Supplemental Digital Content 2

Conventional echocardiographic data collection

Preoperative and postoperative transthoracic echocardiographic assessment of myocardial function was performed by echocardiographic technicians in the Cleveland Clinic Echocardiographic Laboratory using a Vivid E9 Ultrasound system with a GE M5S-D active matrix single crystal phased array transducer and 4V-D active matrix 4D volume phased array transducer (GE Healthcare Vingmed Ultrasound AS, Horten, Norway). Two-dimensional (2D) and Doppler echocardiography were used to assess the severity of aortic stenosis with aortic valve area (using the continuity equation) and transvalvular gradients. Left ventricular (LV) mass was calculated using wall thickness and chamber dimensions measured by 2D or M-mode echocardiography from the parasternal long-axis view.[1] Three-dimensional left ventricular ejection fraction was measured. All echocardiographic data was assessed using EchoPAC v.112 (GE Healthcare Vingmed Ultrasound AS).

Intraoperative transesophageal echocardiographic examination was performed with Vivid S6 or Vivid E9 Ultrasound systems (GE Healthcare Vingmed Ultrasound AS). Transesophageal echocardiographic images were collected with a multi-plane phased array GE 6Tc-RS 2.9-8.0 MHz transducer or an active matrix 4D volume phased array 3.0-8.0 MHz transducer (GE Healthcare Vingmed Ultrasound AS) and stored for off-line analysis.

Analysis of conventional intraoperative echocardiographic parameters included assessment of severity of aortic stenosis by measurement of peak and mean transvalvular gradients and/or aortic valve area calculated by 2D images with planimetry or continuous wave and pulse wave Doppler using the continuity equation. The standardized transesophageal echocardiographic examination included 2D and Doppler measures of left and right ventricular systolic and diastolic function, as well as images stored for off-line assessment of myocardial deformation using

speckle-tracking echocardiography with special analysis software (EchoPAC v. 112). Standard echocardiographic parameters of LV systolic function included the following: 1) LV ejection fraction measured from the mid-esophageal four- and two-chamber (90°) view calculated using Simpson's biplane method of discs; and 2) peak myocardial velocity in systole (s') measured at the lateral mitral annulus using color tissue Doppler. Echocardiographic measures of diastolic myocardial function included: 1) parameters calculated from transmitral inflow velocity, including peak velocity in early (E-wave) and late (A-wave) diastole, and deceleration time of the E-wave; 2) peak myocardial early (e') and late (a') diastolic myocardial velocities measured at the lateral mitral annulus with color tissue Doppler; and, 3) propagation velocity of mitral valve inflow measured with M-mode color Doppler. Right ventricular systolic function was assessed in the 2D transesophageal four-chamber view centered on the right ventricle by fractional area change and tricuspid annular plane systolic excursion assessed by measuring the apical displacement of the lateral tricuspid annulus.

Speckle-tracking echocardiographic analysis of myocardial strain and strain rate

Two-dimensional strain analysis uses grayscale (B-mode) sector images and is based on frame-by-frame tracking of myocardial movement and deformation using a unique pattern of bright and dark pixels, or speckles, in echocardiographic images.[2] These speckles, which are constructive and destructive interference patterns generated by reflected ultrasound from inhomogeneous myocardial tissue, are tracked from one frame to another throughout the cardiac cycle and are used to assess myocardial deformation. Analysis of echocardiographic views for strain analysis involves tracing the endocardial contour on an end-systolic cavitary frame and defining the thickness of the myocardial region. The software automatically tracks the ventricular wall on subsequent frames and divides it into six segments. Manual adjustment of the endocardial contour and thickness of the region is performed when necessary. The software program deems tracking quality acceptable or unacceptable. However, the user can override

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this designation based on visual confirmation of proper tracking of myocardial motion.

References

1.   Devereux RB, Alonso DR, Lutas EM, Gottlieb GJ, Campo E, Sachs I, Reichek N: Echocardiographic assessment of left ventricular hypertrophy: Comparison to necropsy findings. Am J Cardiol 1986; 57:450–8

2.   Duncan AE, Alfirevic A, Sessler DI, Popovic ZB, Thomas JD: Perioperative assessment of myocardial deformation. Anesth Analg 2014; 118:525–44