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REVIEW

Echocardiographic Strain in Clinical Practice

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The accurate evaluation of left ventricular (LV) function has been central to monitoring of therapy, institution of specific therapeutic interventions and as a prognostic marker for risk stratification in a variety of cardiovascular conditions. However, LV ejection fraction, the most commonly used measure of LV systolic function, is a 'coarse' measure of global LV function, with several limitations. Strain analysis, a measure of myocardial deformation, has come to the forefront more recently as a more sensitive measure of myocardial function than LV ejection fraction. Its utility in detection of early subclinical LV dysfunction, defining regional variation in specific cardiomyopathies, utility to monitor improvement with therapy and as a prognostic marker in a variety of cardiac conditions has led to its increasing use in clinical practice. This review will briefly summarise specific methodological aspects, use in diagnosis and prognostic utility of strain analysis in various cardiovascular conditions.

Keywords Echocardiography • Global longitudinal strain • Speckle tracking • Left ventricular function

Introduction

Left ventricular ejection fraction (LVEF) is the most widely used echocardiographic parameter to quantify LV systolic function; it is a powerful prognostic predictor in cardiovascular disease. LVEF is utilised in the selection of patients for device insertion, valve surgery, and initiation of specific pharmacological therapy. However, LVEF has several limitations, including the geometric assumptions made in its calculation, its load-dependence, significant intraobserver, interobserver and test-retest variability (6–12%) [1], and that it only measures global LV function.

The left ventricle works by contraction and relaxation of a complex structure of muscular fibres, organised in layers. Left ventricular subendocardial and subepicardial fibres are arranged longitudinally, forming a spiral around the ventricle (subepicardial oriented clockwise, subendocardial oriented counter clockwise) [2] (Figure 1). Mid myocardial fibres are oriented in a circumferential manner [2]. The contraction and relaxation of these various groups of fibres results in a complex 'deformation' of the LV myocardium in systole and diastole [3]. LVEF does not account for the multiplanar and multidirectional components of myocardial deformation, instead providing only a global index of LV function. As a result, early alterations and regional variations in LV function may not be reflected by LVEF, which, in early stages of a disease process, may remain normal [4].

Echocardiographic strain imaging can quantify regional and global myocardial function, specifically quantifying multiplanar LV function, comprising of longitudinal, radial and circumferential contraction [5–8]. Incorporation of strain imaging, particularly global longitudinal strain, is increasingly utilised in routine clinical practice and has recently been recommended in major guidelines [9]. This review

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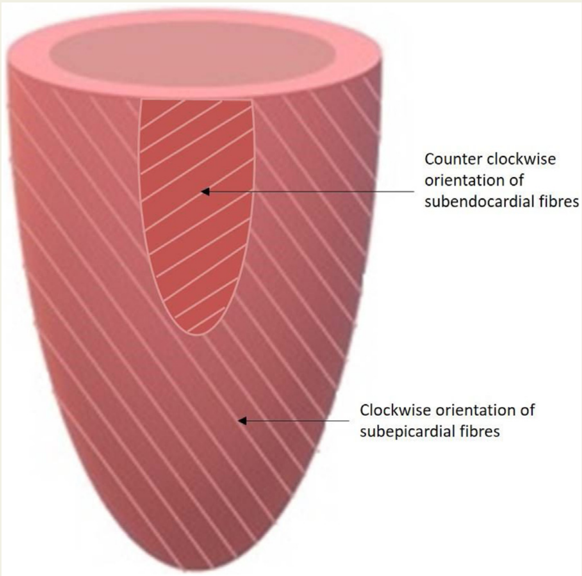

Figure 1 Schematic representation of myocardial fibre orientation.
Myocardial fibres in the subepicardium are oriented in the clockwise direction, whereas fibres in the subendocardium are oriented in the counter clockwise direction.

outlines briefly the physics, technical aspects and potential clinical applications of myocardial strain analysis.

Strain

Strain (ε), is a dimensionless measure of tissue deformation [10,11] calculated as, $\varepsilon = (L - L_0)/L_0$, where L is final length and L_0 the original length [12]; Strain is positive with lengthening, and negative with shortening [12]. As the LV contracts, myocardial fibres shorten in the longitudinal and circumferential plane (i.e. negative strain) and thicken or lengthen in the radial direction (positive strain).

Strain rate (unit s^{-1}), is the rate at which this deformation occurs, i.e. change in velocity between two points divided by distance between the points [12].

Lagrangian Strain

If the length of the myocardium is known before, during, and after deformation, strain $\varepsilon(t) = (L(t) - L(t_0))/L(t_0)$, where $L(t)$ is the final length and $L(t_0)$ is the initial myocardial length. This expression relative to the initial length is known as Lagrangian Strain [12], and two dimensional (2D) speckle tracking strain is an example of Lagrangian Strain.

