Future Cardiology

ISSN: 1479-6678 (Print) 1744-8298 (Online) Journal homepage: www.tandfonline.com/journals/ifca20

Predicting adverse outcomes after cardiac surgery and structural interventions: the role of right ventricular function

Eszter Pál, Veronika Párkányi, Tímea Katalin Turschl, Alexandra Fábián, Andrea Ferencz, Márton Tokodi, Máté Tolvaj, Andrea Nagy, Attila Kovács, Béla Merkely, Bálint Károly Lakatos & Zsuzsanna Ladányi

To cite this article: Eszter Pál, Veronika Párkányi, Tímea Katalin Turschl, Alexandra Fábián, Andrea Ferencz, Márton Tokodi, Máté Tolvaj, Andrea Nagy, Attila Kovács, Béla Merkely, Bálint Károly Lakatos & Zsuzsanna Ladányi (2026) Predicting adverse outcomes after cardiac surgery and structural interventions: the role of right ventricular function, Future Cardiology, 22:4, 417-429, DOI: 10.1080/14796678.2026.2643096

To link to this article: https://doi.org/10.1080/14796678.2026.2643096

Published online: 25 Mar 2026.

FUTURE CARDIOLOGY
2026, VOL. 22, NO. 4, 417–429
https://doi.org/10.1080/14796678.2026.2643096

REVIEW

Predicting adverse outcomes after cardiac surgery and structural interventions: the role of right ventricular function

Eszter Pál*, Veronika Párkányi*, Tímea Katalin Turschl, Alexandra Fábián, Andrea Ferencz, Márton Tokodi, Máté Tolvaj, Andrea Nagy, Attila Kovács, Béla Merkely, Bálint Károly Lakatos and Zsuzsanna Ladányi

Department of Cardiology, Semmelweis University Heart and Vascular Center, Budapest, Hungary

ABSTRACT

Right ventricular (RV) function is a major determinant of clinical outcomes in patients undergoing cardiac surgery and transcatheter interventions. Although left ventricular morphology and function have been the traditional focus of preprocedural assessment, RV dysfunction is now recognized as an important predictor of morbidity and mortality. Therefore, inclusion of RV-related parameters in preprocedural risk assessment is on the rise. This review summarizes current evidence on the role of RV function in various cardiac diseases that require surgery or interventions. Conventional two-dimensional echocardiographic parameters, such as tricuspid annular plane systolic excursion, RV fractional area change, and peak systolic tissue Doppler velocity, provide limited information due to the complex RV geometry. Advanced imaging techniques, including speckle-tracking, three-dimensional echocardiography, and cardiac magnetic resonance imaging, enable more accurate quantification of RV volumes, ejection fraction, strain, RV motion components and RV-pulmonary artery coupling, and have demonstrated superior prognostic value. Therefore, a comprehensive assessment of RV function using advanced imaging techniques should be incorporated into routine clinical practice to improve risk stratification and preprocedural planning before cardiac surgery and transcatheter interventions. However, it is necessary to standardize imaging protocols and define validated reference thresholds to support the clinical implementation of these state-of-the-art parameters.

ARTICLE HISTORY
Received 31 October 2025
Accepted 6 March 2026

KEYWORDS
right ventricle; 3D echocardiography; strain analysis; cardiac surgery; transcatheter interventions; outcomes

PLAIN LANGUAGE SUMMARY

When people undergo heart surgery or minimally invasive procedures, doctors have traditionally focused on how well the left side of the heart works. However, strong evidence shows that the right heart is just as important for predicting recovery, complications and survival. If the right heart does not work properly, patients are more likely to experience complications. Right heart dysfunction can also reduce exercise capacity and quality of life, even when the left heart appears normal.

In everyday practice, right heart function is often assessed using simple ultrasound measurements. While these are quick and widely available, they only examine small parts of the right ventricle. Because the right ventricle has a complex shape, these basic measurements may miss important abnormalities. Newer imaging techniques allow doctors to assess the right ventricle more accurately. Many studies show that these advanced measurements predict complications and survival better than traditional methods.

Across a wide range of conditions, right heart function has proven to be a key determinant of complications and survival. Despite this, advanced right heart imaging is not yet used routinely everywhere, and standardized measurement guidelines are still evolving.

Overall, careful and modern assessment of right ventricular function can improve treatment planning. Therefore, it may lead to fewer complications and better survival after cardiac surgery.

1. Introduction

Cardiovascular morbidity and mortality are major challenges for the healthcare systems worldwide. With the constant expansion and refinement of pharmacological therapeutic options, robust improvements were achieved in the field [1–3]. Nevertheless, cardiac surgery still plays a major role in the treatment of a wide variety of cardiac disorders. However, transcatheter interventions are becoming progressively more common as they offer a generally safer alternative for elderly, fragile, multimorbid patients with high surgical risk. The assessment of cardiac morphology and function is important for preprocedural risk stratification in these patients. Traditionally, emphasis has been dominantly on left ventricular (LV) function, while the right ventricle (RV) was believed to be only a conduit between the venous system and the lungs [4,5]. Even in the era of evidence-based medicine, experimental studies concluded that RV function can be completely omitted without significant compromise of the circulation. However, contradictory evidence

CONTACT Zsuzsanna Ladányi lazsuzs9@gmail.com Department of Cardiology, Semmelweis University Heart and Vascular Center, Városmajor utca 68, Budapest 1122, Hungary
*Eszter Pál and Veronika Párkányi contributed equally as first authors.

Article highlights

- While left ventricular (LV) function has been the traditional focus of preoperative assessment, right ventricular (RV) dysfunction is strongly associated with the symptomatic status of patients in various cardiovascular diseases.
- Conventional 2D echocardiographic RV functional parameters, such as tricuspid annular plane systolic excursion (TAPSE), fractional area change (FAC), and tissue Doppler imaging (TDI) S,' are limited due to the complex geometry of the RV.
- Advanced imaging techniques, such as speckle-tracking, 3D echocardiography, and cardiac magnetic resonance imaging, enable more accurate quantification of RV volumes, ejection fraction (EF), strain and motion components.
- RV function is an important determinant of morbidity and mortality in patients undergoing cardiac surgery and transcatheter interventions.
- The comprehensive assessment of RV function using state-of-the-art modalities has additional value in risk stratification and preprocedural planning before cardiac surgery and transcatheter interventions.

has been rapidly accumulating, indicating that structural and functional alterations of the RV play an important role in determining symptoms, hemodynamic status, and long-term prognosis of these patients, as RV dysfunction is a major or even leading factor in a wide spectrum of cardiovascular diseases [6–8]. Beyond these hard endpoints, RV performance was also shown to be a determinant of quality of life and functional status in a wide variety of diseases [9–11]. Therefore, accurate characterization of the RV is of great importance for patients undergoing cardiac surgery or transcatheter interventions.

Echocardiography is the most commonly utilized imaging modality for quantifying cardiac morphology and function. Notably, the echocardiographic evaluation of RV function poses significant challenges due to the complex anatomy of the chamber, limiting the ability of two-dimensional (2D) echocardiography to fully characterize it. Still, in routine clinical practice, relatively simple echocardiographic functional parameters, such as tricuspid annular plane systolic excursion (TAPSE), right ventricular fractional area change (FAC), and peak systolic tissue Doppler velocity (TDI S'), are most frequently applied. However, being one- or two-dimensional measurements, they focus only on certain parts of the RV wall, and do not provide an adequate measure of global RV function [12]. Advances in cardiovascular imaging, such as speckle-tracking echocardiography analysis and three-dimensional (3D) echocardiography, allow a more comprehensive characterization of RV mechanics. RV global longitudinal strain (GLS), 3D echocardiography-derived RV ejection fraction (EF) and assessment of 3D RV mechanics provide added prognostic value in various cardiovascular diseases [13–17]. The development of deep-learning and artificial intelligence-based tools can also make the calculation of RV EF easier [18–20]. Additionally, RV myocardial work indices can also be calculated, and their association with contractility has been validated with invasive measurements. Thus, they can also provide valuable added information [21]. Specifically, in dedicated populations (e.g., congenital heart disease), cardiac magnetic resonance (CMR) imaging is also frequently used, further expanding the toolset for RV assessment. These modalities provide deeper pathophysiological understanding, prognostic information, and support individualized risk stratification [22–24] (Figure 1).

In the current era of cardiovascular surgery and catheter interventions, multidisciplinary Heart Teams consider the optimal treatment modality for each patient, based on many individual factors. As a major determinant of morbidity and mortality, RV imaging markers should also be incorporated into the decision-making process. Notably, the current guidelines lag in providing clear recommendations with disease-specific RV data. Therefore, this review aims to summarize the use of state-of-the-art imaging modalities for evaluating RV function in patients undergoing cardiac surgery and interventional procedures and to examine the association between RV dysfunction and adverse outcomes.

2. Right ventricular function in cardiac surgery and transcatheter interventions

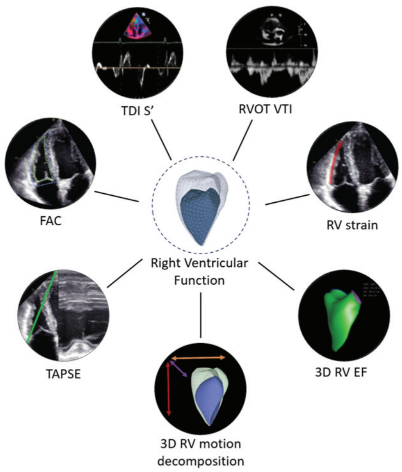
RV function has been increasingly investigated in recent years across a broad spectrum of cardiovascular diseases, with accumulating evidence supporting its expanding prognostic importance [25]. The summaries of the studies discussed below are presented in Table 1.

