for transcatheter tricuspid repair are excluded not only because of anatomical constraints, but also because of clinical futility, underscoring the importance of earlier referral before irreversible right-sided failure develops. In this context, systematic integration of risk scores into structured Heart Team discussions can help shift transcatheter tricuspid intervention from a "last-resort" strategy toward earlier, goal-directed intervention within a multidisciplinary framework (6).

Anatomical and imaging challenges

The tricuspid valve presents with remarkable anatomical variability: three or more leaflets, fragile tissue, frequent tethering, and annular dilation. Imaging this complex structure remains difficult. Advances in three-dimensional transesophageal echocardiography and cardiac computed

tomography (CT) have improved pre-procedural assessment, but large coaptation gaps and device-chordal interactions are frequently underestimated. Overreliance on suboptimal imaging, leading to device malposition or incomplete reduction of regurgitation, is a common mistake.

In parallel, several anatomical scoring systems have been proposed in an effort to standardize patient selection and procedural planning. Among these, the GLIDE score (7) represents an early attempt to provide a reproducible, anatomy-based framework to predict residual tricuspid regurgitation following transcatheter edge-to-edge repair and to guide selection between repair and replacement strategies. Importantly, such tools emphasize that procedural success is closely linked to leaflet morphology, coaptation gap, image quality, and jet location, reinforcing the need for rigorous multimodality imaging rather than a device-driven approach.

From a practical standpoint, a contemporary tricuspid program should rely on a multimodality imaging approach integrating three-dimensional transesophageal echocardiography for leaflet-level assessment, cardiac CT for annular sizing and spatial orientation, and the selective use of advanced intracardiac imaging, including four-dimensional (4D) intracardiac echocardiography, in complex anatomies or suboptimal echocardiographic windows. The absence of standardized imaging pathways across centers remains a major contributor to variable outcomes.

Device limitations and operator learning curve

Another reality of TTVI is that no single device can address the heterogeneous mechanisms of tricuspid regurgitation. Tricuspid transcatheter edge-to-edge repair (T-TEER) may be effective for central malcoaptation, but annular dilation, leaflet tethering, or pacemaker lead-related regurgitation often preclude optimal results. Annuloplasty technologies face their own anatomical and technical constraints, and early feasibility does not always translate into durable clinical adoption. The recent discontinuation of the Cardioband tricuspid annuloplasty system serves as a concrete reminder that procedural feasibility alone is insufficient if reproducibility, durability, and broad anatomical applicability cannot be achieved at scale. Replacement technologies are expanding rapidly, introducing additional technical considerations. Innovations in access routes, including transjugular delivery (8,9), may improve coaxiality and device positioning in selected anatomies, but also add complexity to procedural planning. These evolving technologies, combined with a steep learning curve, result in outcomes that remain highly dependent on operator and institutional experience. A common mistake is using available devices too confidently outside their optimal anatomical range, leading to only partial or temporary benefits.

Pacemaker leads and device-valve interactions

Pacemaker and defibrillator leads represent a frequent and often underestimated mechanism of tricuspid regurgitation, either through leaflet impingement, restricted motion, or progressive annular distortion. These patients are commonly poor candidates for transcatheter repair, and residual or recurrent regurgitation remains a concern. Recent data from TTVR cohorts demonstrate that right ventricular lead entrapment is common and generally well tolerated, with a low incidence of early clinically significant lead-related complications. However, non-negligible risks of delayed lead fracture, changes in pacing thresholds, or the need for subsequent lead revision have been reported. These findings highlight that lead management should not be considered a secondary technical issue, but rather an integral component of pre-procedural planning and lifetime management, requiring close collaboration between structural heart teams and electrophysiologists (10,11).

Uncertain long-term outcomes

To date, evidence for TTVR has primarily focused on procedural feasibility and symptomatic improvement. While these benefits are important, robust data on long-term survival, hospitalization, right ventricular remodeling, and end-organ function remain limited. Recently, two-year results from TRILUMINATE (12) demonstrated for the first time a quality-of-life improvement associated with a clear benefit in hospitalizations for heart failure and repeated TTVI. Nevertheless, real-world registries, including large contemporary datasets such as the TRIGISTRY (13), continue to report marked heterogeneity in clinical outcomes, with residual or recurrent tricuspid regurgitation and advanced baseline right ventricular dysfunction emerging as major drivers of limited benefit and reintervention. Defining the true prognostic impact of TTVR will require longer follow-up and more refined patient selection. Ongoing studies must address these knowledge gaps to define the true prognostic impact of TTVR.

Right ventricular function and post-procedural physiology

An important and often underappreciated pitfall in tricuspid intervention is insufficient attention to right ventricular function and post-procedural physiology. Baseline right ventricular dysfunction limits contractile reserve, and the risk of right ventricular-pulmonary circulation mismatch may substantially influence outcomes. In selected patients, particularly those undergoing replacement strategies, abrupt elimination of tricuspid regurgitation may unmask or exacerbate right ventricular failure. Incorporating systematic assessment of right ventricular function and reserve into procedural planning is therefore essential when choosing the timing and modality of intervention (14).

The need for multidisciplinary lifetime management

Finally, tricuspid valve disease cannot be viewed in isolation. It often arises in the setting of atrial fibrillation, pulmonary hypertension, left-sided valve disease, or device leads. Repair may be one step in a patient's lifetime journey, but not necessarily the final one. A tailored approach—where interventionists, surgeons, and heart failure specialists work independently—represents a major pitfall. The best outcomes undoubtedly result from accurate, multidisciplinary decision-making, where timing, modality (repair *vs.* replacement *vs.* surgery), and long-term surveillance are collectively planned. The tricuspid patient requires not just a procedure, but a strategy for lifetime management.

Transcatheter tricuspid valve repair represents one of the most exciting frontiers in structural cardiology, with the potential to transform outcomes for a historically neglected patient population. Yet, progress is tempered by recurring pitfalls, including late referral, anatomical complexity, device-specific limitations, uncertain long-term impact, and fragmented systems of care. Overcoming these challenges will require earlier recognition, refined imaging, tailored device selection, robust clinical trial evidence, and truly multidisciplinary lifetime management strategies.

The last decade has demonstrated that the tricuspid valve is no longer forgotten. The next decade must be remembered not for its challenges but for the tangible benefits conferred upon patients through thoughtful, evidence-based, and collaborative interventions.

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Footnote

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