Pediatric cardiology with the iE33 echocardiography system

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The Children’s Heart Centre Linz was created in 1995 with the cooperation of the Department of Pediatric Cardiology of the Maternity and Children’s Hospital of Linz (Figure 1) and the Department of Cardiac surgery of the General Hospital of Linz.

The department of Pediatric Cardiology is part of the Gespag Organization (Oö Gesundheits- und Spitals-AG), which is Austria’s largest hospital group with 11 hospitals at 14 locations, comprising eight general hospitals and three specialist hospitals.

Established in 1993, the Pediatric Cardiology Department is one of Austria’s leading and best-equipped clinics for pediatric cardiology, with its own modern cath lab and MRI installation. In October 2006, the department was the first in Austria to be equipped with the Philips iE33 echocardiography system (Figure 2). This system represents a new generation of ultrasound equipment for echocardiography, with live high-definition 3D imaging and on-cart data analysis tools.

**Pediatric echocardiography**

Echocardiography has become the primary imaging modality for the diagnosis and assessment of congenital and acquired heart disease in infants, children, and adolescents. Currently, some 6,000 to 7,000 echocardiographic exams are performed annually in the Department, 4,000 of which are in outpatients.

The principal advantages of echocardiography are that it is noninvasive, and is capable of providing detailed morphological, hemodynamic and physiologic information.

Pediatric echocardiography may be indicated for a number of conditions, including:

- Congenital heart disease
- Acquired heart disease
- Arrythmias
- Transplants
- Noncardiac disease.

**Congenital heart disease**

The term “congenital heart disease” covers a wide spectrum of anomalies, including intracardiac left-to-right or right-to-left shunts, obstructive lesions, regurgitant lesions, conotruncal anomalies, coronary artery anomalies, functionally univentricular hearts, and other complex lesions, including abnormal laterality (heterotaxy/isomerism).

Congenital heart disease can manifest itself by a variety of symptoms and signs, but echocardiography may also be indicated by a family history of inherited heart disease or abnormalities on other tests such as electrocardiography.

**Acquired heart disease**

Echocardiography may also be indicated for the evaluation of acquired heart diseases in children, including infective endocarditis, rheumatic fever, myocarditis, pericarditis, and exposure to cardiotoxic drugs.
Doppler allows precise quantification of flow velocities and gradients.

The new X7-2 transducer was used to acquire 3D loops in real-time, offering the possibility of storing a complete dataset for post-processing. ECG triggering is, of course, not possible in fetal echocardiography, but the “estimate fetal heart rate” option overcomes this problem and allows triggered acquisition of several heart cycles, thus improving image quality.

Technical requirements

The minimum requirements for pediatric echocardiography are facilities for M-mode, 2D imaging, color flow mapping, and spectral Doppler studies, including pulsed wave and continuous wave capabilities. The electrocardiogram should be displayed simultaneously with the image, and there should be an indication of range or depth.

Measurement facilities should be available for distances, areas, blood flow velocities, time intervals, and peak and mean gradients from spectral Doppler studies.

There should also be adequate provision for the transmission and storage of moving images.

Examination protocol

In the conventional echocardiographic examination, a large number of 2D images are acquired in multiple orthogonal imaging planes, supplemented by Doppler and color Doppler information. Particular attention is paid to acquiring the subxiphoid (or subcostal), suprasternal notch, and parasternal views.

This is a time-consuming procedure, and can be particularly difficult in the case of uncooperative patients.

The Philips iE33 echocardiography system

With the Philips iE33 “intelligent” echocardiography system (Figure 2), acquisition is very much faster than with the conventional examination protocol. The images are acquired as a complete 3D data set in a single sweep. Free navigation through the 3D data set allows any plane through the heart to be visualized, and the images are precisely reproducible.

The ability to perform a complete acquisition in a few seconds, rather than a quarter of an hour, allows much faster diagnosis, which is of great importance in pediatric applications.
Case 1.

Color tissue Doppler and strain of a fifteen year old boy with dilated cardiomyopathy following a viral myocarditis. The ejection fraction is less than 50%. There is asynchronicity due to the lack of septal contraction. (Figure 3)

Case 2.

