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● *Original Contribution*

SPECKLE TRACKING USING GRAY-SCALE INFORMATION FROM TISSUE DOPPLER RECORDINGS *VERSUS* REGULAR GRAY-SCALE RECORDINGS IN TERM NEONATES

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Abstract—The use of 2-D strain speckle tracking echocardiography in B-mode images from tissue Doppler (TD) recordings was compared with its use in regular gray-scale (GS) recordings in healthy and asphyxiated neonates at days 1–3. Single-cycle and three-cycle longitudinal deformation indices were assessed. Median B-mode frame rates were 38/s (TD) and 77/s (GS). Systolic indices were similar for TD and GS recordings. Diastolic indices were lower for TD recordings. Single-cycle and three-cycle indices were equal. TD and GS recordings were similar in reproducibility, except for single-cycle inter-observer peak systolic strain rate and three-cycle intra-observer strain rate during atrial systole. Single-cycle reproducibility was lower than three-cycle reproducibility in all TD recording indices, GS recording inter-observer peak systolic strain and GS recording inter-observer early diastolic strain rate. Inter-observer reproducibility and intra-observer reproducibility were similar, except GS recording single-cycle peak systolic strain. In conclusion, use of TD and GS recordings interchangeably was feasible for systolic but not for diastolic indices. Three-cycle analyses improved reproducibility, especially in TD recordings.
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Key Words: **Repeatability, Speckle tracking echocardiography, Heart function, Deformation analysis, Cardiology, Infant, Myocardial function, Echocardiography, Myocardial performance assessment, Tissue Doppler imaging.**

INTRODUCTION

The use of echocardiography for functional assessment in neonates is emerging (Kluckow et al. 2007; Mertens et al. 2011). Assessing cardiac structural normality in neonates with impaired circulation is paramount because neonates with structural versus functional disturbances might have similar clinical presentations and even share many echocardiographic findings. A cyanotic neonate might have right-to-left ductus arteriosus shunting, but the management depends on whether the condition is due to high pulmonary vascular resistance or a congenital heart defect with ductus-dependent systemic circulation. The images at the initial examination must therefore have sufficient spatial and temporal resolution for identification of all relevant structures to assess structural normality. However, once structural normality is established, the intensivist can perform subsequent examinations with a focus on functional assessment.Accordingly, consensus statements from the European Society for Paediatric Research and the European Society for Neonatology (de Boode et al. 2016), from the American Society of Echocardiography (ASE) in collaboration with the European Association of Echocardiography (EAE) and the Association for European Pediatric Cardiologists (Mertens et al. 2011) and from UK Neonatologists with an Interest in Cardiology and Haemodynamics in collaboration with the British Congenital Cardiac Association (BCCA) and the Paediatricians with Expertise in Cardiology Special Interest Group (PECSIG) (Singh et al. 2016) recommend an initial comprehensive study to ensure structural normality when echocardiography is used for assessment of function in neonates.

It is possible to perform speckle tracking echocardiography (STE) by 2-D strain in B-mode images from tissue Doppler (TD) and gray-scale (GS) recordings

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because both recordings contain B-mode images. The intensivist can acquire the images more rapidly if it is sufficient to obtain B-mode images from TD recordings and omit the GS recordings. This decreases the time needed for image acquisition in vulnerable and fragile newborns. However, the lower quality of the B-mode images from TD than from GS recordings might affect STE measurements. In children, analysis of B-mode images of high frame rate (55–90/s) versus analysis of the same B-mode images after transformation into lower frame rate (30/s) for archiving in standard format (Digital Imaging and Communications in Medicine [DICOM]) has revealed lower left longitudinal global Lagrangian strain values after transformation (Koopman et al. 2011). On the other hand, a meta-analysis of right ventricle systolic and diastolic deformation indices in children found that frame rate did not explain the heterogeneity between studies (Levy et al. 2014). In neonates, the small image sector enables high frame rates. However, as neonatal heart rates are high, the ratio between frame rate and heart rate still might be a challenge, and frame rate requirements from pediatric cardiology might not be directly transferable to neonates.

Analysis of more than one cycle can reduce random variation. Current recommendations for adults suggest single-cycle chamber quantification analyses (Lang et al. 2015). Grattan and Mertens (2014) have suggested analysis of one cycle for conventional and newer functional indices in pediatric patients, whereas Lopez et al. (2010) recommended using three cycles for velocity measurements and for assessment of left ventricle diameter. Reproducibility is improved in children by analyzing more cycles, most evident for indices with lower reproducibility (Lee et al. 2014).

Speckle tracking echocardiography analyses are less vulnerable to disturbances from a poor angle of insonation, whereas analyses based on TD velocities have better time resolution. We are not aware of studies comparing STE of B-mode images from TD and GS recordings, and we are not aware of studies comparing single-cycle and multiple-cycle analyses of deformation indices by STE in neonates. If it proves feasible to perform STE in B-mode images from TD recordings, it would be possible to assess functional indices in two dimensions by STE and indices of high frame rate by TD from the same recordings.

The aim of this study was to compare longitudinal STE measurements in B-mode images from TD and GS recordings in neonates to assess whether the lower image quality of the B-mode image from TD recordings, compared with that from GS recordings, had an impact on indices and repeatability. Further, we wanted to assess the effects of analyzing one cycle versus three cycles and to explore if it is feasible to use B-mode images from TD and GS recordings interchangeably in STE.

METHODS

Participants and images

In this observational study, we used images from neonates examined on days 1–3 of life. Images from these patients were earlier included in studies of heart function using TD deformation analyses in healthy neonates (Nestaas et al. 2009) and neonates after perinatal asphyxia treated by normothermia (Nestaas et al. 2011, 2012) and hypothermia (Nestaas et al. 2014).

We randomly selected 27 sets of apical four-chamber recordings from structurally normal hearts: 7 of the right lateral walls, 7 of the septum and 13 of the left ventricle. Each set consisted of TD and GS recordings of the same wall recorded at the same examination. Septum walls were preferably analyzed together with left lateral walls as indices of left ventricle function (Fig. 1), but we included analyses of the septum as a separate wall because images of the septum are more often analyzable than those of the left lateral wall (Nestaas et al. 2009). Therefore, in a clinical setting, images of septum walls could be of sufficient quality for analysis when images of the left lateral walls are not.

The most common reason for excluding images was the presence of substantial amounts of clutter. We found clutter most frequently in the apical part of the left lateral wall. We used three heart cycles from each recording. If fewer than three analyzable heart cycles were available in the B-mode images from either the TD or GS recordings, we replaced the set with another set of TD and GS recordings from the same wall. The study size was based on power calculations from tissue Doppler deformation analysis (Nestaas et al. 2012), aiming at 80% power for detecting 10% differences between measurements in the pairwise analyses by use of two-sided 95% confidence intervals.

We recorded TD and GS multiple-cycle images on Vivid 7 and 6 S scanners (GE, Horten, Norway) by use of a phase-array probe (5 S probe, GE) transmitting at 2.4 MHz. D.F. and E.N. recorded most images. We used second harmonic imaging for all B-mode images. The depth of the image sector was 6 cm, and the angle of the sector approximately 80°, in most images (Fig. 1). During recording, the B-mode frame rate could be adjusted one step up or down from the default settings. We recorded all images by the default frame rate. The beam density for the B-mode image was similar in TD and GS recordings, typically 160 beams per sector. In the TDI recordings, we acquired the TD