Eulerian Strain and Strain Rate

In cases where the initial length of the myocardium is unknown, deformation is expressed relative to the myocardial length at a previous time point, $d_{\varepsilon N}(t) = (L(t + dt) - L(t)) / L(t)$, where dt is the small time interval elapsed and $d_{\varepsilon N}(t)$ is the small amount of deformation during this time interval. Therefore, total strain is obtained by the addition of small strain values, and is known as Eulerian strain [12]. Strain derived by tissue Doppler imaging (TDI) is an example of Eulerian strain.

Parameters of Strain and Strain Rate Imaging

Strain analysis comprises a number of parameters, with peak strain, peak systolic strain and strain rate, being the more commonly used parameters. Peak strain is the maximum strain, whereas the peak systolic strain is the maximum strain that occurs specifically during the LV ejection period (i.e. before aortic valve closure). Post-systolic thickening, and the post-systolic index (ratio of post-systolic increment to the end systolic strain) have also been used (Figure 2). Furthermore, time to peak systolic strain, which is ascertained from multiple LV segments, can measure LV dyssynchrony.

Strain rate parameters are less load dependent than strain. Systolic strain rate (S-Sr), early diastolic strain rate (E-Sr) and late diastolic strain rate (A-Sr) have been validated (Figure 3) [10].

Measurement of Strain–Modalities

Two echocardiographic modalities have been used to quantify strain–TDI and 2D speckle tracking strain.

TDI Strain

Through spatial derivation of the velocity data, Doppler-derived strain rate is determined. Temporal integration of the strain rate will extract the corresponding strain value [12].

The major limitation of TDI strain, as with all Doppler-based techniques, is angle dependency. Thus, TDI strain can evaluate longitudinal myocardial strain, while radial strain is obtained from limited regional segments (e.g. anterior and posterior segments from the parasternal short axis). It is required to manually track the sample volume throughout the cardiac cycle within a particular myocardial segment, to avoid noise arising from sampling blood pool and reverberation on the 2D echo images. High frame rates (>100 Hz) are imperative in order to avoid under-sampling [12].

Two-Dimensional Speckle Tracking Strain

Two dimensional speckle tracking has emerged as an alternative technique, which is semi-automated and evaluates global and regional myocardial function, from multiple planes [8,10]. It is based on tracking ultrasonic speckles within myocardial tissue that can be obtained from routine 2D images. Single speckles are merged into functional units called kernels, with each kernel constituting an ultrasound fingerprint that can be tracked by software during the cardiac cycle.

Although 2D strain can be affected by afterload, it is angle independent, and can quantify LV strain/strain rate in circumferential, radial and longitudinal planes. It has improved intraobserver and interobserver reproducibility [13], is less

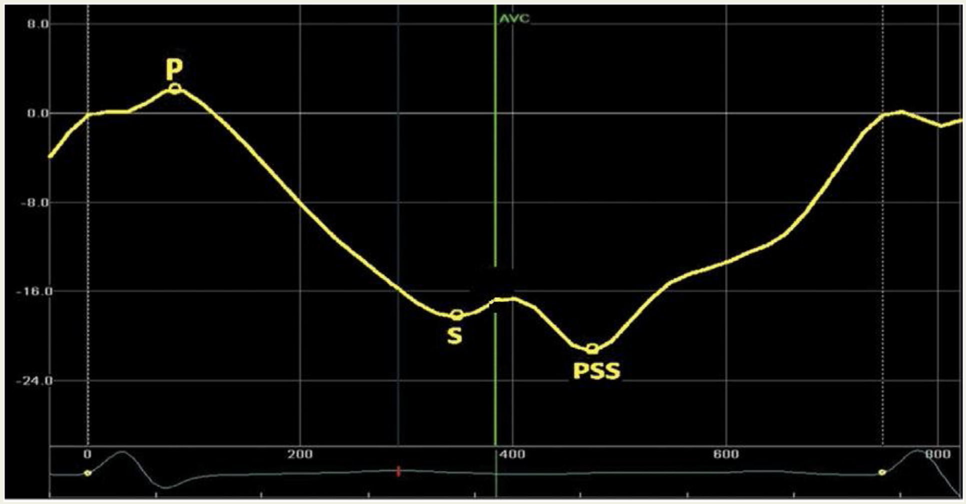

Figure 2 Strain parameters.
Longitudinal strain curve with a selection of strain values at clinically relevant timings.
Abbreviations: P, peak positive strain; S, peak systolic strain; PSS, post systolic strain; AVC, aortic valve closure obtained from left ventricular outflow tract Doppler signal.