2.1. Valvular heart disease

2.1.1. Aortic valve diseases

Diseases of the aortic valve initially affect the LV; however, if left untreated, the progressively worsening diastolic dysfunction and elevated LV filling pressures ultimately lead to adverse pulmonary vascular remodeling along with consequential RV hemodynamic overload and dysfunction.

2.1.1.1. Aortic stenosis. Currently affecting more than 9 million people in developed nations, severe aortic stenosis (AS) is the most common valvular heart disease, and its prevalence is expected to increase as populations age [26]. RV dysfunction in AS has gained increasing attention in recent years. Although the primary lesion is located in the left heart, chronic pressure overload and secondary pulmonary hypertension can significantly affect the RV, resulting in a decreased 3D RV EF [27]. The classification of this extravalvular cardiopulmonary damage into distinct stages has proved to have additional prognostic value in this clinically complex population [28]. Compromised RV function has been associated with higher mortality and adverse outcomes following both surgical and transcatheter aortic valve replacement. Bohbot and colleagues found that TAPSE <17 mm was predictive of all-cause mortality after surgical aortic valve replacement (SAVR) even in asymptomatic patients with severe AS [29]. Nabeshima et al. found that reduced 3D RV EF was associated with adverse cardiac events even in asymptomatic patients with AS. In a large cohort of 392 asymptomatic individuals, the prognostic cutoff for RV EF was approximately 41% [30]. Complementing these findings, Nies and colleagues studied 114 patients with paradoxical low-flow, low-gradient AS



Parameter of right ventricular function	Advantages	Disadvantages
TAPSE	• Easy to measure • Highly feasible • Its decrease predicts hard endpoints well	• Only measures longitudinal function • Heavily preload dependent • Decreases after cardiac surgery without disfunction
FAC	• Represents longitudinal and radial function • Good correlation with MRI • Better for postoperative assessments than TAPSE	• Needs to be measured in a standardized plane • Moderate feasibility • Poor reproducibility
TDI S'	• Good feasibility • More sophisticated measure of longitudinal function • Valuable in total intravenous anesthesia	• Only measures longitudinal function • Angle dependent • Initially always decreases after cardiac surgery
RVOT VTI	• Indirect marker of the stroke volume • Precisely measurable • Valuable in mechanical circulatory support	• No direct information on global function • In many patients somewhat less clinically relevant
RV strain	• Semi-automated • Additional prognostic value • Measures deformation, not motion	• Usually only longitudinal strain components are measured • Requires better image quality
3D RV EF	• Measures global function • Semi-automated • Additional prognostic value	• Requires better image quality • Can only be measured using 3D measurements • Limited general availability
3D RV motion decomposition	• Measures longitudinal, radial and anteroposterior motion components • Semi-automated • Additional prognostic value	• Requires better image quality • Can only be measured using 3D measurements • Limited general availability

Figure 1. The echocardiographic parameters of right ventricular (RV) function.

The echocardiographic evaluation of RV function presents significant challenges due to the complex anatomy of the chamber; thus, numerous parameters are used for its assessment, such as: tricuspid annular plane systolic excursion (TAPSE), fractional area change (FAC), tissue Doppler velocity S' (TDI S'), RV outflow tract velocity time integral (RVOT VTI), RV strain [including global longitudinal strain (GLS) and free-wall longitudinal strain (FWLS)], three-dimensional RV ejection fraction (3D RV EF) and RV motion decomposition. Each of these parameters has different advantages and disadvantages in practice.

undergoing transcatheter aortic valve replacement (TAVR) and demonstrated that impaired RV-pulmonary artery (PA) coupling strongly predicted adverse outcomes. Specifically, a TAPSE/systolic pulmonary artery pressure (sPAP) ratio <0.36 mm/mmHg identified patients at higher risk of mortality and heart failure hospitalization after valvular intervention, and RV–PA coupling remained an independent prognostic factor after multivariable adjustment [31]. In line with these observations, Kitano and coworkers found that in patients with severe AS undergoing TAVR, RV dysfunction assessed by 3D echocardiographic strain is a powerful predictor of outcome. Among 341 patients, about 30% had impaired RV strain prior to intervention, and this subgroup faced higher risks of mortality and heart failure hospitalization after the procedure. The prognostic impact of RV strain was independent of LV function and outperformed conventional RV parameters, underscoring the importance of advanced RV measurements in risk stratification [32].

Altogether, advanced assessment of RV function has emerged as a useful tool for prognostic evaluation in AS. As echocardiography is the gold standard diagnostic method of AS, a detailed examination is performed before valve replacement. In this population, even routine measurements (e.g., TAPSE) show meaningful prognostic value, but evidence also supports the role of RV strain measures.

2.1.1.2. Aortic regurgitation. In aortic regurgitation (AR), chronic LV volume overload also often extends its impact to the RV. Current evidence supports the prognostic importance of RV dysfunction in this population. Mao and colleagues, in a large cohort of 648 patients undergoing TAVR for AR, demonstrated that preexisting RV dysfunction (characterized as FAC < 35%, TAPSE < 1.7 cm and TDI S' < 9.5 cm/s; if >50% of the available RV function parameters were below the lower threshold, RV dysfunction was established) independently predicted two-year all-cause mortality. These results emphasize the importance of systematic RV evaluation in AR, as dysfunction can serve as an early marker of adverse outcomes even after a successful valvular intervention [33].

To conclude, data on the role of RV in preprocedural risk assessment in AR are scarcer compared to stenosis. Also, as dedicated transcatheter solutions for AR were only recently introduced, RV-related data are currently lacking in this regard. However, literature emphasizes the importance of multiparametric assessment of RV function in AR, as the combination of multiple conventional parameters (e.g., TAPSE, FAC, TDI S') showed good association with hard endpoints.

2.1.2. Mitral valve disease

Mitral valve disease is among the most common valvular disorders, with the different degrees of mitral regurgitation (MR) alone affecting nearly 24 million individuals worldwide [26]. Given its high prevalence and clinical burden, mitral valve disease accounts for a significant number of surgical procedures and transcatheter interventions performed each year [34]. Notably, LV backward failure commonly affects RV hemodynamics in these patients. Moreover, the etiology of mitral valve disease is often also presented on the contralateral atrioventricular valve, leading to RV overload directly due to the tricuspid valve dysfunction.

2.1.2.1. Mitral regurgitation. In patients with secondary MR, RV strain parameters have been identified as sensitive predictors of outcome. In a cohort of 142 patients undergoing transcatheter edge-to-edge repair (TEER), Lupi and colleagues found that impaired right ventricular free wall longitudinal strain (RV FWLS) (≥−18%) and RV GLS (≥−15%) were strongly associated with the composite endpoint of all-cause mortality and heart failure hospitalization at 1 year. Compared with conventional RV parameters such as TAPSE and FAC, strain

Table 1. The prognostic value of right ventricular functional parameters.

	Publication	Studied population	Right ventricular parameters	Endpoint	HR/OR
VALVULAR HEART DISEASES	Genereux et al. [28]	SVAR or TAVR n = 1661	RV damage as Stage 4	1-year all- cause mortality after aortic valve replacement	HR 1.46 [CI 1.27–1.67]
	Bohbot et al. [29]	AS AVA <1.3 cm2 n = 2181	TAPSE	All-cause mortality during follow up	TAPSE <17 mm HR 1.55 [CI 1.21–1.97]
	Nabeshima et al. [30]	Asymptomatic AS n = 392	3D RV EF, FAC, RV FWLS, RV GLS	Future cardiac events during median follow up of 27 months	3D RV EF HR 0.891 [CI 0.864–0.917], FAC HR 0.916 [CI 0.884-0.949], RV FWLS HR 0.887 [CI 0.841- 0.963], RV GLS HR 0.820 [CI 0.765- 0.880]
	Nies et al. [31]	pLFLG AS (paradoxical low-flow, low-gradiant aortic stenosis) n = 114	TAPSE/sPAP ratio, FAC, sPAP	All-cause mortality after TAVR	TAPSE/sPAP HR 0.077 [CI 0.009–0.666], FAC HR 0.957 [CI 0.923- 0.993], sPAP HR 1.023 [CI 1.004–1.043]
	Kitano et al. [32]	Patients with cardiac diseases n = 341	3D RV EF, RV GLS, RV GCS, RV GAS, TAPSE	Composit cardiac events (cardiac death, heart failure hospitalization, ventricular tachyarrhythmia) during median 20 month follow up	RV EF <30% HR 4.32 [CI 2.03- 9.22], RV GCS <19% HR 2.40 [CI 1.22- 4.73], RV GLS <15% HR 3.61 [CI 1.70- 7.67], RV GAS <30% HR 3.37 [CI 1.59- 7.16], TAPSE <17 mm HR 2.16 [CI 1.08- 4.30]
	Mao et al. [33]	AR undergoing TAVR n = 648	TAPSE	2-year all-cause mortality	HR 0.553 [CI 0.338- 0.905]
	Lupi et al. [35]	Severe MR undergoing TEER n = 142	RV FWLS, RV GLS, FAC	Composite endpoint: all-cause mortality or heart failure hospitalization at 1-year follow up	RV FWLS HR 1.24 [CI 1.15–1.33], RV FWLS >−18% HR 5.34 [CI 2.75–10.4], RV GLS HR 1.049 [CI 1.017–1.082], RV GLS > −15% HR 3.06 [CI 1.6–5.84], FAC HR 0.96 [CI 0.92–0.99]
	Lachmann et al. [36]	Severe MR undergoing TEER n = 1154	Deep-learning predicted RV EF, TAPSE, FAC, RV FWLS	1-year all-cause mortality after TEER	RV EF HR 0.687 [CI 0.642- 0.731], TAPSE HR 0.625 [CI 0.576-0.674], FAC HR 0.577 [CI 0.521- 0.633], RV FWLS HR 0.637 [CI 0.566–0.708]
	Tokodi et al. [38]	Open heart mitral valve replacement/repair n = 42	LEF, 3D RV GLS, RV FWLS	Identification of patients at risk for early post-operative RV dysfunction	Preop. LEF OR 1.33 [CI 1.08–1.77], preop. 3D RV GLS OR 0.82 [CI 0.68–0.94]
	Shechter et al. [39]	MR undergoing TEER n = 707	TAPSE/sPAP ratio	Composite endpoint: all-cause mortality or heart failure hospitalization at 1-year follow up	Lower TAPSE/sPAP ratio (<0.37 mm/mmHg) HR 2.84 [CI 1.09–7.43]
	Ladányi et al. [44]	Secondary TR n = 205	RV EF	Composite endpoint: heart failure hospitalization and all-cause mortality	HR 0.98 [CI 0.961–1.000]
	Ancona et al. [45]	Isolated TV surgery n = 79	RV FWLS	30-day mortality	HR 0.83 [CI 0.73–0.94], AUC 0.833 [CI 0.72–0.95]
	Kim et al. [46]	Isolated TV surgery severe TR n = 111	RV GLS	Composite endpoint: cardiovascular mortality, heart failure hospitalization, reoperation or transplantation	Preop HR 0.86 [CI 0.79–0.93]. postop HR 0.89 [CI 0.82–0.96]
	Kim M et al. [47]	Isolated TV surgery for severe tricuspid regurgitation n = 115	RV FWSL	5-year composite of cardiac death or unplanned, cardiovascular -related rehospitalization	Absolute preop. RV FWLS <24% HR 2.30 [CI 1.22–4.36]
	Kresoja et al. [48]	Severe TR TTVR n = 79	RV EF	Composite endpoint: all-cause mortality or heart failure hospitalization	HR 6.62 [CI 2.77–15.77]
	von Bardeleben et al. [49]	Moderate-to-severe or severe tricuspid regurgitation undergoing TriClip n = 85	TAPSE	Composite endpoint: mortality, heart failure hospitalization	HR 7.19 [CI 1.44–35.9]
	Orban et al. [50]	Severe TR TTVR n = 75	RV EF	All-cause mortality at the 1-year follow-up	HR 0.18

