Global longitudinal strain for predicting outcome after mitral repair or cardiac surgery: here to stay?

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Speckle tracking two-dimensional (2D) strain echocardiography is a novel and promising technique with multiple emerging clinical applications.1,2 In most patients, the method is easy to perform during routine transthoracic echocardiography by the acquisition of the regular 2D gray-scale images, which can then be evaluated offline by the use of work stations. Strain echocardiography has been demonstrated to be useful for assessing and monitoring left ventricular (LV) systolic function in several cardiac disease entities. A major advantage of speckle tracking echocardiography is its angle-independency in comparison with tissue Doppler (TDI) which enables regional and global analysis of myocardial velocities and deformation parameters such as strain or strain rate by the use of an image-processing algorithm of the grey scale pixels. In principle, strain measures the myocardial fibre contraction magnitude, and therefore may detect subtle subclinical LV dysfunction in an early stage.

LV function presents a well-established prognostic factor strongly influencing outcome in valve disease and is included in the EuroSCORE preoperative risk calculation for cardiac surgery.3 However, the echocardiographic assessment of the LV ejection fraction (EF) faces several major limitations, including load dependency and imaging quality for endocardial border delineation.1 Importantly, it has been repeatedly observed, that despite apparently preserved ‘normal’ LV EF, myocardial contractility may already be reduced, reflected by impaired longitudinal 2D strain.1,2

In the setting of severe mitral regurgitation, compensatory LV dilatation and geometry changes may sustain a normal stroke volume at rest, although myocardial contractile reserve may already deteriorate even in asymptomatic patients. Therefore, careful assessment of the LV function including longitudinal strain in asymptomatic patients with severe organic mitral regurgitation and borderline values in terms of the EF or the LV end systolic diameter has been recommended, along with analysis of the aetiology and mechanism in the view of possible mitral repairability.4

In the present issue of the Journal, the incremental influence of preoperative global longitudinal 2D strain (GLS) to predict the postoperative outcome in contemporary patients after valvular and other cardiac surgery is intriguingly demonstrated in two studies.5,6 In the study of Witkowski et al.,7 a large series of patients undergoing mitral repair for severe organic mitral regurgitation during the last decade according to current guideline recommendations were followed for 34 ± 20 months. The postoperative long-term incidence of LV dysfunction was relatively low with a presence of EF <50% observed in 12% of 233 patients. Importantly, preoperative GLS and not EF was the strongest independent predictor of long-term postoperative LV dysfunction, together with and superior to the LV dimension (LVESD ≥40 mm).

These observations are of clinical impact in several ways. First, the implementation of advanced surgical mitral repair techniques in experienced centres shows clear benefit in a majority of patients undergoing contemporary mitral surgery.7 Secondly, however, even the close adherence to current surgical indications as outlined in the guidelines8,9 may still not prevent development of postoperative myocardial dysfunction. The incidence of preoperative LV dysfunction in the studied series was rather low with the EF ≤60% present in 21% of patients, and LV dilatation with LVESD ≥40 mm in 11% of patients. Therefore, most of the patients were referred for mitral repair at an early stage of the disease. Furthermore, only patients with successful repair without residual regurgitation were included.

There is ongoing debate of the recommended watchful waiting strategy of referral to surgery when symptoms occur or when asymptomatic patients with mitral regurgitation develop LV enlargement, LV dysfunction, pulmonary hypertension or atrial fibrillation, and different outcomes have been reported.10,11 The current study5 underscores the importance of detecting early deterioration of LV function and points out the benefit of assessing myocardial deformation parameters in patients with mitral regurgitation for predicting functional recovery after mitral repair, extending previous studies of longitudinal function and contractile reserve.12

The opinions expressed in this article are not necessarily those of the Editors of the EHJCI or of the European Society of Cardiology.

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Owing to the hyperdynamic LV function with reduced afterload and increased preload in severe organic mitral regurgitation, 'higher than normal' longitudinal strain values are encountered (e.g. −22%) and the observed cut-off −19.9% might therefore be considered as 'pseudo-normal' or reduced for this group of patients. The cut-off value GLS −19.9% showed a sensitivity and specificity of 90 and 79% to predict long-term LV dysfunction.3 As subtle LV dysfunction occurs, strain values are altered despite preserved EF and may help in identifying patients who might benefit from early elective mitral surgery before myocardial damage occurs with progressive eccentric hypertrophy.

