Whitepaper

Dynamic Automatic Gain Adjustment May Improve Echocardiographic Examinations in Infants and Children

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Setting

Tertiary care pediatric cardiology center. Academic institution.

Objective

To examine a commercially available ultrasound technology for dynamic automatic gain adjustment (Native™ TEQ ultrasound tech-nology from Siemens Medical Solutions, Ultrasound Division) as an imaging technology in pediatric echocardiography to improve outcomes.

Design

Prospective non-randomized clinical study.

Patients

Twenty three infants and children, age 6.5 years (range 2 days – 16.2 years) with innocent murmurs or simple asymptomatic congenital heart malformations.

Results

A total of 276 digital video clips, 138 with NTEQ ultrasound technology and 138 without, were recorded by an echo-technician and later examined by an independent pediatric cardiologist. Statistical analyses showed that the NTEQ ultrasound technology provided optimized studies in 122 examinations. Additional manual adjustments were required in 16 examinations. In the 122 studies where NTEQ technology provided optimized images, image quality was improved in 58 patients and demonstrated equal image quality in 64 patients. Non-parametric sign test was significant for improvement with NTEQ ultrasound technology ($p=0,003$). A by-group analysis showed a positive correlation between quality of the recording without NTEQ ultrasound technology and improvement with NTEQ ultrasound technology ($r=0.55$, $p<0.01$).

Summary

Dynamic automatic gain adjustments (NTEQ ultrasound technology) provided optimized echocardiographic recordings in the majority of infants and children without the need for manual image adjustments, resulting in simplified system operation. In subjects with low image quality, NTEQ ultrasound technology did not improve the images and in these cases we recommend that the function be deactivated. In all other cases, we recommend that NTEQ ultrasound technology be activated from the beginning of the examination. Although not measured, the main advantage with dynamic automatic gain adjustment may be the time saved from manual gain adjustments during examinations of non-compliant infants and children which may lead to a reduction in overall examination time.

Background

Innovative ultrasound technology has been one of the major technical improvements in the care of infants and children with congenital heart disease.

Echocardiography, using sector (2D), color Doppler (CD), spectral Doppler in pulsed wave (PW) and continuous wave (CW) modes and tissue Doppler techniques, is routinely used for diagnostic examinations in all age groups. Infants and small children usually have very good acoustic windows to the heart and central major blood vessels allowing the use of high frequency transducers and limited depths. On the other hand, infants and children are often not compliant with the examination and sedation is routinely used in many institutions. The time available during the examination, for gain and other control adjustments, is often very limited and optimal adjustments of the image quality may not be feasible. In order to optimize image quality, the manufacturers of ultrasound equipment are developing automatic gain adjustments which can be initialized by the examiner during the examination.

Introduction

A new dynamic gain adjustment system, Native TEQ dynamic ultrasound technology by Siemens Medical Solutions, Ultrasound Division, has been developed for the ACUSON Sequoia™ echocardiography systems. NTEQ ultrasound technology was assumed to be an image enhancement methodology, provided that its image optimization characteristics could be shown to be equal to or superior to the manual adjustment in our pediatric population.

The NTEQ ultrasound technology is based on two automated, synergistic processes: a real-time monitoring function that continuously checks the image for subtle tissue and interface changes, and an optimization function that is instantly triggered when changes are detected in the image plane. The system then instantaneously calculates the new optimal settings for lateral, axial and overall gain, immediately distinguishing between soft tissue, artifacts, noise and specular reflectors (Siemens Medical Solutions, Ultrasound Division).

We tested this technology on a group of infants and children in order to evaluate the potential benefits of dynamic automatic gain adjustment on image quality.

Patients

Twenty-three infants and children were prospectively enrolled during routine first-visit examinations for heart murmurs. The mean age was 6.5 (SD 4.9) years. Range: 3 days – 16 years (Fig 1).

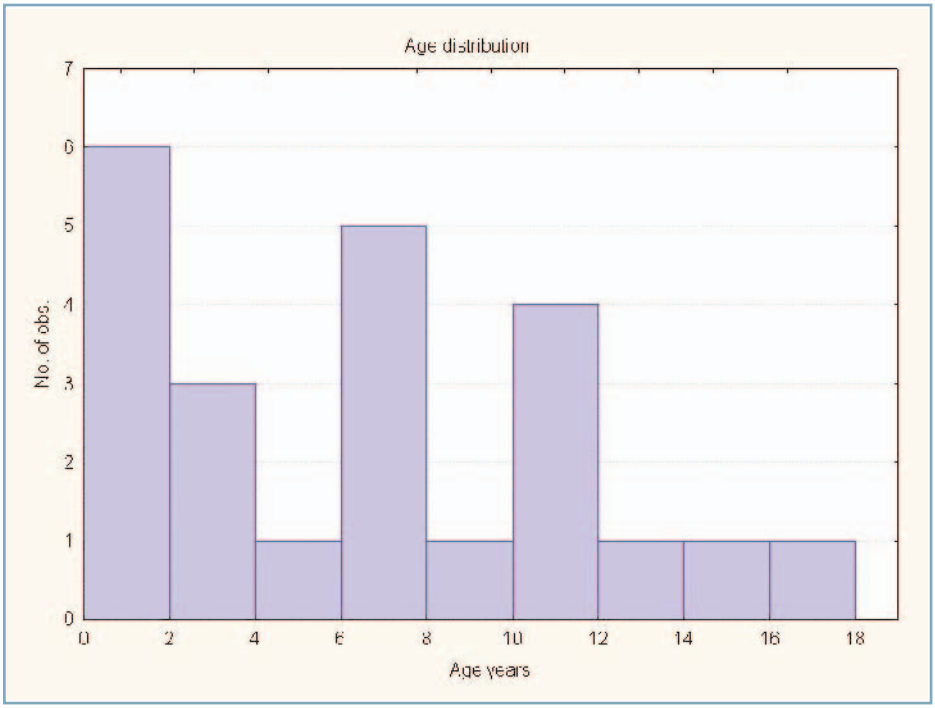

Figure 1: *All patients were asymptomatic. The diagnoses were innocent murmurs in all but three who had small patent foramen ovale (PFO) and in one a small muscular ventricle septal defect (VSD).*