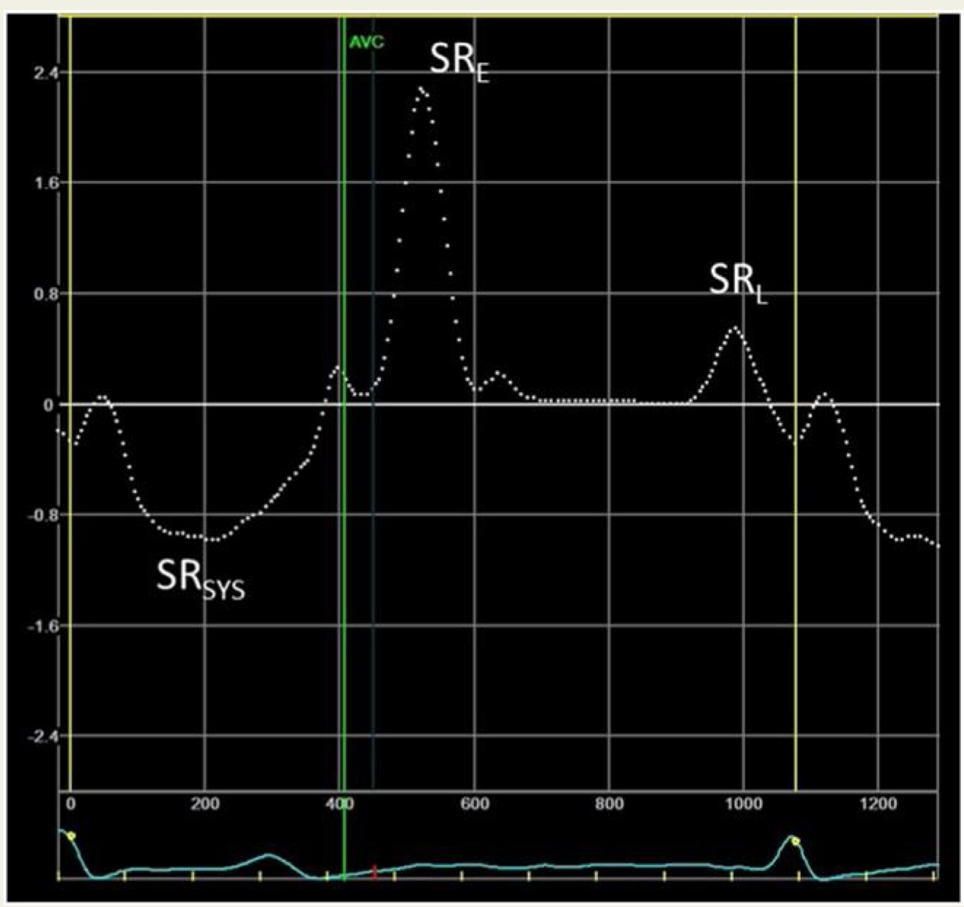

Figure 3 Strain rate parameters.
Global longitudinal strain rate curve over the cardiac cycle (lines representing segmental strain rates have been removed).
Abbreviations: SR_{SYS}, systolic strain rate; SR_E, early diastolic strain rate; SR_L, late diastolic strain rate.

Table 1 Difference between measurement of strain with TDI and 2D speckle tracking.

	TDI strain	2D strain
Technique	Doppler based; therefore, angle dependent	Non-Doppler based; not angle dependent
Frame rates	>100 fps	>60 fps
2D image quality	Not reliant on 2D image quality	Very reliant on 2D image quality
Processing time	Increased as sample needs to be manually tracked	Semiautomated; so relatively quick
Multiplanar strain	Measures longitudinal and limited radial segmental strain	Measures longitudinal, circumferential and radial strain
Property	Excellent temporal resolution	Lower temporal resolution
Clinical application	Limited as time consuming	Expanding due to feasibility and reproducibility

Abbreviations: TDI, tissue Doppler imaging; 2D, two dimensional; fps, frames per second.

time consuming than TDI strain (Table 1), and has been validated against sonomicrometry and tagged magnetic resonance imaging (MRI) [14]. Speckle-tracking strain analysis is performed offline, using conventional 2D greyscale images, with an optimal frame rate of >60 frames per second.