In the French study of Ternacle et al.,4 longitudinal strain was analysed for predicting early postoperative death in a large series of 425 patients referred for cardiac coronary bypass or left heart valve surgery (CABG: n = 155, aortic valve: n = 174, mitral: n = 96). Despite preserved EF ≥50%, impaired GLS ≥−16% (range −15 to −8%) was measured in more than half of all patients referred for aortic stenosis (AS, 53%), 38% referred for CABG and 27% of patients with mitral regurgitation. In reflection of the latent LV dysfunction, plasma NT-proBNP levels were also significantly higher (median 1025 vs. 503 pg/mL) in patients with impaired longitudinal strain, along with higher NYHA class. Importantly, despite similar surgical risk EuroSCORE, the postoperative death rate was significantly and 2.4-fold increased in patients with abnormal GLS even in preserved EF.

The natriuretic peptide BNP has been established as a powerful parameter of survival and has been shown to relate to speckle tracking strain in heart failure or after myocardial infarction.13 BNP is released in response to increased myocardial wall stress, and predicts progression, as well as the postoperative outcome in severe AS, or prognosis in asymptomatic mitral regurgitation and is also related to GLS.14–16 Together with 2D strain and clinical symptoms, plasma BNP or its pro-form NT-proBNP is easily obtained in clinical routine and appears useful for risk stratification in valvular disease for optimal timing of surgery. Importantly, in the present study, longitudinal strain incrementally improved the risk stratification of both valvular and CABG surgery patients obtained even by the recently proposed EuroSCORE II.3 These findings add important knowledge to the mounting evidence that longitudinal strain may help in defining optimal timing of surgery in valvular disease by detecting latent LV contractile impairment which may occur early in the subendocardial myocardial layers. In another concurrent study of patients with severe AS, GLS also predicted mortality or hospitalization after aortic valve replacement.17

GLS has been validated against the LVEF measured by magnetic resonance imaging even in poor acoustic windows where traditional EF by the method of Simpson may not be obtained in transhoracic echocardiography. A limitation in clinical use of 2D strain remains the inter-observer variability when calculating strain, although the reproducibility appears more reliable in longitudinal strain as compared with radial or circumferential strain, as well as the dependency on imaging quality and sufficient frame rate.1,2 Uncertainties remain concerning normal reference ranges, and which cut-offs should be used in specific cardiac disease entities. Furthermore, standardization of reference values among different manufacturers and systems is urgently needed to allow more widespread application of strain. Biomarkers (BNP) and strain are now mentioned as possibly helpful in the new valvular guidelines, although their incremental value should be validated further in large prospective studies despite the promising findings of the present studies.

In conclusion, preoperative GLS is a powerful parameter of LV dysfunction after mitral repair together with LV dimension. Risk stratification with 2D strain adds incremental information for the prediction of postoperative death after aortic-, mitral valve-, or coronary bypass surgery superior to currently implemented clinical and imaging parameters. Together with plasma BNP and clinical symptoms, 2D global strain is easy to obtain, and can be simply assessed from routine transthoracic echocardiography in every day practice. Therefore, speckle tracking strain is convincingly here to stay.

References

A 29-year-old man was referred to our attention for a right bundle branch block occasionally found at a sport medical. The patient’s history was unremarkable after a perinatal closure of a Botallio’s ductus arteriosus. A cardiac magnetic resonance (CMR) study was prescribed to better evaluate the echocardiographic finding of an interventricular septum abnormality, suggestive for an interventricular septal defect, but without evidence of shunt. CMR described a fissure-like protrusion (Figure 1, white arrows), confined in the compacted myocardium and penetrating more than 50% of wall thickness on the basal posterior septum. This lesion showed a near-total obliteration during systole (see online Video) and fulfilled all the magnetic resonance imaging criteria for myocardial cleft diagnosis.

Ventricular clefts are increasingly seen with the growing of advanced cardiac imaging. They represent occasional findings without any clinical relevance, and no case report exists of any consequence of this imaging finding. Myocardial cleft has to be differentiated for prognostic reasons from left ventricle diverticulum (saccular protrusion with all myocardial layers extending beyond the confines of the myocardial margins), which, although usually asymptomatic, could be associated with systemic embolization, heart failure, valve regurgitation, arrhythmias, and sudden death.

**Authors’ contribution.**

A.C. conceived the study idea, wrote the first draft, and led the project from the beginning to the end. A.B., P.G.M., and G.M.R. assisted the study in data collection, draft revision, and coordinating with all co-authors. L.M. provided expert opinion throughout the study.

**Supplementary data are available at European Heart Journal – Cardiovascular Imaging online.**

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**Figure 1** White arrow pointing the left ventricular cleft during diastole and systole in the transaxial view (A and B) and in the vertical long-axis view (C and D). The cleft’s diameters were 30 × 13 mm in diastole, with complete obliteration in systole (RV, right ventricle; LV, left ventricle).