Techniques

Two Sequoia C512 echocardiography systems, upgraded to the latest standards, were equipped with NTEQ ultrasound technology and Encompass technologies. Transducers were chosen and all adjustable controls for optimal clinical echocardiographic examination were set according to our previous experience with the systems without NTEQ ultrasound technology (Table 1).

Protocol

An experienced echo-technician (SLB) performed all examinations and stored the digital clips. All patients were examined with and without the NTEQ ultrasound technology activated. No changes in settings were made between the examinations and no manual adjustments were made during the NTEQ ultrasound technology recordings. The same transducer and echocardiography equipment was used for each patient.

Standard transducer positions were used, subcostal four-chamber projection with focus on atrial septum, apical four-chamber projection with focus on atrioventricular valves and parasternal long-axis projection with focus on mitral and aortic valves. All projections were made in 2-D and color Doppler modes with and without the NTEQ ultrasound technology activated. Clips of two heart beats were triggered from the ECG recording and stored. A total of 12 digital video clips were stored from every patient, six with and six without NTEQ ultrasound technology. A total of 276 clips were analyzed.

Analyses of all stored clips were made off-line by an experienced pediatric cardiologist (BL) who did not participate in the examinations and had no contact with the patients. All stored images were retrieved and displayed on one of the ultrasound machines used for the examinations and the image quality was assessed and rated as: poor, acceptable or good.

Transducers	Pat.N	Frame rate Hz	Image frequency MHz	Dynamic RangedB	Space/Time	Persist/Edge/ Postproc./Delta
4V1c	19	48-73	H4,25	81-84	T1	1/1/1/4/2
7V3c	3	53-64	6,0	90	S2	1/1/1/4/2
10V4c-S	1	52	6,0	81	S1	1/1/1/4/2

Table 1. *Transducers and basic settings.*

Results

The image quality change with NTEQ ultrasound technology (higher/equal/lower) was compared with the image quality rating in 2D with manual settings.

The image quality rating for all clips with NTEQ ultrasound technology was higher in 58 patients, equal in 64 patients and lower in 16 patients, compared with the manual technique. This difference is significant with p=0,003. When the color Doppler clips were analyzed separately, the same difference was observed with 26 higher, 36 equal and seven lower quality scores when using NTEQ ultrasound technology (p=0,01). The effect of NTEQ ultrasound technology was similar on 2D and 2D clips with color Doppler. In total, the NTEQ ultrasound technology showed image quality improvement in 42 percent of the patients, image quality in 46 percent of the patients, and lower image quality in 12 percent of the patients, as compared to the corresponding images with manually set controls.

In a linear regression model there was a weak positive significant correlation between manual 2D image quality and NTEQ ultrasound technology improvement of the same (r=0,55, p=0,004).

In addition the NTEQ ultrasound technology mode is likely to have saved some time in subjects where equal or improved image quality was achieved. It may also have delayed the examination in 12 percent of images where the NTEQ ultrasound technology mode gave the opposite effect.

Discussion

Modern echocardiography equipment has a large number of time and gain controls, filters, image enhancements, focus, compression and other algorithms to improve image quality. Every center and most examiners have their own preferences and standards. Time is often a limiting factor to optimize the settings for each patient and projection. This is especially true in the young pediatric age group where patience and compliance is often very limited. Although some centers use sedation routinely, most centers prefer to avoid this and respect the child's anxiety and perform very short examinations with ultrasound. This may be acceptable, provided that the image quality can be rapidly optimized so that good diagnostic imaging and calculations can be made.

In the past, we used an automatic gain adjustment technology (TEQ™ ultrasound technology), which required manual activation repeatedly during the examination. During most examinations however, the examiner tended to rely on manual optimization rather than activating the automatic adjustment system. In many situations one is likely to have settled for less than optimal image quality.

Our limited test of image quality with the NTEQ ultrasound technology showed improvement in 42 percent of the patients, equivalency in 46 percent of the patients, and deterioration of 2D-image quality in 12 percent of the patients, as compared to the corresponding images with manually set controls. The positive effect was significant in both 2D and 2D-images with color Doppler mode.

We observed a weak positive correlation between image quality with manual settings and the degree of improvement with NTEQ ultrasound technology. In patients with excellent acoustic properties and images, the use of NTEQ ultrasound technology provided no additional image optimization benefit over the image quality achieved with manual optimization. When the manually optimized image quality was reasonably good, activation of NTEQ technology provided additional image quality improvements. In exams where the patient had very poor acoustic properties and poor image quality, NTEQ technology did not improve but worsen the 2D-image quality in comparison to manual optimization.

Therefore, we recommend that the NTEQ technology function be activated from the beginning of the examination. Only in cases with very poor image quality do we suggest the operator selectively deactivate the automatic NTEQ function, since manual control, in experienced hands, may be superior to automatic optimization.

Our conclusion is that the tested NTEQ ultrasound technology for continuous image enhancement may improve image quality and facilitate the examination in infants and children. ■

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