The endocardium is manually traced by a point-and-click approach; an epicardial surface tracing is automatically generated creating a 'region of interest' (ROI). After manual adjustment of the ROI width and shape, the software automatically divides the ROI for each apical view into six segments. The tracking quality for each segment is scored as either acceptable or unacceptable, with the possibility of further manual correction. Segments without adequate image quality are rejected by the software and excluded from analysis. Lastly, after ROI is optimised, the software generates strain curves. If two or more segments are of poor tracking quality in a particular view, strain measurements should be excluded. From the three apical views, the software automatically generates a topographic representation of all 18 analysed segments (a bull's-eye map) (Figure 4) [15].

Longitudinal, Radial and Circumferential Strain

During systole, ventricular longitudinal myocardial fibres shorten, depicted by negative curves [5]. Longitudinal strain from the four-chamber, two-chamber, and apical long-axis views are used to derive regional and global longitudinal strain

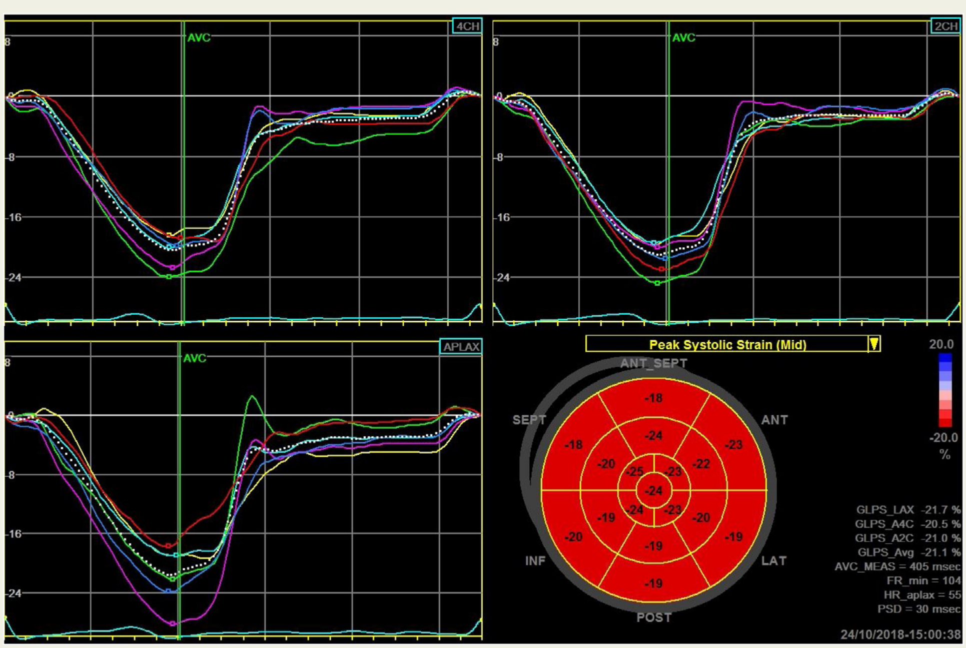

Figure 4 Measurement of global longitudinal strain.
Longitudinal strain curves from the apical 4-chamber, 2-chamber, and long-axis views generating a bulls-eye map of all analysed segments.

(GLS). GLS has been validated as an index for global LV function against cardiac magnetic resonance imaging LVEF [16].

Radial strain represents myocardial deformation directed towards the centre of the LV cavity, and measures LV thickening during systole, represented by positive curves. Radial strain values are derived from LV parasternal short-axis view at the mid cavity or papillary muscle level [17].

Circumferential strain represents LV myocardial fibre shortening along the circular perimeter observed on a parasternal short-axis view at the mid-level [18], with measurements represented by negative curves.

Global Longitudinal Strain

Although assessment of GLS is now routine practice in many echocardiographic laboratories, global radial and circumferential strain analyses are not sufficiently reproducible for routine clinical work in their current form, despite demonstrated utility in research studies [19].

Normal Values

The normal values of LV GLS vary according to age, gender, and ultrasound vendor system [20,21]. As such, current recommendations do not provide a specific lower limit of normality but, as a guide, the expected value of LV GLS in a healthy individual is around −20% [22]. Left ventricular GLS is expressed as a negative value because it represents the 'shortening' of the myocardium during LV systolic contraction. A recent metanalysis of ˜ 2,500 subjects demonstrated mean LV GLS was −19.7% (95% CI −20.4% to −18.9%) [23]. Women show slightly higher LV GLS and LV GLS decreases with age [22].

