21. Nashef SA, Roques F, Michel P, Gauducheau E, Lemeshow S, Salamon R. European system for cardiac operative risk evaluation (euroSCORE). *Eur J Cardiothorac Surg*. 1999;16:9-13.
22. Lang RM, Bierig M, Devereux RB, Flachskampf FA, Foster E, Pellikka PA, et al. Recommendations for chamber quantification: a report from the American Society of Echocardiography's Guidelines and Standards Committee and the Chamber Quantification Writing Group, developed in conjunction with the European Association of Echocardiography, a branch of the European Society of Cardiology. *J Am Soc Echocardiogr*. 2005;18:1440-63.
23. Nagueh SF, Appleton CP, Gillebert TC, Marino PN, Oh JK, Smiseth OA, et al. Recommendations for the evaluation of left ventricular diastolic function by echocardiography. *Eur J Echocardiogr*. 2009;10:165-93.
24. Zoghbi WA, Enriquez-Sarano M, Foster E, Grayburn PA, Kraft CD, Levine RA, et al. Recommendations for evaluation of the severity of native valvular regurgitation with two-dimensional and Doppler echocardiography. *J Am Soc Echocardiogr*. 2003;16:777-802.
25. Bonow RO, Carabello BA, Kanu C, de Leon AC Jr, Faxon DP, Freed MD, et al. ACC/AHA 2006 guidelines for the management of patients with valvular heart disease: a report of the American College of Cardiology/American Heart Association Task Force on Practice Guidelines (writing committee to revise the 1998 guidelines for the management of patients with valvular heart disease): developed in collaboration with the Society of Cardiovascular Anesthesiologists: endorsed by the Society for Cardiovascular Angiography and Interventions and the Society of Thoracic Surgeons. *Circulation*. 2006;114:e84-231.
26. Wilkins GT, Weyman AE, Abascal VM, Block PC, Palacios IF. Percutaneous balloon dilatation of the mitral valve: an analysis of echocardiographic variables related to outcome and the mechanism of dilatation. *Br Heart J*. 1988;60:299-308.
27. Carasso S, Yang H, Woo A, Jamorski M, Wigle ED, Rakowski H. Diastolic myocardial mechanics in hypertrophic cardiomyopathy. *J Am Soc Echocardiogr*. 2010;23:164-71.
28. Carasso S, Yang H, Woo A, Vannan MA, Jamorski M, Wigle ED, et al. Systolic myocardial mechanics in hypertrophic cardiomyopathy: novel concepts and implications for clinical status. *J Am Soc Echocardiogr*. 2008;21:675-83.
29. Yang H, Carasso S, Woo A, Jamorski M, Nikonova A, Wigle ED, et al. Hypertrophy pattern and regional myocardial mechanics are related in septal and apical hypertrophic cardiomyopathy. *J Am Soc Echocardiogr*. 2010;23:1081-9.
30. Marwick TH, Leano RL, Brown J, Sun JP, Hoffmann R, Lysyansky P, et al. Myocardial strain measurement with 2-dimensional speckle-tracking echocardiography: definition of normal range. *JACC Cardiovasc Imaging*. 2009;2:80-4.
31. Fitzmaurice GM, Laird NM, Ware JH. *Applied Longitudinal Analysis*. Hoboken, NJ: Wiley; 2004.
32. Olsen NT, Sogaard P, Larsson HB, Goetze JP, Jons C, Mogelvang R, et al. Speckle-tracking echocardiography for predicting outcome in chronic aortic regurgitation during conservative management and after surgery. *JACC Cardiovasc Imaging*. 2011;4:223-30.
33. Dahl JS, Videbaek L, Poulsen MK, Rudbaek TR, Pellikka PA, Moller JE. Global strain in severe aortic valve stenosis: relation to clinical outcome after aortic valve replacement. *Circ Cardiovasc Imaging*. 2012;5:613-20.
34. Desai MY, Karunakaravel K, Wu W, Agarwal S, Smedira NG, Lytle BW, et al. Pulmonary fibrosis on multidetector computed tomography and mortality in patients with radiation-associated cardiac disease undergoing cardiac surgery. *J Thorac Cardiovasc Surg*. 2013;148:475-81.e3.
35. Boyle CA, Decoufle P. National sources of vital status information: extent of coverage and possible selectivity in reporting. *Am J Epidemiol*. 1990;131:160-8.
36. Lauer MS, Blackstone EH, Young JB, Topol EJ. Cause of death in clinical research: time for a reassessment? *J Am Coll Cardiol*. 1999;34:618-20.

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EDITORIAL COMMENTARY

A not-so-simple measure

James I. Fann, MD

See related article on pages 1643-51.

One can picture a future in which a surgeon sitting comfortably at his console enters patient data into a computer that promptly generates the probability of surgical success. To a large extent today, the Society of Thoracic Surgeons National Database and the European System for Cardiac Operative Risk Evaluation (EuroScore) provide such assessments for many cardiac disorders. Further, clinicians currently rely on various diagnostic tests, many used for

prognostication, to evaluate cardiac function during the perioperative period. However, there are diseases, such as those related to previous thoracic irradiation for malignancy, that continue to frustrate surgeons mainly because there are no good predictors of outcome. What is needed is a method to better understand the degree of myocardial injury to have reliable estimates of recoverability in the

From the Department of Cardiothoracic Surgery, Stanford University Medical Center, Stanford, Calif.

