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REVIEW

Tissue Doppler Imaging in Echocardiography: Value and Limitations

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Tissue Doppler imaging (TDI) is a useful echocardiographic technique to evaluate global and regional myocardial systolic as well as diastolic function. It can also be used to quantify right ventricular and left atrial function. Recent studies have demonstrated its utility as a diagnostic as well as prognostic tool in different cardiac conditions including coronary artery disease, heart failure (both systolic and diastolic), valvular heart disease, cardiomyopathies as well as constrictive pericarditis. TDI measurements are also helpful to identify patients who will benefit from cardiac resynchronisation therapy. Even though it is reproducible and relatively easy to obtain, it is underutilised in routine clinical practice. TDI is readily available on most commercially available echocardiographic systems, and we recommend that TDI be used for routine clinical echocardiographic evaluation of patients.

Keywords Tissue Doppler imaging • Colour tissue Doppler imaging • Myocardial contraction velocity • Left ventricular systolic function • Left ventricular diastolic function

Tissue Doppler imaging (TDI) for echocardiographic evaluation of myocardial function was first described in 1989, [1] and has revolutionised the quantitative evaluation of myocardial function. Doppler ultrasound relies on detection of a frequency shift of ultrasound signals reflected from moving objects. In the heart, both blood flow and myocardial contraction result in velocity changes. Blood flow causes high frequency, low amplitude signals that are obtained using traditional Doppler. Tissue Doppler imaging is designed to characterise low velocity, high amplitude signals from myocardial motion [2], and are obtained by inverting the low pass filter used in traditional Doppler to a high pass filter.

The myocardium has subendocardial and epicardial layers, with the former having longitudinally arranged myofibres [3]. During ventricular contraction, various layers exert varying tension with the endocardium moving greater distances. Tissue Doppler imaging examines the longitudinal component of myocardial contraction throughout the cardiac cycle.

Tissue Doppler imaging is obtained using pulsed wave tissue Doppler or colour tissue Doppler imaging (CTDI). Pulsed wave TDI measures peak longitudinal myocardial velocity from a single segment, but has to be performed 'on line'. Colour tissue Doppler imaging is performed 'off line', and can interrogate velocities from multiple sites simultaneously [4]. However, CTDI represents the mean peak velocity, and are ~25% lower than pulsed wave Doppler [5]. The two methods are therefore not interchangeable. The major disadvantage of TDI is its angle dependence i.e. if the angle of incidence exceeds 15 degrees, there is ~4% underestimation of velocity [6]. Accurate TDI imaging additionally requires high frame rates (>100fps) for image acquisition with excellent temporal resolution.

TDI Measurement

The TDI signal over a cardiac cycle has three peaks, a positive systolic peak and two negative diastolic peaks (Fig. 1A & B).

