Flow speckle tracking provides new information of complex blood flow in congenital heart disease

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Introduction:
Blood flow patterns in the developing heart have been proposed to play a significant role in cardiac morphogenesis, and most congenital heart diseases (CHD) present with altered blood flow. There is a growing interest in understanding the detailed flow behavior in CHD, and this is now possible using high-end ultrasound imaging equipment. In this feasibility study we demonstrate the potential of flow speckle tracking, a next-generation ultrasound imaging method which is able to visualize and analyze complex flow patterns without the need for contrast agents. We studied blood flow patterns in neonates with different types of CHD.

Methods:
The examinations were performed using linear array transducers where a broad unfocused wave was transmitted and multiple image lines were generated simultaneously. Thus, the acquisition time was lowered and substantially higher frame rates were achieved. With frame rates in the kHz range, it is possible to utilize pattern-matching techniques to quantify the movement of the blood speckle. In this way, the velocity and direction of the blood flow can be calculated and shown as arrows or streamlines over the color-Doppler images, thereby highlighting areas of complex flow as shown in the image below.

Results:
We subsequently examined 35 neonates with different CHD ranging from simple septal defects and valvular stenoses, to more complex heart defects and cardiomyopathies. In spite of the wider footprint of a linear probe, it was possible to obtain images from all standard views. With this new technique, we visualized and quantified vortex formations, for example in the right ventricle near ventricular septal defects (image below), circular flow near valvular stenoses and altered flow dynamics in ventricles with reduced function.

Conclusions:
Flow speckle tracking provides new information of blood flow not available in the traditional color-Doppler images. To be able to detect and quantify complex flow patterns such as vortices in CHD, may be of clinical importance, since it is assumed that vortices play an important role in cardiac function. We hope that improved cardiovascular flow imaging can improve the understanding of both physiology and pathology in CHD. Further studies will explore if the method may improve diagnostics.