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REVIEW ARTICLE

Right Ventricular Strain; A New Predictor of Postoperative Outcome: A Narrative Review

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ABSTRACT

Background: Cardiac strain is a dimensionless measure of myocardial deformation. There are two parameters that can be assessed with the right ventricle (RV) strain software the RV free wall longitudinal strain (RVFWS) and the RV global longitudinal strain (RVGLS). The recent studies are recommending RV strain as a reliable marker of RV systolic and diastolic function.

Methods: In this review article, we searched for new publications in the last 10 years from peer reviewed journals related to RV strain. The findings of these studies are summarised.

Result: Seven studies proved the reliability of RV longitudinal strain as a reliable predictor of RV function compared to the TAPSE, RV fraction area change and RV EF, E/A ratio and tissue Doppler. Patients with reduction in RV longitudinal strain have high VIS score and worse postoperative outcome.

Conclusion: Right ventricular strain is a reliable and better marker of RV function. The reduction in RV GLS and free wall strain are predictors of high inotropes and vasopressors requirement; and increase in postoperative morbidity and mortality after cardiac surgery.

KEYWORDS

• Right Ventricular Strain • Postoperative Outcome • Right Ventricle Function • Right Ventricle Free Wall Longitudinal Strain • Right Ventricle Global Longitudinal Strain

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INTRODUCTION

For years, right ventricle has been the "forgotten chamber" of the heart the right heart was viewed as less important than the left heart in the maintenance of normal overall hemodynamic performance. However, there is now considerable evidence that emphasizes the significance of intact right ventricular (RV and has historically been considered less important than the left. While it is true that the left ventricle bears the brunt of most common cardiac diseases, the importance of an adequately functioning right ventricle in maintaining hemodynamics should not be overlooked.

Echocardiography has proved to be an indispensable tool in the assessment of cardiac function and guiding further management, but right ventricular evaluation is far more technically challenging than that of the left because of the distinct anatomical and physiological features of the right ventricle. The complex geometry of the right ventricle combined with its retrosternal position, make visualization challenging. Furthermore, loading conditions greatly affect RV function and should be taken into consideration during evaluation.[2] There are plenty of approaches for both qualitative and quantitative assessment of right ventricular function by echocardiography including 2D echocardiography, Doppler, Tissue Doppler Imaging (TDI), 3D imaging and Speckle tracking echocardiography. A complete and reliable assessment is possible only with a holistic approach and not with just a single parameter.

The crescent shape of the right ventricle allows only the assessment of "fractional area change" and not the ejection fraction. Methods like cardiac MRI and three dimensional (3D) transthoracic echocardiography are considered gold standard in assessment of right ventricular systolic function as they do not rely on the geometry of the ventricle and can measure the ejection fraction, but they are not without their shortcomings[3] Other parameters used to assess RV function are also often one dimensional and do not consider the entire geometry of the ventricle.

Cardiac strain is a dimensionless measure of myocardial deformation. Deformation refers to changes in myocardial shape over time. This can occur over 3 dimensions longitudinal, circumferential, or radial.[4] In the right ventricle, it is the longitudinal strain that is usually reported, either of just the lateral free wall or of both the free wall and the septum. The deep muscle fibres arranged longitudinally in the RV contribute to 80% of its contraction, and thus it stands to reason that longitudinal strain is a better marker of RV systolic function than circumferential or radial strain. It can be assessed by both Tissue Doppler Imaging (TDI) or 2D - Speckle Tracking Echocardiography (2D – STE), with the latter providing an angle-independent measurement of RV systolic function with better reproducibility than TDI analysis. Right ventricular strain by echocardiography has been found to correlate with the RV ejection fraction measured on Cardiac MRI.

Speckle tracking echocardiography has become the standard method for assessment of RV and LV strain due to its reduced angle dependency, feasibility and reproducibility as compared to TDI[5] providing additional diagnostic and prognostic insights compared to traditional indices of RV function. Two-dimensional speckle-tracking echocardiography is currently the standardized method of choice for measuring RV longitudinal strain (RVLS. However, evaluation of strain using this method depends greatly on the quality of image acquisition with drop-outs and reverberations leading to erroneous strain values. The software for strain assessment was available only for the left ventricle and the RV strain was calculated using the same. When dedicated software for RV strain analysis was available, it could be used only offline, which precluded its use for real-time monitoring and management. A few of the available software for RV strain analysis include EchoPacby GE®, TomTech, Velocity vector imaging (VVI)[6], Epsilon EchoInsight and Autostrain by Philips®. Autostrain by Philips allows online measurement of RV strain values.

