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Intraoperative three-dimensional echocardiography: comparison of three methods.

Objectives: Intraoperative echocardiography requires reliable three-dimensional (3D) imaging of intracardiac anatomy. Up to now all methods had the major drawbacks of requiring long processing time and of being not directly available during heart surgery. More recently, it became possible to perform intraoperative imaging by "real-time" 3D-echocardiography, which allows to get 3D images just by one heart beat. The acquisition and display of pulse echo information from a 3D volume can be obtained without cardiac respiratory gating.

Methods: We assessed the clinical intraoperative application of different 3D techniques based on transesophageal (TEE) and epicardial (E) echocardiography: (1) 3DTEE, (2) "live" 3D-E and (3) "full volume" 3D-E. Ninety examinations were performed in 3D consecutive patients who underwent cardiac surgery.

Results (see Table):

<table>
<thead>
<tr>
<th></th>
<th>(1) 3D-TEE</th>
<th>(2) live 3D-E</th>
<th>(3) full volume 3D-E</th>
</tr>
</thead>
<tbody>
<tr>
<td>Acquisition time</td>
<td>158±77 sec</td>
<td>1.2±0.46 sec</td>
<td>8.46±0.46 sec</td>
</tr>
<tr>
<td>Reconstruction</td>
<td>480±94 sec</td>
<td>immediate</td>
<td>1.6 ± 0.74 sec</td>
</tr>
<tr>
<td>Additional Info.</td>
<td>3/30 (10%)</td>
<td>7/30 (23.4%)</td>
<td>7/30 (23.4%)</td>
</tr>
<tr>
<td>ECG-triggering</td>
<td>yes</td>
<td>no</td>
<td>yes</td>
</tr>
<tr>
<td>Respiratory</td>
<td>yes</td>
<td>no</td>
<td>no</td>
</tr>
<tr>
<td>Advantages</td>
<td>color Doppler, high resolution</td>
<td>immediate acquisition, reconstruction, quick acquisition and reconstruction, fusion of four subvolumes</td>
<td></td>
</tr>
<tr>
<td>Disadvantages</td>
<td>slow acquisition and reconstruction, small volume data</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Comparison of three methods.

Conclusions: The newly developed real-time 3D-E overcomes the time limitation of former 3D echo techniques and provides, for the first time, instantaneous imaging of intracardiac anatomy during cardiac surgery.

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The aim of the study was to compare 3 dimensional real time echocardiography (3DRT-E) and 2D transesophageal echocardiography (2DTEE) in quick bedside assessment of mitral valve apparatus morphology in patients suspected of acute mitral insufficiency during acute coronary syndrome (ACS).

Material and methods: We analyzed 10 patients with STT elevation ACS with median age 72 (range 51-80). All pts underwent 3DRT-E and 2DTEE at 2 months period. For each patient two echocardiographic studies were successively performed with a HC device (SonoHeart II). The first one was performed by a less experienced cardiologist (level I) whereas the second one by a skilled cardiologist in training (level II) could potentially lead to misdiagnosis. In this study we have assessed the importance of level of training in echocardiography to the diagnostic yield of HC echocardiography in patients (pts) presenting in the emergency department (ED).

Results: RT-3DE acquisition time was approximately 10 seconds. Analysis time was approximately 16 ± 5 minutes (range 10-25).

Conclusions: RT-3DE allows quick and reproducible assessment of LV volumes and EF. This enables its routine clinical use, even without contrast.

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Hand-carried echocardiography as a screening tool in the emergency department. Comparison between cardiologists with level of training I and III.

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Purpose: Hand-carried (HC) echocardiography devices provide rapid and readily available information at bedside, overcoming the difficulties imposed by the cumbersome standard equipment. However, the use of these miniaturized devices by cardiologist in training (level I) could potentially lead to misdiagnosis. In this study we have assessed the importance of level of training in echocardiography to the diagnostic yield of HC echocardiography in patients (pts) presenting in the emergency department (ED).

Methods: Our study population consisted of 1048 pts presented in the ED during a 2 months period. For each patient two echocardiographic studies were successively performed with a HC device (SonoHeart II). The first one was performed by a less experienced cardiologist (with level I of training) whereas the second one by a skilled cardiologist (with level III of training). The later study served as 'gold standard'. All cardiologists had been trained in the use of the HC device, and imaging was limited to a maximum of 15min.

Results: Among the pts studied 125 (i.e. ∼12%) were excluded due to poor acoustic window. From the remainder (i.e. 923 pts), 554 pts (i.e. ∼60%) had a normal cardiovascular pathology in a limited 'goal-oriented' examination. Use of this device was rapidly adopted (agreement 90%, Kappa=0.75), and 29 had severely depressed left ventricular systolic performance (<35%) (agreement 85%, Kappa=0.60).

Conclusions: HC in the ED is a useful screening tool for the rapid identification of cardiovascular pathology in a limited ‘goal-oriented’ examination. Use of this device by less experienced cardiologists could lead to omissions and misdiagnosis with adverse clinical implications.

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Real-time 3D echocardiography: reproducibility of left ventricular volumes and ejection fraction.

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Background: A 2nd generation real-time three-dimensional echocardiography (RT-3DE) machine has become available recently, potentially facilitating quick and easy assessment of left ventricular (LV) volumes and ejection fraction (EF).

