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QUANTIFICATION OF RIGHT VENTRICULAR FUNCTION WITH DOPPLER TISSUE IMAGING

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Introduction: Intraoperative assessment of right ventricular (RV) function during cardiac surgery, often critical during separation from cardiopulmonary bypass, has so far been highly subjective. Imaging strategies to quantify RV function are limited and often difficult to acquire because of the more complex geometry of the RV. Doppler Tissue Imaging (DTI) is a relatively new echocardiographic technique that allows instantaneous and accurate measurement of myocardial velocities. In addition, DTI-derived strain and strain rate have been shown to characterize changes in myocardial deformation. We therefore hypothesized that the intraoperative assessment of RV function could be quantified by the measurement of myocardial velocities and deformation using Pulsed Wave and Color Flow DTI.

Methods: Following IRB approval, 12 patients undergoing elective cardiac surgery were enrolled. Right ventricular stroke work index (RVSWI) was obtained using an indwelling pulmonary artery catheter. As part of the routine TEE examination, 3 beat loops of the mid-esophageal 4-chamber view, optimized to provide a true long-axis view of the RV, were recorded onto magneto-optical disk. From this long-axis view, RV ejection fraction area (RVEFA) and ejection fraction (RVEF) were measured by tracing the RV endocardial border at end-diastole and end-systole, and employing Simpson's method of discs. Additionally, the tricuspid annular plane systolic excursion ratio (TAPSE) was calculated as the end diastolic length minus end systolic length divided by end diastolic length. Furthermore, the Myocardial Performance Index (MPI), defined as isovolumic contraction time plus isovolumic relaxation time divided by the ejection time, was computed by measuring tricuspid inflow intervals and right ventricular outflow time. Subsequently, diastolic (E', A') and peak systolic (S') velocities were acquired from the lateral annulus in the mid-esophageal 4-chamber view and/or the transgastric short axis view, optimized for the best right-sided views and the most parallel incident Doppler pulse. Color Flow DTI of the RV free wall was also recorded for off-line analysis of strain and strain rate using custom software (DTC™, Advanced Medical Imaging Development, Trieste, Italy). All data sets were collected using a Phillips Sonos 5500 ultrasound system and a multiplane probe. Descriptive analysis using Pearson's correlation coefficient was initially conducted to assess the relationship between DTI and conventional measures of RV function. Simple linear regression was then applied to evaluate the null hypothesis that there is no linear relationship between the various measures of RV function. All statistical analyses were conducted using SAS v8.2, and a p-value<0.05 was considered significant.

Results: Diastolic parameters (E', A') were readily obtained in all patients using DTI but were quantifiable using tricuspid inflow velocities in only 58% of patients. RV diastolic dysfunction by DTI (E'/A'<1) was present in 10/12 patients (83%). The distribution and variance of the 8 measures of RV function are shown in Table 1. Peak systolic DTI velocity was significantly correlated with TAPSE (r=0.56), RVEF (r=0.77), RVEFA (r=0.70), and MPI (r=-0.63). Strain and strain rate were significantly correlated only to TAPSE (r=-0.70 and -0.82). Regression analysis revealed a linear relationship between peak systolic DTI velocity and RVEF (p=0.004), RVEFA (p=0.01) and MPI (p=0.03), and between strain rate and TAPSE (p=0.01).

Conclusions: Diastolic dysfunction of the RV is common in patients undergoing cardiac surgery and readily identifiable by DTI. Peak systolic DTI velocity of the lateral annulus may provide a new method for quantifying RV function. Although strain and strain rate are thought to be less influenced by overall cardiac motion and tethering effects, they were not useful markers of RV function in this study possibly as a result of the smaller sample size.

Figure 1: Pulsed Wave DTI of RV lateral annulus

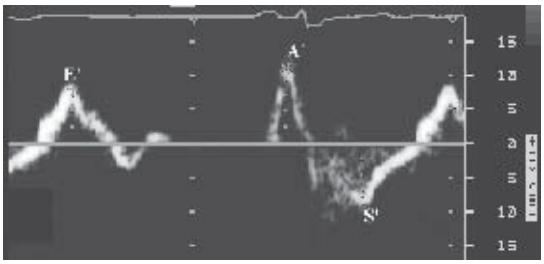

Table 1: Measures of RV function

	N	Mean (SD)
TAPSE	12	0.20 (0.06)
RVEF (%)	12	47.8 (12.1)
RVEFA (%)	12	34.9 (11.2)
MPI	12	0.37 (0.21)
RVSWI (g-m/m^2/b)	11	6.3 (2.5)
Peak systolic velocity (cm/s)	12	-7.8 (3.0)
Strain (%)	8	-20.9 (8.1)
Strain rate (s^{-1})	8	-1.27 (0.58)