There are two parameters that can be assessed with the RV strain software (depending on the vendor) the RV free wall longitudinal strain (RVFWS) and the RV global longitudinal strain (RVGLS). The former is the average strain of 3 segments on the RV free wall, while the latter is the average strain of 6 segments, on the RV free wall and the interventricular septum. Although the interventricular septum has components from both the ventricles, the major

contributor to its contraction is the LV, making it mainly a constituent of the LV7. Therefore, RVFWS is independent of left ventricular contractility and is thought to provide a more accurate evaluation of RV systolic function than RVGLS (Figure 1 and Figure 2). The value of the RVFWS is found to be more negative than the RVGLS, with a difference of approximately 5% between the values 7. As per the American Society of Echocardiography guidelines (2025), RVFWS and RVGLS values more negative than -20% to -25% are considered normal8. The guidelines recommend the integration of RV strain analysis into routine assessment of the right ventricle.

In this review article, we searched for new publications in the last 10 years from peer reviewed journals. The findings of these studies are summarised and discussed. (Table 1).

Table 1:

Authors	Year of publication	Type of study	Population studied	Parameters measured	Result
Orwat *et al*[9]	2015	Prospective observational	372 patients with repaired TOF	Longitudinal, circumferential and radial global strain on CMR	LV – CS and RV – LS found to predict outcome independent of other factors
Krishna SN *et al*[10]	2018	Prospective observational	60 children undergoing TOF repair	RV function parameters (RV Fractional Area Change (FAC), Tricuspid Annular Systolic Plane Excursion (TAPSE), Tricuspid Peak Systolic Velocity (S'), Myocardial Performance Index (RMPI), offline RV – GLS) by TEE and P(RV/LV).	TAPSE, RV GLS, RV GLS rate and Prv/lv had significant predictive strength and reasonable sensitivity and specificity for predicting high mean VIS.
Gao Y *et al*[11]	2022	Retrospective	179 patients with repaired TOF	RV – Free wall strain, Global longitudinal strain, LV Global longitudinal strain, RV FAC by TTE	RV FAC, RV - FWS, RV - GLS and LV - GLS were predictive of poor outcomes in patients with r- TOF but RV - FWS was found to predict poor outcomes more accurately
Thomas *et al*[12]	2024	Prospective observational	307 patients with repaired TOF	Longitudinal, circumferential and global longitudinal strain on CMR	Biventricular strain parameters predicted clinical outcomes and post-PVR remodeling in rTOF
Ting *et al*[13]	2017	Prospective observational	68 consecutive patients posted for cardiac surgery	RV function parameters (RV Fractional Area Change (FAC), Tricuspid Annular Systolic Plane Excursion (TAPSE), Tricuspid Peak Systolic Velocity (S'), Myocardial Performance Index (RMPI), RV GLS.	RVGLSs performed using perioperative TEE are reliably associated with hemodynamic instability following cardiac surgery.
Rong *et al*[14]	2019	Prospective observational	53 patients undergoing cardiac surgery	RV function parameters - RV FAC, TAPSE, S', RV GLS	RV strain - provides incremental value to traditional RV indices in predicting those who will develop RV dysfunction.
Liang *et al*[15]	2019	Retrospective observational	55 patients who underwent LVAD implantation	RV GLS	Pre-operative RVLS was a useful predictor of RV Failure (RVF) in multiple view. 2D RVLS outperformed previously used clinical, hemodynamic, and echocardiographic based metrics as a predictive marker for early RVF and may be a useful tool in risk stratification of pre-operative LVAD patients

The use of RV strain in the perioperative period to improve outcomes has garnered a lot of importance in the past few years. A study by Ting *et al* (2017) showed that RV strain (RVGLS) was a better indicator of RV mechanics than the conventional RV indices.[13] The authors attributed the superiority to the lesser angle dependency in STE than in the othermethods and to its ability to assess the global RV function. Rong *et al* (2019), in their study, corroborated these findings and also determined that impaired RV strain is associated with intraoperative RV functional decline and provides incremental value to traditional RV indices.[14]