(Continued)

Table 1. (Continued).

	Publication	Studied population	Right ventricular parameters	Endpoint	HR/OR
CORONARY ARTERY BYPASS GRAFT SURGERY	Keller et al. [25]	Cardiac surgery including on and off pump CABG n = 439 retrospective, n = 128 prospective	RV GLS, RV GCS, RV GAS, RV EF, LEF, AEF, REF	Primary: in hospital mortality, ECLS secondary: prolonged mechanical ventilation exceeding 48 hours, need for inotropic support 12 hours after surgery, acute kidney injury	RV GLS cutoff: −17.4%, retrospective cohort: OR 3.35 [CI 2.06–5.46], prospective cohort: OR 3.00 [CI 1.17–7.69]
	Keller et al. [54]	Mixed cardiac surgery n = 496	RV GLS	Primary: in hospital mortality, ECLS secondary: prolonged mechanical ventilation exceeding 48 hours	Primary: OR 1.15 [CI 1.07–1.25]
	Keller et al. [55]	Mixed cardiac surgery n = 357	Inflow RV EF, inflow rel. SV, apex rel. SV, apex to inflow relative stroke volume ratio	In-hospital mortality or the need for extracorporeal circulatory support	Inflow RVEF OR 0.95 [CI 0.92–0.99], inflow rel. SV OR 0.94 [CI 0.90–0.99], apex rel. SV OR 1.07 [CI 1.02–1.13] and apex to inflow rel. SV ratio OR 5.81 [CI 1.90–17.77]
CONGENITAL HEART DISEASES	van Grootel et al. [57]	Repaired Tetralogy of Fallot n = 151	RV FWLS	Primary: mortality or heart failure, secondary: death, heart failure, arrhythmia, reintervention or hospitalization for cardiac reasons	Primary: 0.34 [CI 0.20–0.58] secondary: 0.63 [CI 0.49–0.84]
	Knauth et al. [58]	Repaired Tetralogy of Fallot n = 88	RV size and systolic function measured by CMR	Composite endpoint: all-cause mortality, sustained ventricular tachycardia, and progression of heart failure	RV end-diastolic volume Z> or =7 OR = 4.55 [CI 1.10–18.8] RV EF <45% OR = 5.6 [CI 1.47–21.2]
	Surkova et al. [60]	Systemic RV n = 38	GCW, GWI	Composite endpoint: all-cause mortality or heart transplantation	GCW HR 0.995 [CI 0.992–0.998], GWI HR 0.995 [CI 0.991–0.998]
	Egbe et al. [61]	Congenitally corrected transposition of the great arteries n = 233	RV GLS	Composite end point of heart failure hospitalization, heart transplant and cardiovascular death	HR 0.90 [CI 0.84–0.92]
	Diller et al. [62]	Systemic RV n = 129 n = 87 with TGA after atrial switch + n = 42 with congenitally corrected TGA and n = 38 healthy controls	Systemic RV 2D longitudinal strain	Composite end point: symptomatic progression to New York Heart Association class ≥ 3, clinically relevant cardiac arrhythmia or death	HR 1.31
	Alsaied et al. [63]	Cone operation for Ebstein's anomaly n = 26	RV EF	Early postoperative RV dysfunction (moderate/ severe) assessed by echocardiography at discharge	Preoperative RV ejection fraction (per 5% increase) OR 0.61 [CI 0.48–0.76]
HEART TRANSPLANTATION	Li et al. [68]	HTX n = 155	3D RV FWLS, RV EF, 2D RV FWLS, TAPSE	Composite endpoint: allcause mortality and major adverse cardiac events	3D RV FWLS HR 0.24 [CI 0.13–0.44], RV EF HR 0.82 [CI 0.68–0.99], 2D RV FWLS HR 0.84 [CI 0.71–0.99], TAPSE HR 0.78 [CI 0.63–0.97]
MECHANICAL CIRCULATORY SUPPORT	Rapis et al. [72]	Impella support patients n = 41	RV FWLS	Successful weaning from Impella support	OR 1.358 [CI 1.078- 1.810]
	Puerto et al. [73]	VA-ECMO patients n = 87	RV dysfunction	Successful decannulation	Absence of RV dysfunction OR 14.7 [CI 13.3–140.3], absence of RV dysfunction in the last day of support OR 9.5 [CI 1.6–54], partial recovery OR 6.2 [CI 1.7–22.4], RV systolic dysfunction OR 0.2 [CI 0.1–0.9]
	Huang et al. [74]	VA-ECMO patients n = 46	3D RV EF	All-cause mortality in 30 days	RV EF <24.6% HR 15.86 [CI 3.56–70.73]

Several RV functional parameters have prognostic power in patients undergoing cardiac surgery or structural intervention. In aortic valve diseases, even simpler parameters like TAPSE can have additional value, as well as the more sophisticated strain- and 3D measures. In mitral valve disease several parameters have prognostic value, suggestion a more comprehensive evaluation of the RV. In tricuspid valve disease mostly strain and RV RF values are valuable. In coronary artery bypass graft surgery patients mostly strain- and advanced motion decomposition parameters have additional value. In congenital heart disease patients mostly RV EF, strain- and myocardial work parameters have prognostic value. In heart transplantation patients besides RV EF, interestingly parameters examining longitudinal function, including TAPSE and RV FWLS, emerged with prognostic value. In the complex population receiving mechanical circulatory support, mostly more advanced measurements of the RV, including RV FWLS and RV EF, show prognostic value.

Abbreviations: HR – hazard ratio, OR – odds ratio, SAVR – surgical aortic valve replacement, TAVR – transcatheter aortic valve replacement, RV – right ventricle, CI – confidence interval, AS – aortic stenosis, AVA – aortic valve area, TAPSE – tricuspid annular plane systolic excursion, 3D – three-dimensional, EF – ejection fraction, FAC – fractional area change, FWLS – free wall longitudinal strain, GLS – global longitudinal strain, pLFLG – paradoxical low-flow, low-gradient, sPAP – systolic pulmonary artery pressure, GCS – global circumferential strain, GAS – global area strain, AR – aortic regurgitation, MR – mitral regurgitation, TEER – transcatheter edge-to-edge repair, LEF – longitudinal ejection fraction, TR – tricuspid regurgitation, TV – tricuspid valve, AUC – area under the curve, TTVR – transcatheter tricuspid valve replacement, CABG – coronary artery bypass grafting, AEF – atrial ejection fraction, REF – right atrial ejection fraction, ECLS – extracorporeal life support, SV – stroke volume, CMR – cardiac magnetic resonance, GCW – global constructive work, GWI – global work index, 2D – two-dimensional, TGA – transposition of the great arteries, HTX – heart transplantation, VA ECMO – veno-arterial extracorporeal membrane oxygenation.

analysis revealed a stronger association with clinical outcomes [35]. The study of Lachmann et al. enrolled 1154 patients with severe MR undergoing TEER and calculated RV EF using a deep-learning-based method. Survival analysis showed that patients with RV EF <45% had significantly worse 1-year survival rates than patients with preserved RV EF [36]. Fortmeier et al. found in a population of 851 patients who underwent TEER due to severe MR that, while yielding important benefits for LV hemodynamics, the procedure did not result in RV functional recovery at a 3-month follow-up echocardiography exam, neither by measuring traditional parameters, such as TAPSE, nor by employing artificial intelligence predicted RV EF [37].