Methods: 11 healthy volunteers and 6 patients (1 with congeugic cardiomyopathy, 1 with moderate aortic regurgitation, 1 with severe mitral regurgitation, 3 with ischemic cardiomyopathy) underwent RT-3DE using a Philips 7000TM RT-3DE machine. A pyramidal dataset, up to 90 by 90 degrees, is acquired by a high-resolution matrix transducer in 8 ECG-triggered heart beats, during one breath-hold. Echo images were stored on harddisk and transferred to a TomTec workstation with TomTec 4D Cardio-View software. LV end-diastolic (EDV) and end-systolic (ESV) volumes and ejection fraction (EF) were measured by manual tracing of the endocardial border. Measurements were repeated to assess reproducibility by the same observer.
A hand-carried cardiac ultrasound device in the diagnosis of cardiac abnormalities. A comparison to physical examination.

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**Background:** A hand-carried cardiac ultrasound (HCU) device (OptiGoTM, Philips Medical Systems) in a cardiology outpatient clinic. A full-featured standard echocardiographic system (SE) was used as a reference.

**Methods:** 300 consecutive patients referred for the first time to the cardiology outpatient clinic were studied with the HCU device by an experienced investigator prior to their visit to the cardiologist. The echocardiographer noted whether the HCU was able to confirm or reject the referral diagnosis, which pathology was detected and whether SE investigation was necessary. Physical examination by a cardiologist followed and thereafter, an echocardiographer performed a complete study with a SE whenever the cardiologist required it. Both were blinded to the results of the HCU. HCU and SE data were independently evaluated for major and minor cardiovascular abnormalities. The HCU data were compared to the clinical diagnosis by the cardiologist and the SE diagnosis.

**Results:** The cardiologist referred 203 patients for a SE study, 13 patients for transesophageal echocardiography, and in 84 patients no further examination was considered necessary. The most frequent question the SE was asked for, was the assessment of left ventricular function (60%), followed by the evaluation of valvular abnormalities (30%), congenital abnormalities (7%) left ventricular hypertrophy (11%), and endocarditis (3%). HCU echocardiography was able to confirm or reject the suspected clinical diagnosis in 159 of 203 patients (78%) whereas in 44/203 patients (22%) a hemodynamic assessment with SE Doppler was needed after the HCU. In 84 patients that were not referred for SE study by the cardiologist, in 83% of the patients there was an excellent agreement with the clinical diagnosis (100%) and in 17% of the patients, unsuspected major findings were detected by the HCU and missed with the physical examination. Those findings were verified with the SE after the request of the HCU echocardiographer. The agreement between the HCU and SE for the detection of major abnormalities was 98%, k=0.95. The HCU device missed 25% of minor and 4% of major abnormalities.

**Conclusions:** HCU showed to be a valuable tool in the detection of new patients at the outpatient cardiology clinic often allows an instant diagnosis, the detection of unexpected cardiovascular abnormalities and may avoid referral to the expensive diagnostic ultrasound facilities in a considerable number.

High diagnostic accuracy of hand-held echocardiography with cw/pw Doppler and tissue harmonic imaging.

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**Background:** Previously developed hand-held echocardiography was evaluated with divergent results due to inherent technical limitations. New hand-held devices with CW/PW Doppler as well as tissue harmonic imaging were introduced in identical clinical settings. Comparisons were drawn between standard echocardiography (the gold standard) and these new devices.

**Methods:** In 315 patients, two consecutive echocardiographic examinations were performed by experienced and independent examiners using hand-held echocardiography (the hand-held echocardiography device used was a Sonosite 180plus (Sonosite Inc. Washington, USA) with a C15/4-2 (15 mm broadband, 4-2 MHz) transducer. Standard devices employed included Vingmed Vivid 5 &7 (GE, Horten, Norway).

The diagnostic accuracy of hand-held echocardiography was assessed by 2 x 2 tables with kappa statistics. Kappa values of 0.81 or greater were considered as an almost perfect strength of concordance between the two modes of echocardiography. The agreement was measured as the sum of true positive and true negative results divided by the total number of patients.

**Results:** Of the 315 patients, 171 (54.3%) were male, 144 (45.7%) were female, with a mean age of 55.6 years (SD 16.8). Ten patients were excluded due to a reduced acoustic window. 177 (56.2%) patients had normal cardiac function; 138 (43.8%) had underlying cardiac pathology. The overall diagnostic accuracy of hand-held echocardiography is defined as the ability to detect the clinically relevant finding for which the echocardiographic examination was ordered. In this regard, hand-held echocardiography has an agreement of 94.8% and a kappa of 0.89. Hand-held echocardiography detected valve disease with an agreement of 96.7% and a kappa of 0.93. With this new technique, the global left ventricular function was assessed correctly in 85.6% of cases (compared to standard echocardiography). A pericardial effusion was diagnosed with an agreement of 91.2%. Dyskinesia was confirmed by hand-held echocardiography with an agreement of 95.4% and a kappa value of 0.88.

**Conclusion:** The previously published studies showed that hand-held echocardiography without harmonic imaging and PW-Doppler failed to quantify valve disease and left ventricular kinetics. This study demonstrates: (a) the high diagnostic accuracy of new hand-held devices with CW/PW Doppler and harmonic imaging; and (b) that these devices broaden the diagnostic spectrum, while allowing for enhanced mobility in everyday clinical applications.

Eur J Echocardiography Abstracts Supplement, December 2003