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Address for reprints: James I. Fann, MD, Department of Cardiothoracic Surgery, Stanford University Medical Center, FALK CVRC, 300 Pasteur Dr, Stanford, CA 94305 (E-mail: jfann@stanford.edu).

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short and long term. Not to be overlooked are noncardiac-related confounders, such as the degree of pulmonary compromise, that influence long-term survival in these challenging patients.

In this issue of the *Journal*, Chirakarnjanakorn and colleagues¹ are to be commended for carefully evaluating the usefulness of echocardiographic parameters in assessing patients with radiation-associated cardiac disease. In addition to ejection fraction, left ventricular end-diastolic volume, left ventricular end-systolic-volume, and the degree of diastolic function and of valvular disease, the investigators employed echocardiographic speckle tracking to quantify myocardial strain or regional deformation. In this case, the measurement is focused on the long axis (ie, the left ventricular global longitudinal strain [LV-GLS]), where negative strain means regional shortening and positive strain means regional elongation. For those not familiar with this approach, LV-GLS is generated based on an average of 18 segmental strains in the long-axis and multiple chamber views. Endocardial borders are traced and myocardial deformation is tracked using existing software. Measurements made at 3 left ventricular levels provide composite LV-GLS values. Abnormal LV-GLS is defined as equal to or worse than -14.5% (or 14.5% shortening). Such a technique has been posited by many to be more sensitive in detecting myocardial dysfunction than standard echocardiographic parameters and to be predictive of surgical outcomes.

Previous investigators have shown the utility of speckle tracking and LV-GLS measurement in assessing patients with aortic insufficiency and aortic stenosis.^{2,3} Employing LV-GLS assessment as a predictive marker in a high-risk cohort with radiation-associated cardiac disease is of particular interest to surgeons. In this series of patients undergoing cardiac surgery, even with a 30-day mortality rate of only 2%, an additional 8% die during the first year. At a mean follow-up of 6.6 years, more than one-half of patients have died. These mortality rates occur despite the fact that nearly three-fourth of patients have an ejection fraction $\geq 50\%$ at time of surgery. The caveat is that because more than one-half of patients had at least moderate mitral regurgitation, left ventricular function is likely overestimated by measuring ejection fraction; nonetheless, the outcomes are much worse than one would expect.

As attractive as LV-GLS assessment may seem initially, reviewing the study findings points to potential weaknesses of the technique—at least in this patient population and as

acknowledged by Chirakarnjanakorn and colleagues.¹ First, it is not surprising that given its sensitivity, LV-GLS measurements provide no additional predictive value in high-risk patients (ie, high EuroScore). In patients with normal ejection fraction, the mortality rate in those with an abnormal LV-GLS is higher than in those with normal LV-GLS. In low-risk patients (ie, low EuroScore), an abnormal LV-GLS is also associated with higher mortality. Notwithstanding, LV-GLS does not emerge as an independent predictor of long-term outcomes; that is, for ejection fraction and LV-GLS measurements, there is substantial overlap between survivors and nonsurvivors. So, one proposal to enhance the predictive ability is to combine the estimates of outcomes from large databases with LV-GLS measurements, or perhaps consider coupling LV-GLS with assessment of diastolic function. This approach appears reasonable, but more work will be needed to determine the relative weight of each modality and the degree of incremental utility.

So, will LV-GLS be a button on the console of the future? Clearly, LV-GLS measurement is an interesting technique that may enhance our assessment of cardiac function. On the other hand, current utility (and resolution) of this method is not quite there—perhaps because of the limits of the technology itself or because we are just short of realizing its potential. Further, because injury to the thoracic contents by radiation therapy may be diffuse, one wonders whether a single measurement can be predictive. As Chirakarnjanakorn and colleagues¹ suggest, a more comprehensive cardiac and pulmonary evaluation is likely more helpful before consideration of cardiac surgery. As we gain greater experience with various high-risk cardiac disorders, other modalities, such as magnetic resonance imaging or 3-dimensional echocardiography, may emerge as strong competitors in our quest to better detect cardiac dysfunction. In the meantime, predicting surgical outcomes is not so simple.

References

1. Chirakarnjanakorn S, Popovic ZB, Wu W, Masri A, Smedira NG, Lytle BW, et al. Impact of long axis function on cardiac surgical outcomes in patients with radiation associated heart disease. *J Thorac Cardiovasc Surg*. 2015;149:1643-51.e2.
2. Olsen NT, Sogaard P, Larsson HBW, Goetze JP, Jons C, Mogelvang R, et al. Speckle-tracking echocardiography for predicting outcome in chronic aortic regurgitation during conservative management and after surgery. *J Am Coll Cardiol Img*. 2011;4:223-30.
3. Luszcak J, Olszowska M, Drapisz S, Plazak W, Karch I, Komar M, et al. Assessment of left ventricular function in patients with symptomatic and asymptomatic aortic stenosis by 2-dimensional speckle-tracking imaging. *Med Sci Monit*. 2012;18:91-6.