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Diagnosing congenital heart disease with three – dimensional echocardiography

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Introduction

Three-dimensional echocardiography is a diagnostic imaging tool used to assess and quantify cardiac anatomy and function. The unique ability of visualizing cardiac structures in three-dimensional ultrasound is obvious in 2016. Moreover, three-dimensional echo is performed with either transthoracic or transesophageal methods. This article will present an overview of 3d echo capabilities and limitations, as well as, a look at its future applications.

3D Echocardiography

Over the past twenty-five years, the field of echocardiography has experienced dramatic technological advancement in image quality, portability, and quantification capabilities. Further, a great deal of time and investment dollars was allocated to 2D echocardiography. The technological limitations were too great to perfect 3D echo in the early eighties. However, Moore law beauty is present in the field of echocardiography. With the advent of advanced matrix array transducers, three- dimensional echocardiography became a reality for the cardiovascular community in the early 90s.

Volumetric acquisition

Three-dimensional echocardiography has many advantages over 2D echocardiography. 2D echocardiography has many technological limitations and barriers to gathering effective clinical data on congenital heart disease. Three-dimensional echo allows images to be presented in all three spatial dimensions: height, width, and depth. Today, 3D echo offers the ability to visualize the whole heart in one full volume image capture. Once this image is acquired, a clinician can cut and crop, the data necessary for diagnosis of congenital heart disease. The key to good image capture is avoiding breathing artifacts, or extremely high heart rates. Due to this limiting factor, 3D echo is not applicable for neonate echo exams now.

Modes of acquisition

There are a few dynamic modes of 3D echo that can be used in either transthoracic or transesophageal modalities. The first mode is live 3D echo. This mode allows for real time visualization of cardiac structures. The next mode is narrow angle or zoom mode. This mode allows for a focused examination of a cardiac structure. There is reduced spatial resolution with this methodology. In addition, full volume mode is best suited for performing ejection fraction measurements. 3D color Doppler provides utility for the grading of stenosis, as well as, assessing cardiac murmurs.

Atrioventricular valves

Three–dimensional echo is uniquely suited for the quantification of vavular disease due to its way of imaging non-planer valve leaflets, chordal structures, and papillary muscles. Three-dimensional echo is vital for the presurgical and postsurgicial follow up of cardiac valve replacements. Morever; three-dimensional color Doppler has utility for assessing mitral regurgitation. 3D echo technology made the TAVR procedure a success story for interventional cardiology.

Congenital heart lesions

3D echo has demonstrated great utility in the diagnosis of complex congenital heart lesions. In addition, 3D echo clarifies the complex interspatial relationship between normal cardiac anatomy and congenital septal defects. This knowledge is vital to the pre surgical planning process for interventional cardiology. The one current technical limiting factor in neonate echocardiography is the fast heart of newborn babies. 3D echo has difficulty trying to process those fast frame frames into an interpretable image.

Ejection fraction quantification

3D echo has improved the ability to acquire a more accurate and reproducible ejection fraction. With 3d echo, there are no geometrical assumptions for calculating an accurate left ventricle volume. This is a great benefit for the pediatric echo community.

Future directions of 3D echo

The future capabilities of this technology are likely to be just as amazing as its initial rollout a decade ago. There will continue to be technological advancements in transducers design, quantification packages etc. In addition, the rise of three-dimensional printing should create excellent symettery with 3D echo ultrasound. It's wholly conceivable a decade from now that 3d echo volumes, will be fed, into a 3D printer for designing artificial heart valves, patches, etc. The era of bio–printing of heart valves will arrive in the twenty-first century.

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Conflicts of interest

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