Clinical Applications of Speckle Tracking Echocardiography

Two dimensional speckle tracking echocardiography derived GLS, is increasingly utilised in routine clinical practice due to its reproducibility and feasibility. Global longitudinal strain provides information beyond LVEF in a variety of conditions, as discussed below. Not only has a good correlation between GLS and LVEF been demonstrated [16,24], GLS detects subclinical systolic dysfunction even when LVEF is preserved, and provides quantitative segmental LV function [25]. Additionally, in a group of unselected patients, GLS demonstrated improved prognostic value over LVEF [26]. Furthermore, LVEF loses its prognostic value with LVEF over 40%, whereas GLS retains this across the range [27]. In a large cohort of patients with acute heart failure, GLS demonstrated improved prognostic value over LVEF, with increased mortality in patients with a reduced GLS, but no difference in LVEF in patients who died [27].

Coronary Artery Disease (CAD): Revascularisation and Recovery

In patients with suspected angina, GLS was significantly lower in patients with coronary artery disease (CAD) compared to patients without, and was an independent predictor of CAD [28]. In patients with acute myocardial infarction, GLS correlated with LV infarct size [29] and peak cardiac troponin T levels as one of its surrogates [30]. In acute myocardial ischaemia, end systolic rather than peak strain is used as affected segments may demonstrate post systolic shortening. Moreover, following reperfusion, GLS is an excellent predictor of LV remodelling and adverse events (heart failure and death) [31]. In addition, GLS correlated with the transmurality of scar tissue on contrast-enhanced MRI [32,33].

The effects of balloon occlusion and time to reperfusion on regional myocardial function have been evaluated, demonstrating a transient reduction in GLS in 'at-risk' segments, which normalise following reperfusion [34]. Shorter symptom-to-balloon times typically resulted in lower impairment of GLS [30,35]. Global longitudinal strain has also been useful in identifying myocardial segments that will improve following revascularisation [36].

In recently published prospective studies that analysed mortality and the incidence of ventricular arrhythmias after myocardial infarction, GLS was a better marker of mortality compared to LVEF [37,38]. In addition, a new parameter termed 'mechanical dispersion', was an excellent predictor of ventricular arrhythmias. Mechanical dispersion is calculated as the standard deviation of time to peak strain from the 18 L V segments; a longer mechanical dispersion reflecting myocardial contraction heterogeneity with consequent regional dyssynchrony [39]. Global longitudinal strain was also a superior prognostic predictor of morbidity and mortality in unselected populations with ischaemic cardiomyopathy [40].

Sudden Cardiac Death (SCD)

Myocardial strain can improve risk stratification of SCD in individuals with ischaemic cardiomyopathy [38] and also in those with relatively preserved myocardial function [39]. Heterogeneous myocardial contraction characterised by prolonged mechanical dispersion, was shown in the long QT syndrome (LQTS), a cardiac ion channel disease that previously was considered purely an electrical disorder with risk of SCD. Studies utilising strain echocardiography demonstrated that a prolonged mechanical dispersion in LQTS was associated with an increased risk of ventricular arrhythmias [41].

Valvular Heart Disease: Mitral Regurgitation and Aortic Stenosis

Optimal timing for surgical intervention in asymptomatic patients with moderate-to-severe valvular heart disease is difficult, and is based on symptoms, lesion severity and its impact on LV volume and LVEF. Currently, there is a shift towards valvular intervention being performed earlier, and emerging data suggest that strain may identify myocardial dysfunction at an early stage, prior to overt reduction in LVEF.

With severe mitral regurgitation (MR), the LVEF is often overestimated. Recent studies have demonstrated that preoperative GLS at rest and during exercise, but not LVEF, provide accurate information about contractile reserve and predicted improvement in postoperative LV function. In 88 patients with severe MR undergoing mitral valve repair, those who developed postoperative LV dysfunction had a lower resting GLS [42]. These results were confirmed in 233 patients with moderate-severe organic MR who underwent mitral valve repair, demonstrating that GLS $>-19.9\%$ was an independent predictor of long-term LV dysfunction [43].

Evaluation with exercise is also important in patients with MR. Global longitudinal strain both at rest and peak exercise were predictors of postoperative LV dysfunction [44]. Lack of augmentation in GLS $\geq 2\%$ with exercise predicted a two-fold increase in cardiovascular events, whereas a 4% increase in LVEF (indicative of preserved LV contractile reserve) did not affect outcome [45].

Global longitudinal strain demonstrates subclinical LV dysfunction in patients with aortic stenosis (AS) (Figure 5A) [46]. Patients with severe AS and preserved LVEF had lower GLS compared to controls, with reduction in strain more pronounced in the basal LV segments [47]. A lower GLS was associated with a higher LV mass index and relative wall thickness, supporting a direct correlation between concentric remodelling and contractile dysfunction [46]. Among recent prognostic studies [48,49], a study of 163 patients with asymptomatic moderate to severe AS demonstrated that a GLS ≥ -15.9 was a predictor of adverse events [48]. In patients with paradoxical low-flow, low-gradient severe AS, those with impaired GLS (GLS $\geq -17\%$) had a lower 2-year event free survival compared to those with preserved GLS [50].

