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Temporal and spatial accuracy of 3D real time echocardiography in the neonatal and pediatric setting - Validation studies using small moving and pulsative phantoms

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Objective: Purpose of the study was to verify the accuracy of RT-3DE for the assessment of small cardiac volumes and high frequencies similar to newborn and pediatric hearts.
Material & Methods: For the assessment of spatial and temporal resolution of 3D-matrix transducer, customized, small test phantoms were moved linear in a water basin. The accuracy of 3D-volume calculations and measurement of time periods was tested by pulsatile balloon-phantoms. The calibrated phantoms were controller-operated to ascertain the exact end-diastolic and end-systolic volume, cardiac cycle length, isovolumetric phases and volume time curves. Artificial cardiac cycles with different volumes (5-17ml) and variably frequencies (60-150/min) were acquired by a commercial RT-3DE-System (iE33, Philips, X7-2, X5-1). 3D-volumes were calculated with two semi-quantitative software algorithms (QLab, Philips and LV Analysis, TomTec).
Results: Spatial and temporal resolution: 3D-scans of moved test objects showed a spatial distortion which is attributed to the inherent sequential scanning mode of the matrix transducer. Different parts of the test objects are not scanned simultaneous; they are acquired with a time delay between 22-45.2 ms, which is equally to the time duration of a single 3D-frame.
Assessment of 3D-volumetry: 3D-data sets did not include the complete cardiac cycle, 15% of the end-diastolic period were missing (fig 1). Prolonged isovolumetric phases were not recognized. Volumes were underestimated.
Conclusion: RT-3DE is an established tool to assess ventricular function and volume, but different segments of moving objects are scanned with delay. This can result in significant misinterpretation of segmental synchrony and averaging of volumes. Quantification of volume time curves by software systems follows strict algorithms which are adapted to a normal cardiac cycle. If time flow (prolonged isovolumetric phases) or geometry deviate from this, imprecise calculations of the volume changes over time can be caused. Clinicians have to consider these limitations, when using 3D-RTE for volumetry, synchronicity analysis or assessment of valvular movement in fast beating and small hearts.

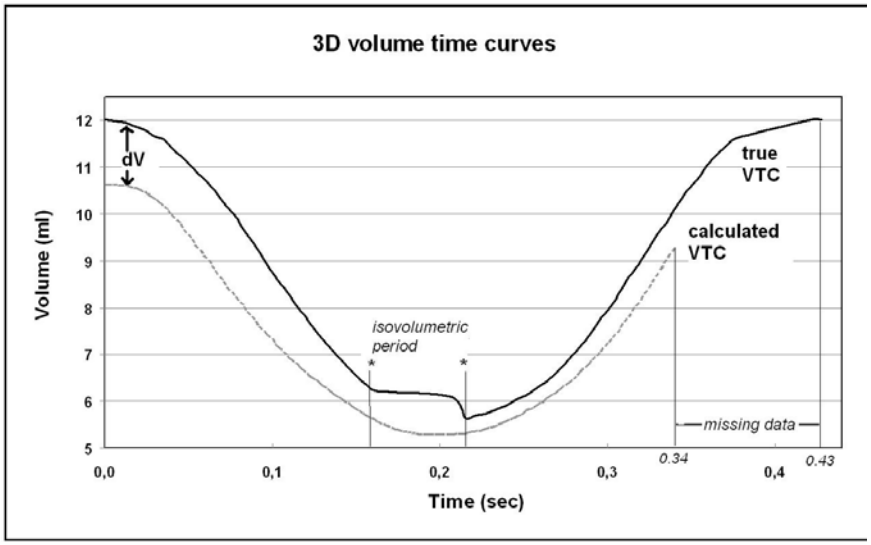

Fig: True (upper, black) vrs. measured 3D-volume time curve (dotted, grey): calculated volumes are smaller than true volumes (dV), cardiac cycle length is incomplete (0.34 vrs 0.43 s; “missing data”), prolonged isovolumetric periods are not recorded (*)