Beyond TEER populations, advanced imaging has also provided important insights into perioperative RV adaptation in open-heart mitral valve surgery. In a prospective study of 42 patients undergoing mitral valve replacement, Tokodi and colleagues used 3D echocardiography to decompose RV EF into longitudinal and radial components. They observed a transient postoperative shift from longitudinal to radial contraction, which normalized within 6 months. From a clinical perspective, the preoperative longitudinal ejection fraction was an independent predictor of early postoperative RV dysfunction, suggesting that 3D RV mechanics may not only capture perioperative adaptation but also identify patients at risk for acute RV failure [38]. To further emphasize the importance of the right heart in this population, in a large, single-center study of more than 700 patients, Shechter and colleagues confirmed the prognostic importance of RV – PA coupling, quantified by the TAPSE/sPAP ratio. A baseline ratio below 0.37 mm/mmHg was associated with significantly higher mortality and rehospitalization rates [39].

These studies highlight that modern echocardiographic modalities provide clinically relevant prognostic information in secondary MR, emphasizing the need for detailed RV assessment prior to mitral interventions as RV overload plays an important role in symptomatic status, pathophysiology and outcomes of MR [40]. Given that 3D echocardiographic assessment is necessary before TEER, 3D RV EF (which outperforms conventional functional measures in predicting clinical outcomes) should be easily incorporated into routine preprocedural assessment.

2.1.2.2. Mitral stenosis. As the incidence of mitral stenosis (MS) has decreased dramatically over the past few decades, data on the role of the RV in these patients are scarcer. In a recent study, Ladányi and colleagues used 3D echocardiography to assess the impact of MS on RV mechanics in 39 MS patients compared with 39 matched controls. They found that MS significantly impairs global RV function, with reduced RV EF and decreased longitudinal and radial motion components, while the relative contribution of the anteroposterior motion component increased. The presence of atrial fibrillation further worsened RV function. These observations highlight that MS induces complex RV mechanical alterations even at an early stage, which may remain undetected by conventional echocardiography [41]. Additionally, Kumar et al. found that in patients undergoing balloon mitral valvuloplasty TAPSE, FAC, global RV systolic strain, and segmental strain at basal, mid and apical septum showed a statistically significant rise after balloon mitral valvuloplasty [42].

With the increasing implementation of advanced cardiac imaging and interventions in developing countries, we may expect expanding data on the role of the RV in patients with MS.

2.1.3. Tricuspid regurgitation

For a long time, tricuspid regurgitation (TR) was considered less important than left-sided valvular diseases. However, the latest studies identified that TR has a significant impact on morbidity and mortality [43]. A study of 205 secondary TR patients showed that people with different TR severity did not differ in global 3D RV EF; however, the longitudinal motion component decreased with regurgitation severity. Interestingly, however, the radial motion component showed association with the composite endpoint of heart failure hospitalization and all-cause mortality [44]. Traditionally, surgical intervention – valve repair or replacement – has been the standard treatment for severe TR. Nevertheless, it carries a relatively high perioperative risk, and in recent years transcatheter interventions have emerged as less invasive alternatives for treating symptomatic severe TR in high-risk patients. Ancona et al. retrospectively analyzed 79 patients undergoing isolated tricuspid valve surgery and found that RV FWLS was the strongest predictor of 30-day mortality, outperforming conventional echocardiographic measures. Incorporating RV FWLS into risk scores improved prognostic accuracy, highlighting its potential role in preoperative risk stratification and perioperative management [45]. Kim et al. retrospectively analyzed 111 patients with severe isolated TR undergoing tricuspid valve surgery. Impaired RV and biventricular GLS, measured pre- and postoperatively by speckle-tracking echocardiography, were independently associated with adverse outcomes, including death, heart failure hospitalization, reoperation, or transplantation. RV GLS <17.2% and biventricular GLS <34.0% identified high-risk patients, demonstrating that strain assessment provides incremental prognostic value beyond conventional echocardiographic parameters [46]. In patients undergoing TEER for TR, early RV reverse remodeling has been observed, characterized by significant reductions in RV end-diastolic area and tricuspid annular diameter. Although conventional RV echocardiographic parameters, such as TAPSE and FAC, illustrated minimal change following the intervention, RV–PA coupling, assessed by the TAPSE/sPAP ratio, improved significantly. Better RV–PA coupling was correlated with favorable clinical outcomes, including symptomatic improvement and reduced heart failure-related events [47]. Kresoja and colleagues studied right ventricular contraction patterns in patients undergoing transcatheter tricuspid valve repair for severe TR using CMR. Preserved or compensated RV function was associated with favorable outcomes, while reduced longitudinal and global RV function predicted more frequent adverse events, highlighting the potential importance and prognostic value of assessing the RV contraction pattern [48]. The TRILUMINATE study showed that TEER with the TriClip device led to reverse remodeling due to the decreasing volumetric overload on the RV; RV end-diastolic diameter, TAPSE and FAC all improved after the structural intervention [49]. Orban and his colleagues included 75 patients with severe TR who underwent TEER. RV function was assessed using 3D echocardiography before and after the procedure. Although RV volumes decreased after the procedure, 3D RV EF also declined. Importantly, lower preprocedural 3D RV EF was independently associated with higher 1-year mortality, while conventional RV functional parameters, e.g., TAPSE, did not have significant prognostic value in this population. The postprocedural RV EF reduction did not predict poor outcomes and was likely due to reduced preload [50].

With the rapidly accumulating evidence in the field, precise recommendations for TEER for TR can be expected in the near future, with a strong emphasis on advanced RV imaging markers. Similarly to TEER for MR, 3D echocardiography is also necessary during preprocedural assessment in this population, so the results emphasizing the value of strain analysis and 3D RV EF in patient selection and risk stratification before TEER could be incorporated into routine practice with ease.

2.2. Coronary artery bypass graft surgery

Coronary artery bypass graft surgery (CABG) is the most commonly performed cardiac surgical procedure worldwide [51]. Notably, the involvement of the RV is also important in ischemic heart disease [52].

In a study of 140 CABG patients, Liu et al. found that intraoperative TAPSE measured by transesophageal echocardiography was not an independent predictor of postoperative acute kidney injury [53]. The study of Keller et al. contained various cardiac surgery patients, including on- and off-pump CABG patients. 3D RV GLS, measured by 3D transesophageal echocardiography, was an independent predictor of adverse postoperative outcomes. The composite endpoint included in-hospital mortality, the need for veno-arterial extracorporeal life support, prolonged mechanical ventilation exceeding 48 h, the need for inotropic support 12 h after surgery, and/or acute kidney injury, characterized by a serum creatinine increase of >0.3 mg/dl within the first 2 days of intensive-care unit (ICU) admission or the initiation of renal replacement therapy during the ICU stay [25]. In another study, 3D RV GLS measured by 3D transesophageal echocardiography was independently associated with the primary endpoint of in-hospital death or the need for extracorporeal life support in patients undergoing mixed cardiac procedures, typically consisting of CABG and concomitant valve surgery. In contrast, TAPSE, FAC, or even 3D RV EF or LV functional parameters, such as 3D LV EF or LV GLS, did not show any association with the outcome [54]. The same research group showed in a mixed cardiac surgery population that 3D RV motion decomposition of transesophageal echocardiography-based acquisitions also carries significant prognostic value. Inflow RV EF, inflow relative stroke volume, apex relative stroke volume and apex to inflow relative stroke volume ratio were significantly associated with the composite endpoint of in-hospital mortality and need for extracorporeal circulatory support using univariable Cox analysis [55].

These studies suggest that conventional measures of RV function are severely limited in CABG patients, and 3D RV measures (strain and motion decomposition) show the strongest association with outcomes. This supports the integration of 3D echocardiography into preoperative assessment.

2.3. Congenital heart disease

It is widely recognized that in congenital heart disease, RV dysfunction frequently emerges as the strongest predictor of disease progression and clinical outcomes [8,14]. This population is characterized by highly diverse disruption of normal cardiac anatomy, resulting in a wide range of RV morphology and mechanics.

2.3.1. Tetralogy of Fallot

Bidviene et al. showed on a cohort of 33 repaired Tetralogy of Fallot patients and 30 age- and sex-matched controls that in repaired Tetralogy of Fallot patients with severe pulmonary regurgitation, 3D RV EF is lower and the chronic volume overload mainly impaired the longitudinal motion component of the RV function. In contrast, the radial and anteroposterior components were similar to controls [56]. In a cohort of 151 adults with surgically corrected Tetralogy of Fallot, van Grootel et al. demonstrated that RV FWLS assessed by 2D speckle-tracking echocardiography independently predicted adverse clinical outcomes, such as sustained ventricular tachycardia or resuscitated cardiac arrest, sudden cardiac death, hospitalization due to heart failure, pulmonary valve replacement performed for clinical reasons, cardiac transplantation, or implantation of an implantable cardioverter defibrillator for secondary prevention, over a median follow-up of 71.5 months. RV FWLS was significantly associated with the composite endpoint of all-cause mortality and heart failure, even after adjustment for conventional risk markers, including LV EF and LV GLS. In particular, RV FWLS provided incremental prognostic information beyond standard echocardiographic parameters, such as RV FAC. These findings highlight the clinical relevance of RV myocardial deformation analysis in long-term risk stratification and follow-up of adults with repaired Tetralogy of Fallot [57]. In a cohort of 88 adult patients late after surgical repair of Tetralogy of Fallot, Knauth et al. confirmed that RV size and systolic function, as measured by CMR, are independent predictors of major adverse clinical outcomes, including all-cause mortality, sustained ventricular tachycardia, and progression of heart failure. Specifically, an indexed RV end-diastolic volume Z-score ≥7 was associated with a significantly increased risk of adverse events. Furthermore, RV EF below 45% independently predicted poor prognosis, even after adjustment for LV function and QRS duration. These findings emphasize the critical role of comprehensive RV volumetric and functional assessment by CMR in the long-term risk stratification and management of patients following Tetralogy of Fallot repair, supporting its use for timely intervention decisions, such as pulmonary valve replacement or arrhythmia monitoring [58].