However, to establish the unequivocal role of GLS for clinical assessment of patients with valvular heart disease, large prospective randomised controlled trials that include strain imaging need to be performed.

Cardiomyopathy and Heart Failure

Dilated cardiomyopathy has a reduction in strain in all three planes: longitudinal, radial and circumferential [51]. A recent study in heart failure patients (50% of whom had dilated cardiomyopathy), demonstrated that reduced GLS was

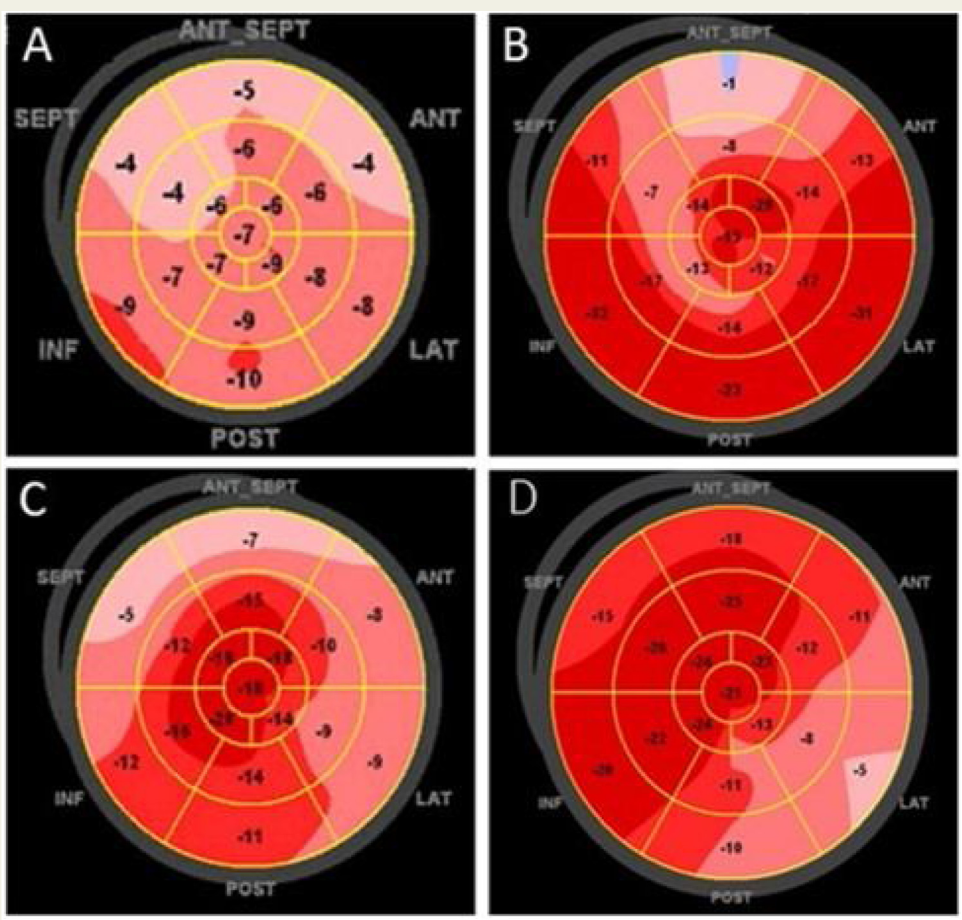

Figure 5 Global longitudinal strain bulls-eye maps for various pathologies.
Global longitudinal strain (GLS) bulls-eye map in a patient with (A) aortic stenosis, demonstrating patchy reduction in strain, (B) hypertrophic cardiomyopathy, showing impaired strain in the basal anteroseptal segment, (C) amyloidosis, showing an apical-sparing appearance of strain, and (D) Fabry disease, demonstrating impaired strain in the basal posterolateral segments.

associated with poor long-term prognosis [52]. Diabetes is a cardinal risk factor for cardiovascular disease and heart failure. In asymptomatic diabetic patients with a preserved LVEF, GLS was reduced, demonstrating subclinical myocardial dysfunction, before the development of an overt diabetic cardiomyopathy [53,54]. In addition, the subclinical LV dysfunction measured by GLS in patients with type 2 diabetes is associated with adverse long-term prognosis [55].

