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Editorial

Global Left Ventricular Strain: Exciting Applications In Perioperative Practice

Perioperative assessment of ventricular function by echocardiography is common in the contemporary practice of cardiac anesthesiology.[1] Although left ventricular ejection fraction is a gold standard for evaluating left ventricular function, it has shortcomings, including observer variability, load dependency, and a lack of sensitivity for the detection of early ventricular dysfunction.[1-3] Newer echocardiographic modalities, such as strain analysis, can be effective in measuring systolic function for cardiac surgical patients, but still require further validation and broader implementation in the operating room setting.[2-3] Speckle-tracking echocardiography is a powerful clinical tool for quantifying myocardial strain.[3] Multiple trials have demonstrated that strain measured with two-dimensional speckle tracking can accurately quantify global and regional myocardial function as compared to contrast-enhanced magnetic resonance imaging.[3-5] The analysis of left ventricular strain examines myocardial mechanics in three spatial dimensions: longitudinal, circumferential, and radial.[3-4] Global longitudinal strain is a widely reported parameter that determines strain in individual LV segments to predict the estimated average left ventricular function.[3-6] This important strain measure has been shown to be highly reproducible and to predict mortality and morbidity, including the perioperative outcomes in cardiac surgical patients.[6-9]

The quantification of global longitudinal strain has been validated primarily with transthoracic echocardiography in awake, spontaneously breathing patients rather than with transesophageal echocardiography in anesthetized patients in the setting of mechanical ventilation.[3,10-12] In this issue of the *Journal*, Labus et al have analyzed the perioperative course of two-dimensional left ventricular global longitudinal strain in an effort to bridge this evidence gap.[12] In their study of 40 patients with preserved biventricular function undergoing cardiac surgery, two-dimensional strain analysis and the left ventricular ejection fraction were assessed at the following four time points: preoperatively, intraoperatively before sternotomy, intraoperatively after sternotomy, and postoperatively. The preoperative and postoperative assessments were undertaken with transthoracic echocardiography. The intraoperative assessments were undertaken with transesophageal echocardiography. This noteworthy trial by Labus et al has yielded three findings that merit further discussion.

First, the investigators have demonstrated that left ventricular global longitudinal strain did not significantly differ between the awake state with spontaneous ventilation (first time point) and the anesthetized state with mechanical ventilation (second time point).[12] This observation took into account not only differences between the awake and anesthetized states, but also the differences in transthoracic and transesophageal imaging. The investigators have thoughtfully discussed these findings in light of the recent literature, interpreting the context of their study with respect to confounders, such as clinical hemodynamics, heart rhythm, anesthetic technique, and study population.[12] The study context is important since left ventricular function and, consequently, strain assessment may be influenced by multiple variables, such as selected population, anesthetic technique, ventilation strategy, cardiac rhythm, vasopressor and inotrope selection; and surgical considerations, such as sternotomy and cardiopulmonary bypass.[13-16] In an effort to minimize these confounding effects, Labus et al have evaluated strain in a homogeneous study cohort with preserved biventricular function undergoing coronary artery bypass grafting with cardiopulmonary bypass. Furthermore, the study cohort had a predefined anesthetic regimen without exposure to vasopressors or pacing. By standardizing the patient population and perioperative regimen, this study has highlighted novel data in the assessment of perioperative strain with echocardiography. Although their findings suggested that strain measurements with transthoracic and transesophageal echocardiography likely correlate, future trials are required to explore whether this observation can be extended still further in the perioperative setting.

Secondly, Labus et al also have demonstrated that left ventricular global longitudinal strain was not affected by sternotomy in their study model (second and third time point assessments).[12] Considering the integral spatial relationship

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between the chest wall and cardiac structures, this finding suggested that mechanical deformation and displacement of the ribcage do not necessarily influence myocardial performance. A fortuitous consequence of this finding was that strain assessment can be postponed until after sternotomy. This consequence is significant in the dynamic and busy environment of the operating room, where cardiac anesthesiologists also are managing the anesthetic and patient hemodynamics, as well as echocardiography.

Third, these investigators have demonstrated that left ventricular global longitudinal strain significantly deteriorated in this model of coronary artery bypass surgery with cardiopulmonary bypass, despite the preservation of both the left ventricular ejection fraction and systolic velocity of the lateral mitral annulus (third and fourth time point assessments).[12] This finding was in agreement with previous trials that have reported significant impairment of left ventricular global longitudinal strain in this setting, coupled with minimal changes in left ventricular ejection fraction.[17-18] The study by Labus et al included patients who had an uncomplicated perioperative course. This deterioration in postoperative left ventricular global longitudinal strain, despite preservation of the ejection fraction, suggested that strain assessment is a more sensitive imaging technique for detecting subclinical myocardial damage that may be due to incomplete myocardial protection during the surgical procedure. Further trials likely will explore the clinical implications of the perioperative changes in global longitudinal strain both in cardiac and non-cardiac surgery.