2.3.2. Systemic RV

Undoubtedly, systemic RV patients are a highly specific subgroup, in which RV morphological and functional assessments require a completely different approach. Still, they represent a clinically important group with a considerable body of data on the matter. Surkova et al. investigated 38 systemic RV patients with transposition of great arteries post-atrial switch operation and with congenitally corrected transposition of the great arteries. Systemic RV EF showed correlation with B-type natriuretic peptide (BNP) levels. In patients with transposition of the great arteries, the anteroposterior motion component of the RV was significantly greater than the longitudinal and radial components [59]. In another study, myocardial work indices, including Global Myocardial Work Index (GWI) and Global Constructive Work (GCW), were evaluated as novel load-adjusted measures of systemic RV function. Both indices showed strong correlations with ejection fraction and BNP levels and were significantly lower in patients with moderate or severe TR. Importantly, reduced GWI and GCW values were independently associated with adverse clinical outcomes, such as death or heart transplantation, suggesting that myocardial work analysis may provide incremental prognostic information beyond conventional strain parameters [60]. In a retrospective study of 233 adult patients with congenitally corrected transposition of the great arteries, transthoracic echocardiography, including strain analysis, was used to estimate cardiac remodeling and predict cardiovascular outcomes. Systemic RV was highly prevalent in the cohort (61% of the patients). RV GLS was independently associated with adverse events, including heart failure and cardiovascular death [61]. The study of Diller et al. investigated systemic RV function using 2D peak longitudinal strain in adult patients with congenitally corrected transposition of the great arteries. RV longitudinal strain was significantly reduced compared to healthy controls, reflecting impaired systemic RV systolic function. Furthermore, systemic RV longitudinal strain is correlated with subpulmonary ventricular function, indicating ventricular interdependence in this population. Importantly, reduced RV longitudinal strain was independently associated with adverse clinical outcomes, including heart failure and arrhythmias. These results support the use of systemic RV longitudinal strain as a sensitive marker of ventricular dysfunction and a predictor of prognosis in adult patients with congenitally corrected transposition of the great arteries [62].

2.3.3. Ebstein's anomaly

In a cohort of 26 Ebstein's anomaly patients undergoing the Da Silva cone operation, reduced preoperative RV EF (<35%) measured by CMR was independently associated with moderate-to-severe RV dysfunction at discharge. Importantly, it was also linked to greater postoperative inotropic support and prolonged ICU stay. The findings highlight the prognostic utility of preoperative CMR in surgical planning and perioperative risk stratification [63]. In the study of Yu et al. assessing patients after tricuspid valve repair in Ebstein's anomaly, both RV and right atrial volumes decreased markedly after surgery and remained reduced at mid-term follow-up. While RV EF initially declined postoperatively, partial recovery was observed over time. However, RV GLS and right atrial reservoir strain were significantly impaired immediately and mid-term after surgery. Importantly, baseline features such as smaller RV and right atrial volumes, higher LV EF, and preserved right atrial reservoir strain were associated with favorable RV volume normalization after surgery [64].

2.3.4. Atrial septal defect

Percutaneous atrial septal defect closure induces marked remodeling of the RV, evidenced by significant reductions in RV end-diastolic volume and improvements in RV myocardial deformation parameters, particularly RV GLS. Post-procedural increases in RV GLS reflect enhanced myocardial contractility and improved RV systolic performance. These echocardiographic improvements correlate with favorable clinical outcomes, including improved functional status and exercise capacity [65].

2.3.5. Pulmonary outflow tract dysfunction

Transcatheter pulmonary valve replacement is a minimally invasive procedure for the treatment of RV outflow tract (RVOT) dysfunction in surgically repaired congenital heart diseases. Transcatheter pulmonary valve replacement is performed in these patients to avoid the high risk and complexity of repeat surgeries. Evidence suggests that RV GLS and RV FWLS are more sensitive than conventional parameters, such as TAPSE or RV FAC, in detecting early RV functional improvement after transcatheter pulmonary valve replacement. RV GLS and RV FWLS typically improve within 6 months after the procedure. However, no current evidence supports their predictive value for adverse outcomes, such as re-intervention or persistent RV dysfunction [66].

As one of the "earliest adopters" of RV-focused imaging, specialists in congenital heart diseases constantly expand the field's data. Growing evidence suggests that advanced RV metrics (e.g., strain parameters and 3D RV EF) consistently outperform conventional measures in their association with clinical outcomes. Therefore, their incorporation into the preoperative assessment of this special and complex population could hold additional value.

2.4. Heart transplantation

Heart transplantation (HTX) remains the gold standard treatment for end-stage heart failure, yet long-term survival is often limited by complications such as rejection and graft dysfunction. The evaluation of RV function is a cornerstone in post-transplant follow-up, as RV failure is still one of the major determinants of cardiac complications and mortality during the early postoperative period [67]. Conventional parameters, such as TAPSE and RV FAC, are widely used; though they lack sufficient sensitivity to detect changes, especially the decrease in RV function. Advanced modalities, including speckle-tracking-derived strain and 3D echocardiography, may facilitate earlier detection of myocardial dysfunction and support more accurate long-term risk prediction.

3D RV FWLS measured by speckle-tracking echocardiography was shown to be an independent prognostic marker in adult heart transplant recipients. In a prospective cohort of 155 patients, reduced 3D RV FWLS values were significantly associated with adverse clinical outcomes at a median follow-up of 34 months. Notably, other RV parameters, such as impaired 2D RV FWLS and reduced RV EF, were also linked to worse prognosis, highlighting the central role of RV function in post-transplant risk assessment [68]. Lakatos et al., using 3D echocardiography in heart transplant recipients, demonstrated that radial motion of the RV-free wall plays a dominant role in global RV systolic function. In their analysis, heart transplant patients exhibited preserved RV volumes but significantly reduced total EF, particularly due to diminished longitudinal contraction. Through motion decomposition, the authors showed that radial shortening contributed more to overall RV function, while longitudinal components were markedly reduced compared with healthy individuals. These findings further emphasize the unmet need to quantify RV radial function to evaluate RV performance post-transplant and underscore the recommendation to include radial motion parameters in echocardiographic assessments of HTX recipients [69]. In a study involving 115 stable heart transplant recipients, D'Andrea et al. evaluated RV structure and function using conventional and 3D echocardiography. Compared to healthy controls, transplant patients exhibited significant RV enlargement and impaired longitudinal function, as evidenced by decreased TAPSE and TDI S.' However, global RV systolic function, assessed by 3D RV EF, remained largely preserved [70]. Importantly, 3D RV EF independently correlated with patients' exercise capacity, while increased pulmonary artery pressures and older age at the time of transplantation surgery were associated with unfavorable RV remodeling.

These results highlight the value of detailed RV evaluation in long-term post-transplant care, with strain analysis and 3D RV EF serving as determinants of functional status in a population where lifelong TAPSE impairment greatly limits RV functional assessment by conventional measures.

2.5. Mechanical circulatory support

2.5.1. Left ventricular assist device

RV failure remains one of the major complications after left ventricular assist device (LVAD) implantation, often resulting in prolonged ICU stay, need for RV mechanical support, and increased mortality. To address this challenge, Cameli and colleagues proposed the SIENA protocol, a multiparametric echocardiographic approach combining conventional parameters with advanced techniques, including RV strain and 3D RV EF, to predict RV failure after LVAD implantation. Their findings indicate that this comprehensive approach improves risk stratification compared with standard parameters alone and provides additional prognostic value for selecting LVAD candidates [71].

2.5.2. Microaxial flow pump

Moreover, in a prospective study evaluating 41 patients with cardiogenic shock treated with Impella support, Rapis and colleagues observed that failure to improve RV FWLS was strongly associated with unsuccessful weaning. These data suggest that monitoring RV FWLS may help predict the plausibility of safe Impella device removal [72].

2.5.3. Veno-arterial extracorporeal membrane oxygenator

In patients treated with a veno-arterial extracorporeal membrane oxygenator (VA-ECMO), RV dysfunction is also a main prognostic marker, especially influencing the likelihood of successful decannulation. Puerto and colleagues prospectively studied 87 patients with VA-ECMO support. They established that pre-ECMO RV dysfunction (graded as mild, moderate, or severe by integrating the TAPSE value and the visual assessment of the contractility of the RV outflow tract, RV apex, and interventricular septum) was an independent predictor of weaning failure. Additionally, improvement of RV function during support was strongly associated with successful decannulation [73]. Similarly, Huang et al. analyzed 46 VA-ECMO patients using 3D echocardiography and found that RV EF above 24.6% predicted successful decannulation with high accuracy. In their cohort, RV EF ≤24.6% was associated with significantly higher 30-day mortality and poorer clinical outcomes. These findings further support the key role of RV function in determining both ECMO weaning success and short-term prognosis [74].

To summarize, the importance of RV morphology and function in mechanical circulatory support patients is widely accepted, and advanced cardiac imaging, including strain analysis and 3D echocardiography, is increasingly implemented in clinical practice.

3. Limitations

Of note, advanced RV imaging methods and measures are mainly based on local protocols rather than internationally accepted standards. Therefore, the generalizability of the individual studies is limited by the lack of strong consensus on the matter.

RV measurement techniques show great heterogeneity (e.g., RV FWLS is measured by 2D speckle-tracking analysis, while RV GLS can be measured by both 2D and 3D strain imaging; TAPSE and FAC are 2D parameters, while RV EF can only be measured by 3D echocardiography, and deep learning models can also be used for the prediction of a number of these parameters).

