Real-time three-dimensional echocardiography for regional evaluation of aortic stiffness

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Abstract  Aortic stiffness is an important predictor of cardiovascular morbidity and mortality. Non-invasive measurement of aortic stiffness is a promising challenge for echocardiography. The most important limitation of previous studies was that regional differences for aortic stiffness were not taken into consideration. In our patient, we demonstrated the usefulness of real-time three-dimensional echocardiography in assessment of regional aortic stiffness.

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Stiffness of large arteries is an important predictor of cardiovascular morbidity and mortality.1 Two-dimensional transthoracic (TTE) and transoesophageal echocardiography (TEE) are both useful methods for the evaluation of stiffness in different aortic regions calculated from aortic and blood pressure data.2-5 Drozdz et al. demonstrated that three-dimensional TEE has a strong potential for regional aortic stiffness measurements using horizontal cross-sectional imaging of the vessel.6 The objective of the present methodological study was to demonstrate the usefulness of real-time three-dimensional transthoracic echocardiography (RT3DE) for regional assessment of aortic stiffness. For this aim we demonstrate a case in which the aortic arch was evaluated with RT3DE. To our knowledge this has not been described before.

RT3DE was performed with a Philips Sonos 7500 ultrasound system (Philips, Best, The Netherlands) attached to an X4 matrix array transducer equipped with a 3D data acquisition software package. The 3D data sets acquired from the supraclavicular window were analysed off-line with assistance of the TomTec 4D Echo-View 5.3 workstation (TomTec Inc., Unterschleissheim, Germany). The aortic lumen can be divided into several segments allowing regional measurements of aortic stiffness. Several indices are used to describe and quantify the physical behaviour of vessels in response to an intraluminal force. For the evaluation of aortic stiffness index \( \beta \), the following formula is used: \( \ln(\text{PS}/\text{PD})/((\Delta D/\Delta D)) \), where PS and PD are the systolic and diastolic blood pressures, DD is the aortic diastolic diameter, \( \Delta D \) is the systolic minus diastolic aortic diameter and ‘ln’ is the natural logarithm. For this elasticity parameter, \( \Delta D \), DD, PS and PD measurements are necessary.

According to this methodology, we evaluated aortic stiffness with RT3DE in a 24-year-old healthy man. From the supraclavicular window, the aortic arch, the distal part of the ascending aorta and the...
proximal part of the descending aorta were visualized. As seen in Figure 1, the cut planes from the 3D data sets that visualized the aorta “en-face” could be easily reconstructed. The reconstructed images allowed the segmental evaluation of aortic cross-sections at different levels. Regional $\beta$ values were calculated using the blood pressure data (122/80 mm Hg) and regional aortic systolic and diastolic diameters.

Discussion

Aortic stiffness is an important predictor of cardiovascular morbidity and mortality.\(^1\) Non-invasive measurement of aortic stiffness is a promising challenge for echocardiography. In previous studies, it has been demonstrated that aortic stiffness can be measured during TTE and TEE examinations.\(^2-^5\) The most important limitation of these studies was that regional differences for aortic stiffness were not taken into consideration. Regional stiffness of the descending aorta can be characterized by 3D-TEE using horizontal aortic cross-sectional images.\(^6\) In our patient, we demonstrated the usefulness of RT3DE in assessment of regional aortic stiffness. However, it should be noted that the echocardiographic window quality (which is somewhat lower compared to two-dimensional TTE) is still a limitation for 3D imaging in some patients. Theoretically, as evidenced in ventricular quantification and carotid artery studies, use of an echo contrast agent may improve aortic image quality.\(^7,^8\)

References