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Live 3D Echo Facilitates Faster, More Accurate Cardiac Diagnoses, Improving Patient Care

a report by

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Introduction

Every few years, technological advancements come along that provide critical improvements in the way we perform cardiac procedures by giving us the tools to make more accurate diagnoses.

One such advancement is Live 3D Echo. While three-dimensional (3-D) technology in cardiac ultrasound is not a new concept – it has been well known as a clinical application for the last 12–13 years – the use of Live 3D as a clinically viable application is new. Historically, 3-D echocardiography involved the compilation of multiple 2-D images. However, the overall image acquired was not in realtime.

That has all changed within the past 18 months as technology has evolved to make realtime imaging in 3-D possible. As a result, we are now able to diagnose potentially life-threatening medical conditions in realtime, and doctors are better able to communicate the diagnosis and make recommendations for treatment without any guesswork.

The importance of realtime 3-D cannot be emphasised enough. It gives us different levels of knowledge – such as viewing and diagnosing problems with the mitral valve – that could not be obtained before. It is the realtime aspect of this technology that is critical in obtaining a precise diagnosis.

The Evolution of 3-D

As clinicians sought methods to capture Live 3D views to explore the complexities and interrelationships of the heart, they discovered numerous technical hurdles, since extremely high frame rates were required to capture the cardiac motion.

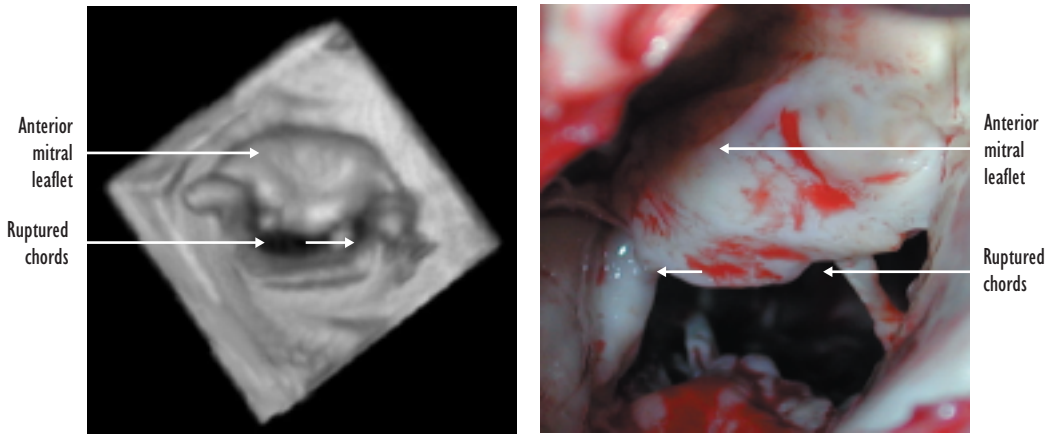
To appreciate the clinical significance of Live 3D Echo, it is important to look at how 3-D has evolved. Early echocardiographic systems relied on m-mode displays that were accurate in the axial dimension only. While sample rates may be low, information obtained from these images was extremely limited.

Two-dimensional echocardiography has been a known technology for 30–40 years. Two-dimensional imaging provided a significant improvement in the ability to obtain data, making it possible to scan and view planes of the heart in such a way that clinicians could visualise the anatomy of the heart. Using 2-D, clinicians could see both the axial and lateral dimensions, and realtime 2-D provided information about the 2-D orientation of the heart's anatomy. However, 2-D also had limitations. Since clinicians were viewing slices of the heart, they were unable to see through these walls and were not able to view the entire heart. Therefore, relying on 2-D became somewhat subjective and depended on the imagination of the person acquiring the images as clinicians were left to deduce what the complete heart image looked like. The difference between 2-D and 3-D is similar to the difference between plain X-ray and computed tomography.

Three-dimensional echocardiography moved a step closer to reality with the adoption of the transoesophageal echo (TEE) probe, which enabled clinicians to gain a new perspective in cardiac imaging by scanning the heart from the oesophageal location, which is immediately next to or behind the heart. The OmniPlane TEE probe also brought the ability to acquire multiple images of the heart from different planes for reconstruction and rendering of a triggered 3-D image. While this offered an opportunity to view the heart in 3-D using ultrasound, it also had limitations, including lack of realtime interaction of the 3-D image. Imaging modes with the biggest impact in echocardiography all have one thing in common: realtime imaging. Every mode interacting with the image in realtime allowed for immediate decision-making.