The availability of these metrics also differs. The conventional 2D metrics (e.g., TAPSE, FAC) have been accessible for decades and are used in everyday clinical practice. Strain imaging and 3D echocardiography are less widespread; however, before specific procedures, e.g., TEER, 3D echocardiography is already necessary during the preprocedural planning; therefore, these measurements (RV FWLS, RV GLS, 3D RV EF) are more suitable for high-volume centers. Also, solely AI-based methods are still research tools, even though more and more commercially available imaging software solutions incorporate AI-enhanced components for semi-automated measurements.

The learning curve in perioperative and intraoperative settings is longer for examiners; however, the 2020 American

Society of Echocardiography guideline for the use of Echocardiography to Assist with Surgical Decision-Making suggests advanced RV measurements in these settings [75].

The use of such a wide selection of techniques limits reproducibility, and possible inter-vendor variability should be noted. Conventional longitudinal parameters, such as TAPSE and TDI S′ typically show relatively low inter-vendor variability, largely because these measurements rely on straightforward linear or Doppler-based acquisition with limited post-processing dependency. Similarly, while FAC is more operator-dependent due to endocardial tracing, it demonstrates reasonable reproducibility when standardized acquisition protocols are applied. Strain parameters show good agreement between vendor-dependent and vendor-independent platforms [76]. However, inter-vendor variability becomes more relevant in 3D echocardiographic assessment of RV volumes and EF. Unlike 2D parameters, 3D RV EF relies heavily on automated border detection, temporal resolution, and proprietary reconstruction algorithms, making measurements particularly sensitive to software architecture and acquisition settings [77].

The lack of standardized cutoffs for RV measures should also be considered, and often study-specific thresholds are used for novel parameters due to the lack of prospective, RV-guided interventional trials.

The conclusions of this manuscript are limited by the studies we discuss, many of which have relatively small sample sizes and varying endpoints, including mortality, heart failure hospitalization or mechanical circulatory support weaning failure.

4. Conclusion

RV function has emerged as a key determinant of prognosis across a broad spectrum of cardiac surgical and interventional procedures. Once believed to have negligible importance compared to the LV, the RV structure and mechanics are now recognized as integral components of preoperative evaluation, perioperative management, and postoperative risk stratification. While the traditional 2D parameters, such as TAPSE, FAC and TDI S′ have been readily available for years, still many clinicians only measure one of them in everyday practice. However, the new 2025 Right Heart Guideline advocates for the use of multiple parameters, including strain parameters like RV FWLS and RV GLS [78]. Advances in cardiovascular imaging, particularly speckle-tracking echocardiography, 3D echocardiography and CMR, have markedly improved the accuracy and reproducibility of RV functional analyses, overcoming many of the geometric and technical limitations of conventional 2D parameters such as TAPSE, FAC, and tricuspid annular TDI S.′ To conclude, using the currently available, highly reliable semi-automated software solutions, the implementation of advanced imaging methods is highly recommended. It is important to mention that access to these technologies is far from universal and the regular and standardized utilization of these software solutions is not part of the routine even in high-volume centers. Nevertheless, the current trends are aiming toward a much more widespread usage of these modalities, to the point where RV dysfunction has already been incorporated into preprocedural risk stratification algorithms, such as the TRI-SCORE (used before isolated tricuspid valve surgery) and the EUROMACS-RHF Score (which determines the risk of RV heart failure in patients after LVAD implantation) [79,80].

To summarize, the most recent studies support the routine integration of advanced RV imaging into clinical workflows for patients undergoing cardiac surgery and transcatheter interventions. Comprehensive RV assessment not only deepens pathophysiological understanding but also refines risk stratification in these often clinically complex patients.

5. Future perspective

Further studies and consensus documents are needed to standardize imaging acquisition and analysis protocols ensuring consistency and reproducibility across centers. Establishing clinically validated reference values and outcome-based thresholds for advanced RV functional parameters, such as 3D RV EF, RV FWLS, and RV-PA coupling, is essential to facilitate their integration into everyday clinical practice, and to significantly improve reproducibility. Moreover, incorporating multiparametric RV functional assessment into the clinical routine could improve patient selection, preprocedural planning and long-term outcomes after cardiac surgeries and transcatheter interventions [81].

Nevertheless, we lack randomized trials on the role of RV parameters in these populations. Designing trials specifically for RV parameter-based decisions regarding the clinical course of dedicated patient populations would improve the integrity of prior observations. From a monetary perspective, cost-effectiveness analyses focusing on RV performance in certain diseases would provide data on a different aspect, aiding more tailored decision-making. Notably, the rapidly evolving field of artificial intelligence has already yielded significant achievements, and further advancements can be expected in the near future [18,82,83].

Acknowledgments

Grammarly Pro and GPT-5.2 were used for language editing and grammar improvement. No generative AI tool was used for content generation.

Author contributions

A.K., B.M., B.K.L. and L.Z. conceptualized the design. E.P., V.P., B.K.L. and L. Z. drafted the manuscript. E.P., V.P., B.K.L. and L.Z. created the figure. E.P., V.P, T.K.T., A.Fáb., A.Fer., M.Tok., M.Tol., A.N., A.K., B.M., L.B.K. and Z.L. all reviewed the final manuscript. All authors contributed to the article and approved the submitted version.

Disclosure statement

A.K. serves as Chief Medical Officer of Argus Cognitive, Inc, and receives financial compensation for his work, outside the submitted manuscript. The authors have no other relevant affiliations or financial involvement with any organization or entity with a financial interest in or financial conflict with the subject matter or materials discussed in the manuscript apart from those disclosed.

Reviewer disclosures

Peer reviewers on this manuscript have no relevant financial or other relationships to disclose.

Funding

Project [2024-1.2.3-HU-RIZONT-2024-00057] has been implemented with support provided by the Ministry of Culture and Innovation of Hungary from the National Research, Development, and Innovation Fund, financed under the 2024-1.2.3-HU-RIZONT funding scheme. Project no. [RRF-2.3.1-21-2022-00003] has been implemented with the support provided by the European Union. A.Fáb. [EKÖP-2025-683], A.Fer. [EKÖP-2025-595], M.Tol. [EKÖP-2025-596] and Z.L. [EKÖP-2025-443] were supported by the [2025-2.1.1-EKÖP-2025-00014] University Research Scholarship Programme of the Ministry for Culture and Innovation from the source of the National Research, Development and Innovation Fund. M.Tok., A. K. and B.K.L. were individually supported by the Janos Bolyai Research Scholarship of the Hungarian Academy of Sciences. A.K. has received grant support from the National Research, Development, and Innovation Office of Hungary [FK 142573]. The funders had no role in study design, data collection and analysis, decision to publish, or preparation of the manuscript.

References

Papers of special note have been highlighted as either of interest (•) or of considerable interest (••) to readers.