Various studies have shown the usefulness of RV strain analysis in patients posted for CABG, valvular heart disease, in cardiac failure, in the placement of Left Ventricular Assist Devices, in Congenital Heart Diseases, with most studies affirming that RV strain helps in assessing the prognosis. Unlu *et al* proposed that RV strain can be used to assess the RV – arterial coupling using the ratio between RVFWS and systolic Pulmonary Arterial Pressure (10) and their study showed that RVFWS/sPAP significantly predicted all-cause mortality and heart–lung transplantation, and was superior to other well-established parameters, in patients with pre-capillary PAH.[16]

There is paucity of data on the usefulness of RV strain in the perioperative period with most studies focusing on transthoracic and not transesophageal echocardiography. But the promising results from the studies done on TTE have spiked an interest in the use of this parameter in the intraoperative period as a tool to guide management of the patient and to predict perioperative outcomes. RV strain should be included in the routine assessment of the right heart function as it can identify subtle decreases in RV function, which might not be picked up by the conventional parameters.

Figure 1: Autostrain by Philips® - Region of Interest generated

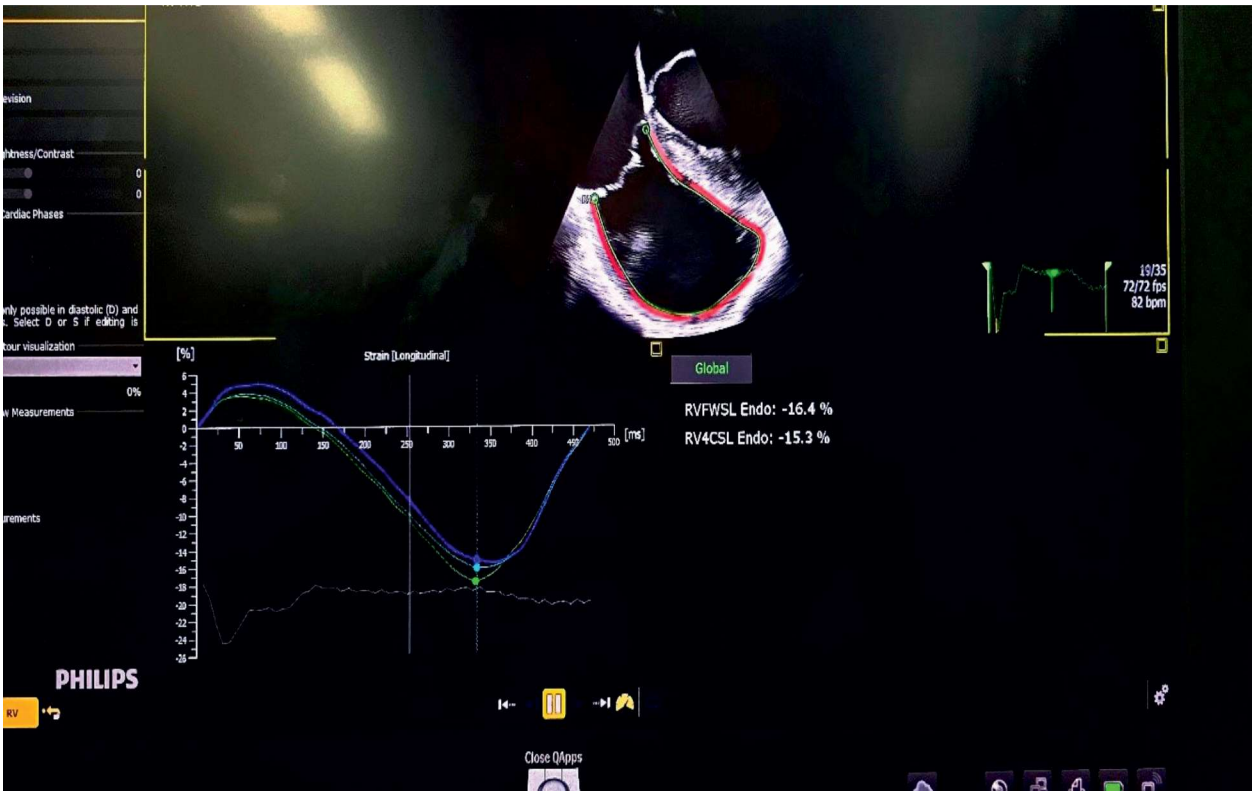

Figure 2: Autostrain by Philips® - RV GLS and RV FWS

CONCLUSION

Right ventricular strain is a reliable and better marker of RV function. The reduction in RV GLS and free wall strain are predictors of high inotropes and vasopressors requirement; and increase in postoperative morbidity and mortality after cardiac surgery.

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