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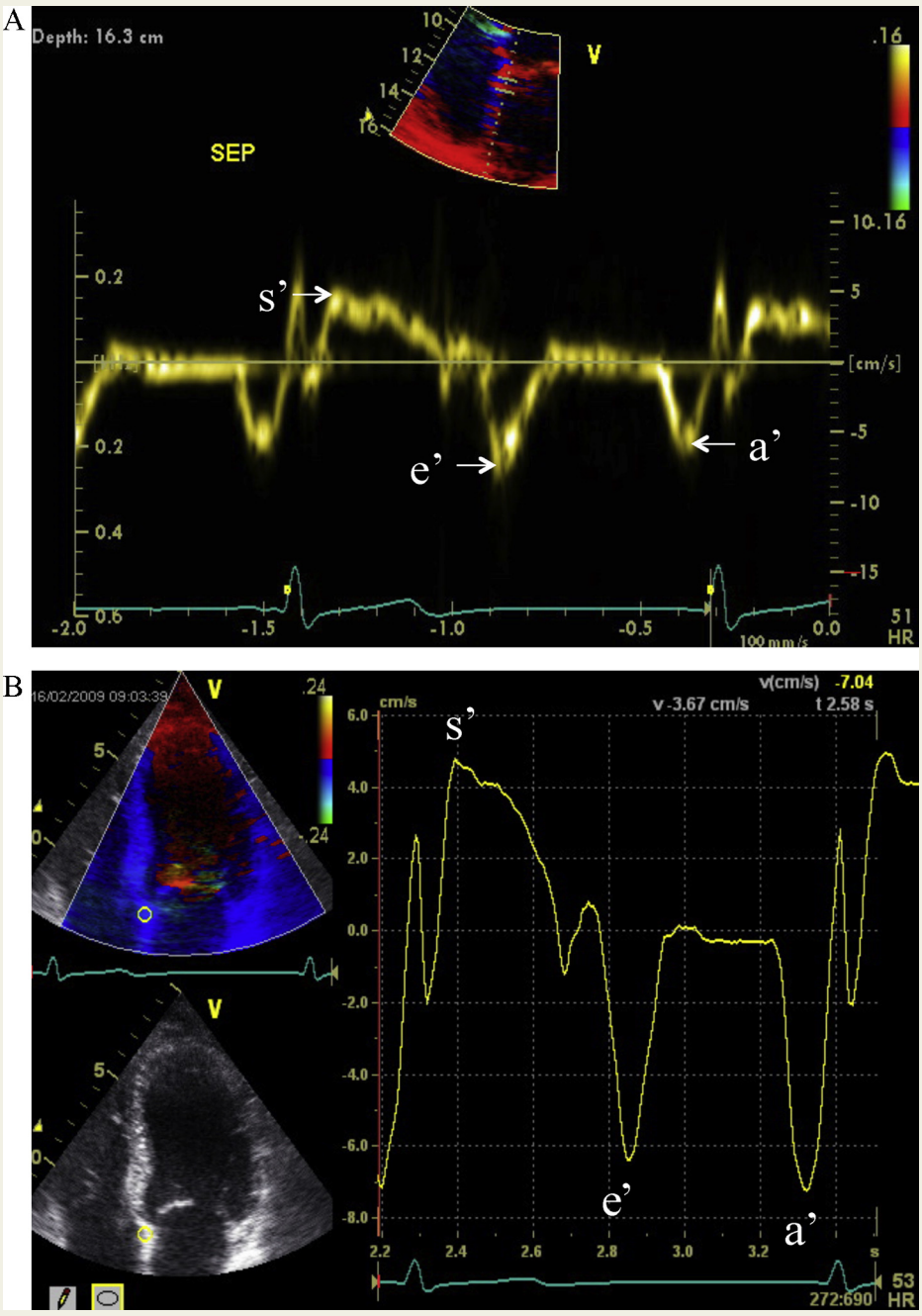

Figure 1 (A) Pulsed wave tissue Doppler Imaging from the apical 4 chamber view sampling from the septal mitral annulus (B) Colour Tissue Doppler Imaging from the apical 4 chamber view sampling from the septal mitral annulus.

The positive systolic wave (s′ velocity, Sa or Sm) represents myocardial contraction. The negative waves represent the early diastolic myocardial relaxation (e′ velocity, Ea or Em) and active atrial contraction in late diastole (a′ velocity, Aa or Am) (Fig. 1 A & B). The time to peak s′ velocity can be measured and segmental heterogeneity can be ascertained using CTDI [7] (Fig. 2). Additionally, isovolaemic contraction and relaxation periods can also be identified. (Fig. 3) Pulsed wave TDI velocity measurements are obtained by placing the sample volume at the mitral annular level (denoted Sa/s′ or Ea/e′ or Aa/a′) or within the basal LV myocardial segment (denoted Sm or Em or Am). Tissue Doppler imaging velocities can be measured either from the septal or lateral annulus, but the current recommendation is that e′ velocity is expressed as the average of septal and lateral measurements [8]. The current accepted nomenclature favours denoting TDI velocities as s′, e′ and a′, although the other abbreviations are also commonly used. Normal pulsed TDI values are given in Table 1.

Normal ageing can alter TDI derived myocardial velocities. There is a decrease in s′ and e′ velocities with ageing,