1. Roth GA, Mensah GA, Johnson CO, et al. Global burden of cardiovascular diseases and risk factors, 1990–2019: update from the GBD 2019 study. J Am Coll Cardiol. 2020;76(25):2982–3021.
2. Shahim B, Kapelios CJ, Savarese G, et al. Global public health burden of heart failure: an updated review. Card Fail Rev. 2023;9:e11. doi: 10.15420/cfr.2023.05
3. Disease GBD, Injury I, Prevalence C. Global, regional, and national incidence, prevalence, and years lived with disability for 354 diseases and injuries for 195 countries and territories, 1990–2017: a systematic analysis for the global burden of disease study 2017. Lancet. 2018;392(10159):1789–1858.
4. Donald DE, Essex HE. Pressure studies after inactivation of the major portion of the canine right ventricle. Am J Physiol. 1954;176(1):155–161.
5. Rose JC, Cosimano SJ, Hufnagel CA, et al. The effects of exclusion of the right ventricle from the circulation in dogs. J Clin Invest. 1955;34(11):1625–1631.
6. Tsipis A, Petropoulou E. Echocardiography in the evaluation of the right heart. US Cardiol. 2022;16:e08. doi: 10.15420/usc.2021.03
   - **This paper includes the echocardiographic methods of right ventricular functional assessment.**
7. Haddad F, Doyle R, Murphy DJ, et al. Right ventricular function in cardiovascular disease, part II: pathophysiology, clinical importance, and management of right ventricular failure. Circulation. 2008;117(13):1717–1731. doi: 10.1161/CIRCULATIONAHA.107.653584
8. Kovacs A, Lakatos B, Tokodi M, et al. Right ventricular mechanical pattern in health and disease: beyond longitudinal shortening. Heart Fail Rev. 2019;24(4):511–520. doi: 10.1007/s10741-019-09778-1
9. Padovani P, Werner O, Huguet H, et al. Health-related quality of life in patients with a systemic right ventricle: the QUALISYSTEMIC study. Eur J Cardiovasc Nurs. 2025;24(8):1260–1271. doi: 10.1093/eurjcn/zvaf156
10. Dubrock HM, Frantz RP, Beck G, et al. Health-related quality of life and noninvasive metrics of right ventricular function across the spectrum of pulmonary hypertension. Chest. 2024;166(4):5783a–5785a. doi: 10.1016/j.chest.2024.06.3430
11. Zhang S, Yang ZG, Sun JY, et al. Assessing right ventricular function in patients with hypertrophic cardiomyopathy with cardiac MRI: correlation with the New York heart function assessment (NYHA) classification. PLOS ONE. 2014;9(9):e104312. doi: 10.1371/journal.pone.0104312
12. Tolvaj M, Kovacs A, Radu N, et al. Significant disagreement between conventional parameters and 3D echocardiography-derived ejection fraction in the detection of right ventricular systolic dysfunction and its association with outcomes. J Am Soc Echocardiogr. 2024;37(7):677–686. doi: 10.1016/j.echo.2024.04.005
13. Ladányi Z, Bárczi A, Fabian A, et al. Get to the heart of pediatric renal transplantation: a three-dimensional echocardiography study. J Am Coll Cardiol. 2023;81(8_Supplement):1515–1515. doi: 10.1016/S0735-1097(23)01959-9
14. Anastasiou V, Papazoglou AS, Moysidis DV, et al. The prognostic value of right ventricular longitudinal strain in heart failure: a systematic review and meta-analysis. Heart Fail Rev. 2023;28(6):1383–1394. doi: 10.1007/s10741-023-10329-y
15. Hinojar R, Zamorano JL, Gonzalez Gomez A, et al. Prognostic impact of right ventricular strain in isolated severe tricuspid regurgitation. J Am Soc Echocardiogr. 2023;36(6):615–623. doi: 10.1016/j.echo.2023.02.009
16. Lakatos B, Toser Z, Tokodi M, et al. Quantification of the relative contribution of the different right ventricular wall motion components to right ventricular ejection fraction: the ReVISION method. Cardiovasc Ultrasound. 2017;15(1):8. doi: 10.1186/s12947-017-0100-0
17. Tokodi M, Staub L, Budai A, et al. Partitioning the right ventricle into 15 segments and decomposing its motion using 3D echocardiography-based models: the updated ReVISION method. Front Cardiovasc Med. 2021;8:622118.
18. Szijarto A, Merkely B, Kovacs A, et al. Deep learning-enabled echocardiographic assessment of biventricular ejection fractions: the dual-task QUEST-EF model. Eur Heart J Cardiovasc Imag. 2025;26(8):1402–1405.
19. Szijarto A, Nicoara A, Podgoreanu M, et al. Artificial intelligence-enabled reconstruction of the right ventricular pressure curve using the peak pressure value: a proof-of-concept study. Eur Heart J Imag Methods Pract. 2024;2(4):qyae099.
20. Tokodi M, Magyar B, Soos A, et al. Deep learning-based prediction of right ventricular ejection fraction using 2D echocardiograms. JACC Cardiovasc Imag. 2023;16(8):1005–1018. doi: 10.1016/j.jcmg.2023.02.017
21. Lakatos BK, Rako Z, Szijarto A, et al. Right ventricular pressure-strain relationship-derived myocardial work reflects contractility: validation with invasive pressure-volume analysis. J Heart Lung Transpl. 2024;43(7):1183–1187.
22. Molnar AA, Santa A, Merkely B. Echocardiography imaging of the right ventricle: focus on three-dimensional echocardiography. Diagnostics (Basel). 2023;13(15):2470. doi: 10.3390/diagnostics13152470
    - **This article details the role of 3D echocardiography in the assessment of right ventricular function.**
23. Rudski LG, Lai WW, Afilalo J, et al. Guidelines for the echocardiographic assessment of the right heart in adults: a report from the American society of echocardiography endorsed by the European association of echocardiography, a registered branch of the European society of cardiology, and the Canadian society of echocardiography. J Am Soc Echocardiogr. 2010;23(7):685–713; quiz 786–8.
24. Lang RM, Badano LP, Mor-Avi V, et al. Recommendations for cardiac chamber quantification by echocardiography in adults: an update from the American society of echocardiography and the European association of cardiovascular imaging. Eur Heart J – Cardiovasc Imag. 2015;16(3):233–271. doi: 10.1093/ehjci/jev014
25. Keller M, Fabian A, Bandini A, et al. Impact of the right ventricular mechanical pattern assessed by three-dimensional echocardiography on adverse outcomes following cardiac surgery. Sci Rep. 2025;15(1):5623. doi: 10.1038/s41598-025-89122-w
26. Aluru JS, Barsouk A, Saginala K, et al. Valvular heart disease epidemiology. Med Sci (Basel). 2022;10(2):32. doi: 10.3390/medsci10020032

27. Fulop P, Valocik G, Barbierik Vachalcova M, et al. Aortic stenosis and right ventricular dysfunction. Int J Cardiovasc Imag. 2024;40(2):299–305. doi: 10.1007/s10554-023-02986-9
28. Genereux P, Pibarot P, Redfors B, et al. Staging classification of aortic stenosis based on the extent of cardiac damage. Eur Heart J. 2017;38(45):3351–3358. doi: 10.1093/eurheartj/ehx381
29. Bohbot Y, Guignant P, Rusinaru D, et al. Impact of right ventricular systolic dysfunction on outcome in aortic stenosis. Circ Cardiovasc Imag. 2020;13(1):e009802. doi: 10.1161/CIRCIMAGING.119.009802
30. Nabeshima Y, Kitano T, Takeuchi M. Prognostic value of the three-dimensional right ventricular ejection fraction in patients with asymptomatic aortic stenosis. Front Cardiovasc Med. 2021;8:795016. doi: 10.3389/fcvm.2021.795016
31. Nies RJ, Nettersheim FS, Braumann S, et al. Right ventricular dysfunction and impaired right ventricular-pulmonary arterial coupling in paradoxical low-flow, low-gradient aortic stenosis. Eur J Heart Fail. 2024;26(11):2340–2352.
32. Kitano T, Kovacs A, Nabeshima Y, et al. Prognostic value of right ventricular strains using novel three-dimensional analytical software in patients with cardiac disease. Front Cardiovasc Med. 2022;9:837584. doi: 10.3389/fcvm.2022.837584
33. Mao Y, Liu Y, Zhai M, et al. Prognostic value of right ventricular dysfunction in aortic regurgitation after transcatheter aortic valve replacement. Front Cardiovasc Med. 2024;11:1424116. doi: 10.3389/fcvm.2024.1424116
34. Marin-Cuartas M, Kang J, Noack T, et al. Surgical mitral valve repair vs replacement after failed mitral transcatheter edge-to-edge repair: the CUTTING-EDGE registry. JACC Cardiovasc Interv. 2025;18(7):912–923. doi: 10.1016/j.jcin.2025.02.008
35. Lupi L, Italia L, Pagnesi M, et al. Prognostic value of right ventricular longitudinal strain in patients with secondary mitral regurgitation undergoing transcatheter edge-to-edge mitral valve repair. Eur Heart J Cardiovasc Imag. 2023;24(11):1509–1517. doi: 10.1093/ehjci/jead103
36. Lachmann M, Fortmeier V, Stolz L, et al. Deep learning-enabled assessment of right ventricular function improves prognostication after transcatheter edge-to-edge repair for mitral regurgitation. Circ Cardiovasc Imag. 2025;18(1):e017005.
37. Fortmeier V, Hesse A, Trenkwalder T, et al. Employment of artificial intelligence for an unbiased evaluation regarding the recovery of right ventricular function after mitral valve transcatheter edge-to-edge repair. Eur J Heart Fail. 2025;27(11):2649–2650. doi: 10.1002/ejhf.3766
38. Tokodi M, Nemeth E, Lakatos BK, et al. Right ventricular mechanical pattern in patients undergoing mitral valve surgery: a predictor of post-operative dysfunction? ESC Heart Fail. 2020;7(3):1246–1256. doi: 10.1002/ehf2.12682
39. Shechter A, Vaturi M, Kaewkes D, et al. Prognostic value of baseline tricuspid annular plane systolic excursion to pulmonary artery systolic pressure ratio in mitral transcatheter edge-to-edge repair. J Am Soc Echocardiogr. 2023;36(4):391–401 e19.
40. Bohbot Y, Essayagh B, Benfari G, et al. Prognostic implications of right ventricular dysfunction in severe degenerative mitral regurgitation. J Am Heart Assoc. 2025;14(1):e036206. doi: 10.1161/JAHA.124.036206
41. Ladanyi Z, Eltayeb A, Fabian A, et al. The effects of mitral stenosis on right ventricular mechanics assessed by three-dimensional echocardiography. Sci Rep. 2024;14(1):17112. doi: 10.1038/s41598-024-68126-y
42. Kumar V, Jose VJ, Pati PK, et al. Assessment of right ventricular strain and strain rate in patients with severe mitral stenosis before and after balloon mitral valvuloplasty. Indian Heart J. 2014;66(2):176–182. doi: 10.1016/j.ihj.2014.02.012
43. Leclercq F, Lorca L, Agullo A, et al. Evolution of right ventricular dysfunction and tricuspid regurgitation after TAVI: a prospective study. Int J Cardiol. 2022;353:29–34. doi: 10.1016/j.ijcard.2022.01.033
44. Ladanyi Z, Lakatos BK, Clement A, et al. Mechanical adaptation of the right ventricle to secondary tricuspid regurgitation and its association with patient outcomes. J Am Soc Echocardiogr. 2025;38(7):601–612. doi: 10.1016/j.echo.2025.02.011
45. Ancona F, Bellettini M, Polizzi G, et al. Short-term outcome after isolated tricuspid valve surgery: prognostic role of right ventricular strain. Eur J Cardiothorac Surg. 2024;66(5). doi: 10.1093/ejcts/ezae405
46. Kim DY, Seo J, Cho I, et al. Prognostic implications of biventricular global longitudinal strain in patients with severe isolated tricuspid regurgitation. Front Cardiovasc Med. 2022;9:908062. doi: 10.3389/fcvm.2022.908062
47. Kim M, Lee HJ, Park JB, et al. Preoperative right ventricular free-wall longitudinal strain as a prognosticator in isolated surgery for severe functional tricuspid regurgitation. J Am Heart Assoc. 2021;10(9):e019856. doi: 10.1161/JAHA.120.019856
48. Kresoja KP, Rommel KP, Lucke C, et al. Right ventricular contraction patterns in patients undergoing transcatheter tricuspid valve repair for severe tricuspid regurgitation. JACC Cardiovasc Interv. 2021;14(14):1551–1561. doi: 10.1016/j.jcin.2021.05.005
49. von Bardeleben RS, Lurz P, Sorajja P, et al. Two-year outcomes for tricuspid repair with a transcatheter edge-to-edge valve repair from the transatlantic TRILUMINATE trial. Circ Cardiovasc Interv. 2023;16(8):e012888. doi: 10.1161/CIRCINTERVENTIONS.122.012888
50. Orban M, Wolff S, Braun D, et al. Right ventricular function in transcatheter edge-to-edge tricuspid valve repair. JACC Cardiovasc Imag. 2021;14(12):2477–2479. doi: 10.1016/j.jcmg.2021.06.026
51. Ramsingh R, Bakaeen FG. Coronary artery bypass grafting: practice trends and projections. Cleve Clin J Med. 2025;92(3):181–191. doi: 10.3949/ccjm.92a.23071
52. Dini FL, Pugliese NR, Ameri P, et al. Right ventricular failure in left heart disease: from pathophysiology to clinical manifestations and prognosis. Heart Fail Rev. 2023;28(4):757–766. doi: 10.1007/s10741-022-10282-2
53. Liu B, Zhang G, Lv M, et al. The relationship between tricuspid annular plane systolic excursion on transesophageal echocardiography and the incidence of postoperative acute kidney injury in patients undergoing coronary artery bypass grafting surgery: a multicenter prospective cohort study. BMC Anesthesiol. 2024;24(1):328.
54. Keller M, Heller T, Duerr MM, et al. Association of three-dimensional mesh-derived right ventricular strain with short-term outcomes in patients undergoing cardiac surgery. J Am Soc Echocardiogr. 2022;35(4):408–418. doi: 10.1016/j.echo.2021.11.008
55. Keller M, Duerr MM, Heller T, et al. Regional right ventricular function assessed by intraoperative three-dimensional echocardiography is associated with short-term outcomes of patients undergoing cardiac surgery. Front Cardiovasc Med. 2022;9:821831. doi: 10.3389/fcvm.2022.821831
56. Bidviene J, Muraru D, Kovacs A, et al. Global and regional right ventricular mechanics in repaired tetralogy of Fallot with chronic severe pulmonary regurgitation: a three-dimensional echocardiography study. Cardiovasc Ultrasound. 2021;19(1):28. doi: 10.1186/s12947-021-00260-3
57. van Grootel RWJ, van den Bosch AE, Baggen VJM, et al. The prognostic value of myocardial deformation in adult patients with corrected Tetralogy of Fallot. J Am Soc Echocardiogr. 2019;32(7):866–875 e2.
58. Knauth AL, Gauvreau K, Powell AJ, et al. Ventricular size and function assessed by cardiac MRI predict major adverse clinical outcomes late after tetralogy of Fallot repair. Heart. 2008;94(2):211–216. doi: 10.1136/hrt.2006.104745
59. Surkova E, Kovacs A, Lakatos BK, et al. Contraction patterns of the systemic right ventricle: a three-dimensional echocardiography study. Eur Heart J Cardiovasc Imag. 2022;23(12):1654–1662. doi: 10.1093/ehjci/jeab272
60. Surkova E, Lakatos BK, Fabian A, et al. Myocardial work of the systemic right ventricle and its association with outcomes. Int J Cardiovasc Imag. 2024;40(5):1105–1114. doi: 10.1007/s10554-024-03081-3