Strain has been shown to predict outcomes with high sensitivity in a variety of advanced cardiac conditions, including chronic heart failure, ischemic cardiac disease, and severe aortic stenosis.[19-22] An important concomitant question is whether the type of strain quantification influences the power to predict outcomes after cardiac surgery. A recent trial compared longitudinal, circumferential, and radial strain for the prediction of clinical outcomes after surgical aortic valve replacement with or without coronary artery bypass grafting.[23] In this multivariate analysis, decreases in global longitudinal strain rather than circumferential or radial strain significantly predicted need for inotropic support (odds ratio 1.8; 99% confidence interval 1.10-2.97; $p = 0.002$) and prolonged hospitalization (odds ratio 1.2; 98% confidence interval 1.01-1.46; $p = 0.01$).[23] Further trials have explored the roles of global longitudinal strain and three-dimensional regional strain in the prediction of clinical outcomes after cardiac surgery as part of the ongoing echocardiographic journey beyond ejection fraction as the gold standard for left ventricular function.[9,24,25]

In summary, Labus et al should be congratulated for highlighting the natural history of strain imaging in the perioperative period for cardiac surgical patients.[12] They have pointed out the value and confounders for strain imaging and analysis with perioperative echocardiography. Their observations have added to the imperative to further evaluate strain imaging in the perioperative period. The important questions in this research domain should be framed with clear criteria for normal values in both adults and children to facilitate interpretation of future findings.[26-28] Although the normal ranges for strain parameters in different settings are in development, significant confounders are still present, including clinical setting, patient age, and vendor platform.[26-28] As a novel and maturing echocardiographic modality, comprehensive strain assessment also can extend beyond the left ventricle to yield further insights into diastolic function.[29] Strain imaging also has the potential to assist in the future priorities for investigation in cardiothoracic and vascular anesthesia, including the refined diagnosis of perioperative myocardial ischemia and the optimization of clinical outcomes after valve interventions.[30]

Conflict of Interest

None.

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References

1 Yu S, Peffley S, Fabbro M, et al. A narrative review of the 2020 guidelines for use of transesophageal echocardiography to assist with surgical decision-making by the cardiac anesthesiologist in the operating room. J Cardiothorac Vasc Anesth 2021;S1053-0770(21)-106-3. Online ahead of print.
2 Zito C, Longobardo L, Citro R, et al. Ten years of 2D longitudinal strain for early myocardial dysfunction detection: A clinical overview. Biomed Res Int 2018;2018:8979407.
3 Benson MJ, Silverton N, Morrissey C, et al. Strain imaging: An everyday tool for the perioperative echocardiographer. J Cardiothorac Vasc Anesth 2020;34:2707–17.
4 Gjesdal O, Hopp E, Vartdal T, et al. Global longitudinal strain measured by two-dimensional speckle tracking echocardiography is closely related to myocardial infarct size in chronic ischaemic heart disease. Clin Sci 2007;113:287–96.
5 Roes SD, Mollema SA, Lamb HJ, et al. Validation of echocardiographic two-dimensional speckle tracking longitudinal strain imaging for viability assessment in patients with chronic ischemic left ventricular dysfunction and comparison with contrast-enhanced magnetic resonance imaging. Am J Cardiol 2009;104:312–7.
6 Kalam K, Otahal P, Marwick TH. Prognostic implications of global LV dysfunction: A systematic review and meta-analysis of global longitudinal strain and ejection fraction. Heart 2014;100:1673–80.
7 Stanton T, Leano R, Marwick TH. Prediction of all-cause mortality from global longitudinal speckle strain: Comparison with ejection fraction and wall motion scoring. Circ Cardiovasc Imaging 2009;2:356–64.
8 Medvedofsky D, Kebed K, Laffin L, et al. Reproducibility and experience dependence of echocardiographic indices of left ventricular function: Side-by-side comparison of global longitudinal strain and ejection fraction. Echocardiography 2017;34:365–70.
9 Sonny A, Alfirevic A, Sale S, et al. Reduced left ventricular global longitudinal strain predicts prolonged hospitalization: A cohort analysis of patients having aortic valve replacement surgery. Anesth Analg 2018;126:1484–93.
10 Jha AK, Malik V, Gharde P, et al. Echocardiographic predictors of immediate postoperative outcomes in patients with severe left ventricular systolic dysfunction undergoing on-pump coronary artery bypass grafting. J Cardiothorac Vasc Anesth 2017;31:184–90.