Strain imaging is becoming increasingly useful in heart failure patients and is recommended in clinical practice guidelines [9]. A recent study of 4,172 consecutive heart failure patients with a mean EF of 40% demonstrated that GLS was independently predictive of mortality but EF was not [27]. Furthermore, in heart failure with preserved ejection fraction (HFpEF) patients, GLS was reduced compared to controls and age- and gender-matched hypertensive patients with diastolic dysfunction [56]. In another report involving HFpEF patients, GLS was the strongest echocardiographic predictor of the composite outcome of cardiovascular death, heart failure hospitalisation, or aborted cardiac arrest [57].

Cardiac resynchronisation therapy is an accepted therapy for patients with heart failure not responsive to medical therapy. Recent studies have focussed on abnormal wall motion patterns; early-systolic shortening and rebound stretch in the septum, combined with early-systolic lengthening and peak shortening after aortic valve closure in the lateral wall, predicts response to cardiac resynchronisation therapy [58].

Hypertrophic Cardiomyopathies

Two dimensional speckle tracking echocardiography strain has been useful in differentiating physiological LV hypertrophy from pathological forms of hypertrophic cardiomyopathies, including infiltrative pathologies (e.g., amyloidosis). The salient differences between the various forms of hypertrophic cardiomyopathies (physiological and pathological) are presented in Table 2 and summarised below.

There are complex adaptive cardiac changes in an athlete's heart; however, a reduction in LV GLS is uncommon, with observed changes considered a physiological adaptation to training [59]. Impaired LV GLS in athletes should raise the suspicion of an underlying myocardial disease, and the individual athlete should be thoroughly evaluated [59].

In newly diagnosed patients with hypertension without LV hypertrophy, 2D speckle tracking GLS helps to unmask early subclinical systolic dysfunction [60]. The basal septum is the first segment to undergo changes under the influence of pressure overload, and longitudinal strain is reduced at this site [61]. Overall, GLS is reduced in hypertensive patients, while LV radial and circumferential strain remain preserved [62]. Worsening GLS was associated with major adverse cardiac events even in asymptomatic hypertensive heart disease [63], with improved GLS demonstrated with beta blocker therapy [63].

Systolic function by LVEF typically remains normal in early stages of hypertrophic cardiomyopathy (HCM), however, GLS is reduced (Figure 5B) [64]. Global longitudinal strain correlates with the phenotypic features of HCM, including septal curvature convexity [65], degree of myocyte hypertrophy, disarray, and interstitial fibrosis [66]. Longitudinal strain is in particular reduced at the site of hypertrophy, and in the classical HCM, corresponding to the interventricular septum [67]. Compared to hypertensive patients, GLS in patients with HCM shows marked compromise [68]. GLS was also a marker of ventricular arrhythmias [39] and was independently associated with adverse cardiovascular outcomes in HCM [69]. A recent study concluded that a reduction of GLS $\leq -15\%$ represented patients with better survival in HCM and suggested that GLS should be considered a valuable subclinical biomarker to be incorporated in the standardised risk stratification workup of HCM patients [70].

Cardiac amyloidosis results in increased LV wall thickness. Left ventricular GLS is significantly reduced in patients with cardiac amyloidosis [71], particularly in the basal and mid LV segments, while the strain in apical segments is relatively preserved (Figure 5C) [72]. Compared to HCM, cardiac amyloidosis presents a global reduction of longitudinal strain of the basal and mid segments and not a focal reduction in longitudinal strain of the interventricular septum, which is the site of greatest LV hypertrophy [73]. An apical septal to basal septal segmental longitudinal strain ratio >2.1 has been suggested as a means of differentiating cardiac amyloidosis from other causes of increased wall

Table 2 Strain patterns in different models of left ventricular hypertrophy.

Type of left ventricular hypertrophy	GLS	Typical pattern of impairment
Athlete's heart	Normal GLS	None
Hypertension	Reduced GLS (+)	Generalised
Hypertrophic cardiomyopathy	Reduced GLS (++)	Interventricular septum
Cardiac amyloidosis	Reduced GLS (++)	Basal and mid LV segments; relative apical sparing
Fabry disease	Reduced GLS (++ especially with more advanced disease)	Basal posterolateral

Abbreviations: GLS, global longitudinal strain; LV, left ventricular.

thickness [74]. In addition, a recent study of 206 consecutive patients with biopsy-proven amyloidosis observed that impaired LV GLS was associated with worse outcome [75].

Studies have demonstrated that patients with Fabry disease, another cause for hypertrophic cardiomyopathy, have significantly impaired GLS, even when LVEF is normal [76,77]. Global longitudinal strain correlated with late gadolinium enhancement (LGE) on cardiac MRI [78]. Regional strain was lowest in the basal posterolateral segments (in keeping with mid-myocardial replacement fibrosis in Fabry disease) (Figure 5D) [78]. Additionally, patients with impaired GLS had worse NYHA functional class than those with normal GLS [77].