61. Egbe AC, Miranda WR, Connolly HM. Role of echocardiography for assessment of cardiac remodeling in congenitally corrected transposition of great arteries. Circ Cardiovasc Imag. 2022;15(1):e013477. doi: 10.1161/CIRCIMAGING.121.013477
62. Diller GP, Radojevic J, Kempny A, et al. Systemic right ventricular longitudinal strain is reduced in adults with transposition of the great arteries, relates to subpulmonary ventricular function, and predicts adverse clinical outcome. Am Heart J. 2012;163(5):859–866. doi: 10.1016/j.ahj.2012.01.038
63. Alsaied T, Castrillon CD, Christopher A, et al. Cardiac MRI predictors of right ventricular dysfunction after the Da Silva cone operation for Ebstein's anomaly. Int J Cardiol Congenit Heart Dis. 2022;7:100342.
64. Yu S, Yang K, Chen X, et al. Cardiac remodeling after tricuspid valve repair in Ebstein's anomaly: a magnetic resonance study. Eur Radiol. 2023;33(3):2052–2061. doi: 10.1007/s00330-022-09190-8
65. Vitarelli A, Sardella G, Roma AD, et al. Assessment of right ventricular function by three-dimensional echocardiography and myocardial strain imaging in adult atrial septal defect before and after percutaneous closure. Int J Cardiovasc Imag. 2012;28(8):1905–1916. doi: 10.1007/s10554-012-0022-8
66. Canan A, Ocazionez-Trujillo D, Vargas D, et al. Pre- and postprocedure imaging of transcatheter pulmonary valve implantation. Radiographics. 2022;42(4):991–1011. doi: 10.1148/rg.210160
67. Badano LP, Miglioranza MH, Edvardsen T, et al. European association of cardiovascular imaging/cardiovascular imaging department of the Brazilian society of cardiology recommendations for the use of cardiac imaging to assess and follow patients after heart transplantation. Eur Heart J Cardiovasc Imag. 2015;16(9):919–948. doi: 10.1093/ehjci/jev139
68. Li M, Lv Q, Sun W, et al. Prognostic value of right ventricular three-dimensional speckle-tracking strain in adult heart transplantation patients. Int J Cardiovasc Imag. 2023;39(7):1275–1287. doi: 10.1007/s10554-023-02842-w
69. Lakatos BK, Tokodi M, Assabiny A, et al. Dominance of free wall radial motion in global right ventricular function of heart transplant recipients. Clin Transpl. 2018;32(3):e13192. doi: 10.1111/ctr.13192
70. D'Andrea A, Riegler L, Nunziata L, et al. Right heart morphology and function in heart transplantation recipients. J Cardiovasc Med (Hagerstown). 2013;14(9):648–658. doi: 10.2459/JCM.0b013e32835ec634
71. Cameli M, Loiacono F, Sparla S, et al. Systematic left ventricular assist device implant eligibility with non-invasive assessment: the SIENA protocol. J Cardiovasc Ultrasound. 2017;25(2):39–46. doi: 10.4250/jcu.2017.25.2.39
72. Rapis K, Lo Muzio FP, Faragli A, et al. Right ventricular longitudinal strain predicts weaning success in cardiogenic shock patients supported by a microaxial flow pump. Crit Care Explor. 2025;7(7):e1283. doi: 10.1097/CCE.0000000000001283
73. Puerto E, Tavazzi G, Gambaro A, et al. Interaction between VA-ECMO and the right ventricle. Hellenic J Cardiol. 2022;68:17–24. doi: 10.1016/j.hjc.2022.07.003
74. Huang KC, Lin LY, Chen YS, et al. Three-dimensional echocardiography-derived right ventricular ejection fraction correlates with success of decannulation and prognosis in patients stabilized by venoarterial extracorporeal life support. J Am Soc Echocardiogr. 2018;31(2):169–179.
75. Nicoara A, Skubas N, Ad N, et al. Guidelines for the use of transesophageal echocardiography to assist with surgical decision-making in the operating room: a surgery-based approach: from the American society of echocardiography in collaboration with the society of cardiovascular anesthesiologists and the society of thoracic surgeons. J Am Soc Echocardiogr. 2020;33(6):692–734. doi: 10.1016/j.echo.2020.03.002
76. Il'giovine ZJ, Mulder H, Chiswell K, et al. Right ventricular longitudinal strain reproducibility using vendor-dependent and vendor-independent software. J Am Soc Echocardiogr. 2018;31(6):721–732 e5.
77. Zhang Y, Wang YB, Yao GH, et al. Right ventricular volume and function by three-dimensional echocardiography: results of the echocardiographic measurements in normal Chinese adults (EMINCA) II. MedComm (2020). 2024;5(5):e550. doi: 10.1002/mco2.550
78. Mukherjee M, Rudski LG, Addetia K, et al. Guidelines for the echocardiographic assessment of the right heart in adults and special considerations in pulmonary hypertension: recommendations from the American Society of echocardiography. J Am Soc Echocardiogr. 2025;38(3):141–186. doi: 10.1016/j.echo.2025.01.006
   •• **These are the new Recommendations regarding Right Heart Echocardiography of the American Society of Echocardiography.**
79. Dreyfus J, Audureau E, Bohbot Y, et al. TRI-SCORE: a new risk score for in-hospital mortality prediction after isolated tricuspid valve surgery. Eur Heart J. 2022;43(7):654–662. doi: 10.1093/eurheartj/ehab679
80. Soliman OII, Akin S, Muslem R, et al. Derivation and validation of a novel right-sided heart failure model after implantation of continuous flow left ventricular assist devices: the EUROMACS (European registry for patients with mechanical circulatory support) right-sided heart failure risk score. Circulation. 2018;137(9):891–906. doi: 10.1161/CIRCULATIONAHA.117.030543
81. Kovacs A, Magunia H, Nicoara A, et al. Challenges and opportunities in assessing right ventricular structure and function: a roadmap for standardization, clinical implementation and research. Nat Rev Cardiol. 2025;23(1):60–77. doi: 10.1038/s41569-025-01180-9
   •• **This is a more general review of the standardization, clinical implementation and research possibilities in assessing right ventricular structure and function.**
82. Akesson J, Ostenfeld E, Carlsson M, et al. Deep learning can yield clinically useful right ventricular segmentations faster than fully manual analysis. Sci Rep. 2023;13(1):1216. doi: 10.1038/s41598-023-28348-y
83. Qin Y, Qin X, Zhang J, et al. Artificial intelligence: The future for multimodality imaging of right ventricle. Int J Cardiol. 2024;404:131970. doi: 10.1016/j.ijcard.2024.131970
   • **This manuscript describes the present and future role of artificial intelligence in right heart imaging.**