Triggered 3-D imaging required an acquisition protocol that took many beats and required many minutes to acquire the images. The acquired data set was transferred to an offline software workstation that reconstructed and rendered the image, which added time to view the 3-D image loop. The loop was reconstructed from many beats, adding two other limiting factors: spatial

Figure 1



discordance due to movement of the heart, transducer or patient during the acquisition process; and temporal discordance due to multiple beats of the rendered image. The process of transferring images to the offline software program was time-consuming – taking a minimum of five minutes to acquire the images and 10–15 minutes for rendering. In addition to technical issues, sedation of the patient was necessary for this unpleasant procedure (TEE), which increased potential risks to the welfare of the patient.

Advantages of Live 3D

Having addressed and resolved the technological and practical issues, Live 3D imaging has great potential to impact both patient care and improve pre and post-surgical planning.

In Live 3D, realtime images of the heart are displayed instantly on the monitor as a patient is scanned, without stopping to render images. As a result, we are able to provide immediate and improved perspective on the heart's size and shape and interrelationships between valves, chambers and vessels.

Providing a 3-D image of the heart gives physicians a complete view from multiple perspectives – images that were not available using conventional 2-D echocardiography. Using 3-D, images can be rotated and cropped to view the heart from all angles, which enables the physician to make a more accurate diagnosis. In other words, 3-D is similar to holding the heart in your hands, compared with 2-D, which left physicians having to visualise the heart.

Benefits of Realtime Echo in Surgical Planning

The ability to view the anatomy from many different vantage points is giving surgeons an advantage in pre and post-surgical planning.

Live 3D Echo reveals cardiac abnormalities and also shows the depth of the abnormality. This view is very similar to the surgical view and gives surgeons an exact snapshot of what they encounter when opening the heart. Armed with this knowledge, the cardiac surgeon can better plan the entire operation knowing exactly what will be seen. Having the defined surgical plan in place prior to opening the patient's heart might save significant time during the procedure as the surgeon should not encounter any surprises that would shift the course of the operation. This is especially valuable in mitral valve operations. Using Live 3D, the surgeon can see what the problems with the valve structures are and determine whether the valve needs repair or replacement. In performing mitral valve repairs, the surgeon can evaluate which part of the valve is affected and map out the operation accordingly. In addition, when surgery is performed using a minimally invasive approach, patient recovery time is usually shorter.

Improved Patient Care

The key to optimal patient recovery and long-term success is early diagnosis and treatment. By having this information prior to surgery, the physician and patient can interact and develop a strategy for the surgical plan in a way that the patient can understand so that they know exactly what will be occurring during the procedure. The ability to gather this data much more quickly shortens examination times and allows for a more complete examination.

Since data is volume-rendered and contains information that can be viewed from any angle and accessed at any time, Live 3D eliminates the need for repeat examinations. The ability to show patients their beating hearts and explain to them the problem and recommended diagnosis provides a level of comfort and confidence through a better understanding of what is happening with their hearts.

The Future of Live 3D Echo

While it is often hard to predict the future of a new technology, many more applications are likely as a result of Live 3D. Just as black and white televisions eventually gave way to colour television and today's high-tech plasma screens, you can expect to see many changes as 2-D and TEE are replaced by Live 3D Echo. The degree of precision is completely different from a previously used baseline cardiac examination. The degree of knowledge gained as a result can be put into action, moving medical science forward. This in-depth knowledge is, without doubt, a major advantage to surgeons.

Currently, only a minority of surgeons in the US can perform mitral valve repair, which has been shown to have significant benefit over mitral valve replacement. This technology should help increase that, thereby greatly improving patients' chances for a prolonged life, while also achieving both doctor and patient satisfaction.

There have been many changes in Live 3D Echo technology over the past 18 months. With every technology, the more we expand our knowledge, the more applications are possible. The more we, as clinicians and surgeons, can learn as a result of this technology, the more patient lives we can save. ■

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