11 Marcucci CE, Samad Z, Rivera J, et al. A comparative evaluation of transesophageal and transthoracic echocardiography for measurement of left ventricular systolic strain using speckle tracking. J Cardiothorac Vasc Anesth 2012;26:17–25.

12 Labus J, Winata J, Schmidt T, et al. Perioperative two-dimensional left ventricular global longitudinal strain in coronary artery bypass graft surgery: A prospective observational pilot study. J Cardiothorac Vasc Anesth 2022;36:166–74.

13 Licker M, Diaper J, Sologashvili T, et al. Glucose-insulin-potassium improves left ventricular performances after aortic valve replacement: A secondary analysis of a randomized controlled trial. BMC Anesthesiol 2019;19:175.

14 Fredholm M, Jörgensen K, Houltz E, et al. Inotropic and lusitropic effects of levosimendan and milrinone assessed by strain echocardiography - a randomized trial. Acta Anaesthesiol Scand 2018;62:1246–54.

15 Saito M, Iannaccone A, Kaye G, et al. Effect of right ventricular pacing on right ventricular mechanics and tricuspid regurgitation in patients with high-grade atrioventricular block and sinus rhythm (from the Protection of Left Ventricular Function During Right Ventricular Pacing Study). Am J Cardiol 2015;116:1875–82.

16 Dalla K, Bech-Hanssen O, Ricksten SE. General anesthesia and positive pressure ventilation suppress left and right ventricular myocardial shortening in patients without myocardial disease - a strain echocardiography study. Cardiovasc Ultrasound 2019;17:16.

17 Juhl-Olsen P, Bhavsar R, Frederiksen CA, et al. Systolic heart function remains depressed for at least 30 days after on-pump cardiac surgery. Interact Cardiovasc Thorac Surg 2012;15:395–9.

18 Yin ZY, Li XF, Tu YF, et al. Speckle-tracking imaging to monitor myocardial function after coronary artery bypass graft surgery. J Ultrasound Med 2013;32:1951–6.

19 Cho GY, Marwick TH, Kim HS, et al. Global 2-dimensional strain as a new prognosticator in patients with heart failure. J Am Coll Cardiol 2009;54:618–24.

20 Zhang KW, French B, May Khan A, et al. Strain improves risk prediction beyond ejection fraction in chronic systolic heart failure. J Am Heart Assoc 2014;3:e000550.

21 Bertini M, Ng AC, Antoni ML, et al. Global longitudinal strain predicts long-term survival in patients with chronic ischemic cardiomyopathy. Circ Cardiovasc Imaging 2012;5:383–91.

22 Lafitte S, Perlant M, Reant P, et al. Impact of impaired myocardial deformations on exercise tolerance and prognosis in patients with asymptomatic aortic stenosis. Eur J Echocardiogr 2009;10:414–9.

23 Zhang K, Sheu R, Zimmerman N, et al. A comparison of global longitudinal, circumferential, and radial strain to predict outcomes after cardiac surgery. J Cardiothorac Vasc Anesth 2019;33:1315–22.

24 Howard-Quijano K, Methangkool E, Scovotti JC, et al. Regional left ventricular myocardial dysfunction after cardiac surgery characterized by three-dimensional strain. Anesth Analg 2019;128:854–64.

25 Feinman J. Beyond ejection fraction: The role of intraoperative left ventricular strain analysis. J Cardiothorac Vasc Anesth 2019;33:1323–4.

26 Yingchoncharoen T, Agarwal S, Popovic ZB, et al. Normal ranges of left ventricular strain: a meta-analysis. J Am Soc Echocardiogr 2013;26:185–91.

27 Truong VT, Phan HT, Pham KNP, et al. Normal ranges of left ventricular strain by three-dimensional speckle-tracking echocardiography in adults: A systematic review and meta-analysis. J Am Soc Echocardiogr 2019;32:1586–97.

28 Levy PT, Machefsky A, Sanchez AA, et al. Reference ranges of left ventricular strain measures by two-dimensional speckle-tracking echocardiography in children: A systematic review and meta-analysis. J Am Soc Echocardiogr 2016;29:209–25.

29 Gold AK, Kiefer JJ, Feinman JW, et al. Left atrial strain − a valuable window on left ventricular diastolic function. J Cardiothorac Vasc Anesth 2021;35:1626–7.

30 Spence J, Mazer CD. The future directions in cardiac anesthesiology. Anesthesiol Clin 2019;37:801–13.