1½ year-old-girl with Down’s Syndrome. Status post repair of a complete AV septal defect at the age of 4 months. Now there is significant AV valve regurgitation. 2D color doppler shows the jet, but the origin is unclear. 3D color Doppler shows that there are multiple origins between the leaflets. Figure 4a shows the heart in diastole, with normal tricuspid valve inflow (shown in red). Figure 4b shows the heart in systole, with the tricuspid valve closed. 3D color Doppler shows tricuspid regurgitation with separate origins.
The Philips iE33 system was installed in our department in October 2006, and has integrated CardioCare software, TomTech QLAB and X47. The system is used to examine children of 2 kg and over. It provides high-quality 2D image quality, high-quality 3D images of the valves, powerful 2D and 3D measurement of cardiac function and anatomy, and live 3D imaging of the moving heart.

Useful quantification functions include HFV (high frequency variability) and EF (Ejection Fraction) calculations.

Other useful features include user-centered ergonomics, a wide range of high-performance features including voice-activated control, and automated image optimization technologies.

New transducers
The Philips iE33’s new line of transducers includes the X7-2 transducer, combining xMATRIX and PureWave crystal technology. PureWave is an entirely new class of piezoelectric material whose properties provide greater transmission efficiency than conventional transducers. The resulting 2D and color flow images display astonishingly crisp and clear anatomic and physiological details which help enhance diagnostic confidence, even on the most technically challenging patients.

Clinical application
The morphological information provided by the iE33 system is excellent. The full 3D data set requires extensive postprocessing, but can provide any required 2D image. There is free navigation though the data set, and the images are precisely reproducible, saving a great deal of examination time. This is important for small, uncooperative children.

The full data set provides the pre- and post-interventional information needed for Amplatz closure, both pre- and post-interventional.

Quantification
The ability to quantify is becoming more and more important. The Philips iE33 system has fully integrated QLAB 2D and 3D cardiac quantification software for measurements such as left ventricle (LV) volume and ejection fraction. The software uses three-dimensional border detection to provide rapid access to ventricular volumes of the whole heart, with waveforms that show the function of up to 17 different segments of the heart simultaneously. The enhanced image quality obtained with the S5-1 transducer helps to ensure accurate detection of the endocardial border.

Global LV volume curves and regional waveforms can be used to identify and measure LV regional timing.

3DQ allows quantification to be performed in both 2D and 3D images. Segmental analysis is possible in the left ventricle. Tissue Doppler is used with a high frame rate of 5 ms per frame. This is very important, and allows early detection of dissynchrony.

3DQ segment analysis in neonates is excellent. The system yields exquisite 3D images, covering every aspect of cardiac morphology and function. However, the images require a certain degree of familiarization. There is a fairly steep learning curve, so some doctors continue to use the 2D images, because they are familiar with them. Nevertheless, 3D imaging is rapidly gaining acceptance because it provides results in a few seconds, rather than quarter of an hour, allows much faster diagnosis.

Electrophysiology
The 3D ultrasound images provide the necessary spatial information for placing resynchronization electrodes, even in the abnormal or incomplete heart. Positioning of electrodes is notoriously difficult. In very small children the electrode is positioned in the left ventricle. In larger children, the left ventricular lead is passed into the coronary sinus and into the back of the left ventricle, as in adult patients.

The high-quality imaging helps to ensure accurate positioning, even in children with severe cardiac abnormalities.

Ergonomics
An added benefit of the Philips iE33 system is its unique ergonomic design that adjusts to the individual user. It is a known fact that some 80% of sonographers have experienced work-related pain, resulting in reduced patient throughput and increased workers compensation claims. The iE33 system has been designed to address these challenges with independent height adjustment of the monitor and control panel, and the full range of viewing distances, meeting the SDMS (US Society of Diagnostic Medical Sonography) Industry Standards.

In addition, the iE33 has voice command, one-button automated optimization controls for quick and consistent image acquisition between users of varying skill levels, and a simpler, easy-to-use interface.
Case 3.

Fetal echo at 29 weeks gestation: Fetus with a large rhabdomyoma. 2D clearly shows the tumor (Figure 5a), and color Doppler demonstrates flow around this tumor (Figure 5b). 3D provides additional information regarding 3-dimensional extension, tumor volume and its relation to the AV valves (Figure 5c).

Conclusion

In spite of some initial reluctance, physicians were agreeably surprised by the high quality of the 3D images.

Free navigation through the 3D data set allows any plane through the heart to be visualized, and the images are precisely reproducible.

The ability to perform a complete acquisition in a few seconds, rather than quarter of an hour, allows much faster diagnosis, which is of great importance in pediatric applications.

Fully integrated QLAB 2D and 3D cardiac quantification software provides fast and accurate measurements, including left ventricle (LV) volume and ejection fraction calculations.