SCIENTIFIC EDITORIAL

Advances in 3D echocardiography: From foetus to printing

Nouveautés en échocardiographie 3D : du fœtus à l’impression

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This special issue of Archives of Cardiovascular Diseases is dedicated to the imaging of congenital heart disease. Major advances in three-dimensional (3D) echocardiography were evoked by John Simpson, in a previous editorial. The following articles, comprising original research and reviews, describe various applications of 3D echocardiography in congenital heart disease: assessment of lesions before heart surgery; guidance for interventional catheterization; and postoperative follow-up. 3D foetal echocardiography has, in turn, also experienced considerable advances, although imaging constraints remain significant. I intend to expand on the three domains that seem the most promising in terms of development of 3D foetal echocardiography, specifically: the advent of foetal matrix transducer probes and of real-time 3D echocardiography; automated 3D navigation and quantification tools; and 3D imaging with greater anatomical resemblance.

The advent of matrix transducer probes has changed the face of 3D echocardiography. For a long time, 3D acquisition was mechanical, with motorized systems external to the phased array transducer probe. 3D echocardiography was neither real-time in its acquisition (several minutes are required during transducer probe rotation) nor in its reconstruction (several hours are required to obtain volume imaging). Furthermore, echocardiograph monitoring requirements rendered 3D acquisition impossible in the foetus.

The first matrix transducer probes appeared in 2002. Therefore, 3D echocardiography became real-time in terms of both acquisition and visualization. The first matrix transducer probes were of low resolution, and were restricted to transthoracic use in adults. Then, higher resolution and more ergonomic transducer probes extended their sphere of application to children and to a transoesophageal approach. We have studied the feasibility of real-time 3D echocardiography in the foetus using a paediatric matrix transducer probe.

* Abbreviations: 3D, three-dimensional; STIC, spatiotemporal image correlation.

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The contribution of the real-time biplane mode to optimizing foetal morphological analysis (particularly vessel outflow tracts, which are difficult to distinguish using two-dimensional echocardiography) has been demonstrated elsewhere [2]. But only recently did the first abdominal matrix transducer probe designed for foetal 3D echocardiography appear. We have reported on its feasibility in 80 foetuses in the absence of heart disease (Fig. 1) [3]. The ergonomics and resolution of the transducer probe made it compatible with clinical use, particularly because matrix transducer probes cover all other modes (M-mode, two-dimensional, flow and tissue Doppler imaging). Further studies are required, especially including foetuses with congenital heart disease, to confirm the superiority of the matrix system in foetal cardiac 3D echocardiography.

3D volume acquisition, even in real-time, is not the overarching solution, as it is still necessary to navigate within this volume. Other 3D acquisition systems preceded the matrix, and used spatial-temporal investigation systems (spatiotemporal image correlation [STIC]). 3D acquisition was mechanical (scanning probe) and navigation was free-hand, which made obtaining cross-sectional views very laborious. Recent automatic recognition software should render the use of STIC easier (Foetal Intelligent Navigation Echocardiography [FINE]) [4]. Automatic retrieval of cross-sectional views may facilitate morphological analysis of the foetal heart, particularly by video transmission. The 3D matrix has also assimilated a system of automatic view recognition (Foetal Heart Navigator); the pertinence of this system in clinical practice is yet to be established [3]. Compared with morphological analysis, 3D echocardiography is an asset to volume quantification. Ventricular volume measurement, widely validated in adult echocardiography, is still complicated in the foetus because of the very small size of the foetal heart. Recent studies have demonstrated the feasibility of left and right ventricular volume measurement in the foetus, providing information on ejection fractions and cardiac debit combined [5].

3D echocardiography allows visualization of intracardiac anatomy, which is much closer to reality and easier to comprehend than 2D echocardiography; its fields of application in children and adults are far reaching, ranging from valvular heart disease to various forms of congenital heart disease, particularly interatrial communication and 3D guidance of percutaneous closure. In the foetus, 3D echocardiography has demonstrated its superiority in its description of surgical repair in the double outlet right ventricle [6]. The fact remains that 3D echocardiography can be theoretical and difficult to interpret for non-users. It is the dream of any cardiac surgeon to hold the model of a heart in his or her hand and form a picture of intracardiac repair. That dream is realised with 3D printing, which is enabled nowadays by volume acquisition produced by a cardiac computed tomography scanner or echocardiography [7]. Studies, which are limited to date, offer hope for a multitude of applications in congenital heart disease, especially interventricular communication and vascular malposition (Fig. 2). The current cost of 3D foetal printing is too high for use in clinical practice.

To conclude, although 3D echocardiography in adults and children has met with great success, imaging constraints remain high in foetuses. 3D foetal echocardiography must break free from these limitations, and improve its ergonomics and resolution before it can be used in clinical practice by specialists in congenital heart disease.

Disclosure of interest

The authors declare that they have no competing interest.
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