Stress Cardiomyopathy

Stress, or Takotsubo, cardiomyopathy is a reversible cardiomyopathy with regional LV systolic dysfunction with reduction in LV strain in a segmental territory that extends beyond any single vascular territory, typically presenting as apical ballooning [79]. It has also been demonstrated that peak systolic strain and strain rate are reduced in both the basal and apical regions in Takotsubo patients during the active phase, and these abnormalities improve during recovery [80]. The reduction in strain is significantly greater in the apical region compared to the base in the acute phase of the disease [79,80].

Chemotherapy Related Cardiotoxicity

There is increasing evidence supporting the use of GLS in oncology patients who receive potential cardiotoxic chemotherapy. This includes evaluation at baseline, for monitoring during treatment, and for ongoing surveillance for cancer therapy-related cardiac dysfunction (CTRCD) [81].

Global longitudinal strain has been shown to be superior to LVEF in cardiotoxicity prediction. In a recent study of 450 patients with haematological malignancy, pre chemotherapy GLS was independently associated with cardiac events at a median follow-up of 4 years [82]. In addition, cardiac death and symptomatic heart failure were increased six times in patients with a GLS absolute value of <17.5%, in patients with a baseline LVEF between 50% and 59%, demonstrating that prechemotherapy GLS is an effective tool to stratify cardiotoxicity risk [83].

In patients who have already received chemotherapy, several studies have demonstrated the short-term utility of GLS in detecting early myocardial dysfunction and predicting CTRCD [81,84–86]. The degree of change in GLS that predicted subsequent cardiotoxicity ranged from 10% to 15% [81]. Data regarding the ability of early changes in GLS to predict long-term CTRCD are awaited.

A relative reduction in GLS of >15% compared to pre chemotherapy GLS is the threshold defined by the American Society of Echocardiography and the European Association of Cardiovascular Imaging to identify subclinical LV dysfunction, whereas a change of <8% appears not to be of clinical significance [87].

Long-term studies on the most appropriate cardioprotective management when an isolated fall in strain is the only abnormality are ongoing [88]. Preliminary data support the use of beta blockers in preventing CTRCD in cancer patients experiencing a significant drop in GLS during treatment [89]. If prospective studies reiterate this finding, this would dramatically change the follow-up of patients receiving potentially cardiotoxic cancer therapy, particularly in patients at increased risk of developing cardiotoxicity.

Limitations and Future Directions

Two dimensional strain has greater clinical utility given it is angle independent, has improved feasibility and reproducibility compared to tissue Doppler strain. Nevertheless, speckle tracking strain is reliant on 2D image quality and frame rates. Three dimensional speckle tracking will eliminate the problem of through-plane motion inherent in 2D imaging, but 3D strain is currently limited by low frame rates. Another advantage of 3D speckle tracking is the evaluation of all myocardial segments in a single cardiac cycle, which significantly reduces analysis time, and beat-to- beat variability, especially in patients with arrhythmias.

A limitation of strain in the past was that results depended on the ultrasound machine on which analyses were performed, with variability in measurements between different vendors [90]. However, recent initiatives of the American Society of Echocardiography and the European Association of Cardiovascular Imaging have demonstrated improved concordance between vendors [91].

Despite the diagnostic and prognostic advantages of 2D strain, there is a lack of specific therapeutic interventions based on strain and a paucity of long-term large-scale randomised trial evidence on cardiovascular outcomes.

What is now evident is that 2D GLS is a validated and reproducible technique that is increasingly available. Global longitudinal strain is more sensitive than LVEF and is able to identify patients with ‘‘subclinical” LV dysfunction (e.g., chemotherapy related cardiotoxicity), improve diagnostic accuracy for specific aetiologies (e.g., hypertrophic cardiomyopathies), guide early therapy even in asymptomatic patients (e.g., diabetic cardiomyopathy), provide risk stratification (e.g., aortic stenosis) and has improved prognostic utility (e.g., heart failure) [92]. Hence, its incorporation in routine patient evaluation and clinical decision making is imminent, but as is the case with all new technologies, education and specific training with performance and interpretation are crucial [92].

Conclusion

The evaluation of LV function using 2D speckle tracking strain provides significant additional information in various cardiovascular conditions. This technology identifies subclinical cardiac dysfunction through the multidirectional and multiplanar assessment of LV deformation. While specific training and education is required, along with establishment of standardised protocols across vendors, the growing utility of this technique, as well as its feasibility and reproducibility will make it a powerful measure in routine clinical practice.

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