Aortic valve sclerosis screening using a hand-held ultrasound device.

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Background: Aortic valve sclerosis (AVS), mitral annular calcification (MAC), and aortic root sclerosis (ARS) have been demonstrated to be markers of coronary artery disease.

Aims: 1) to test the diagnostic potential of a hand-held ultrasound device for the screening for AVS, MAC and ARS in patients with known or suspected coronary artery disease (CAD). 2) To evaluate the relation between AVS, MAC and ARS and CAD assessed as rest or stress induced new wall motion abnormalities during dobutamine stress echocardiography (DSE).

Methods: Seventy-two patients (68% men, mean age 61±12 years) were referred for the evaluation of known or suspected CAD. All patients were examined with a hand-held device (HD) to assess AVS, MAC and ARS. Left ventricular long axis view, short axis, 3 and 5 apical chamber views were acquired by 2 independent cardiologists using the HD and a standard echocardiography-system (SE). The SE was used as reference. AVS was scored using a 4-point grading stage: 1=normal, 2=mildly sclerotic, 3=moderately sclerotic and, 4=severely sclerotic, with calcifications. MAC and ARS were defined as an increased echoreflectance and thickness of the mitral annulus and of the anterior or posterior wall, respectively. Subsequently all patients were evaluated for rest and stress induced wall motion abnormalities.

Results: Aortic valve, mitral annulus and aortic root were visualised in 70 (97%) and 68 (94%) patients respectively with SE and HD (p<0.05). AVS, MAC, and ARS were present respectively in 36 (50%) and 11 (23%) of patients. There was no correlation of aortic sclerosis (kappa=0.80) and moderate in the case of tricuspid regurgitation (kappa=0.48). The differences in the assessment of aortic and mitral regurgitant jets correlated with the image quality (p<0.05). A hand-carried ultrasound device for the sclerosis of all aortic valve cusps (right cusp 93.2%, k=0.89, left cusp 94.7%, k=0.88, non coronary cusps 81.4%, k=0.74). The agreement was also good for evaluation of MAC and ARS, respectively 89.7%, k=0.78 and 98.2%, k=0.96. During DSE wall motion abnormalities at rest and ischemic segments at peak were present respectively in 36 (50%) and 11 (23%) of patients. There was no correlation between the grade of AVS and the number of dysfunctional segments at rest (p=0.20) or the number of ischemic segments at peak DSE (p=0.21).

Conclusion: Aortic valve sclerosis screening with a hand-carried ultrasound device is a simple, reliable and inexpensive tool to screen patients for AVS, MAC and ARS. Image quality was significantly worse in the case of ultrasound stethoscope compared to standard echocardiography. In conclusion, although image quality of hand-held stethoscope was worse, nevertheless it was adequate for the purpose of performing an rapid limited assessment of cardiac function.

NEW ULTRASOUND TECHNOLOGY

Direct and angle-independent determination of local myocardial thickening by multiscale motion mapping - a new frontier in quantification of myocardial motion.

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Background: Regional myocardial thickening can be seen as the “holy grail” of wall motion assessment in echo. Although seen by the eye of the expert, it is difficult to measure by conventional echo methods (even Doppler strain rate imaging detects no regional deformation at the location of where principal axes of radial thickening and longitudinal shortening are in a 45° angle to the Doppler beam). Methods: Based on the recently described method of “multiscale motion mapping”, an echo quantification approach based on computer vision techniques, we developed a method that is based on the mathematics of the affine transformations, works independent of Doppler, and is able to separate translation and thickening and gives information about local rotation as well as shearing as well. The method was validated in synthetic echocardiograms to assess the validity of results in the case where full, quantitative information about all aspects of local motion is known, and was then applied to a range of clinical echocardiograms.

Results: Synthetic and clinical echocardiograms yielded comprehensive myocardial kinetics maps, whereby local motion is given by a quantitative 2D motion vector, and local thickening is given as a local ellipse in which the long axis indicates 2D direction and degree of local thickening, and the short axis gives the 2D direction and degree of myocardial shortening at the same location. Validation showed that the resulting thickening maps correspond to true 2D thickening as prescribed in the synthetic data and as seen by the human eye in the case of clinical echocardiograms. In addition, datasets showing both, overall heart translation as well as local thickening, showed clearly that these two components of myocardial kinetics can be separated by the new method, thus giving a new answer to an old problem for the stress echocardiographer.

Conclusion: Regional myocardial thickening can be determined quantitatively and independent from Doppler angle in 2D greyscale echocardiograms by using Multi-scale Motion Mapping, a computer vision technique. The ability to analyse 2D translations, myocardial thickening and myocardial shortening at each location, offers a new perspective to the difficult problem of comprehensive analysis of myocardial kinetics.
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The influence of temporal filtering procedures on myocardial velocity curves generated by echocardiographic tissue Doppler measurements.
Introduction: Myocardial velocity curves calculated off-line from acquired cine-loops with high frame rate contain several unknown motions. Especially longitudinal motions during the isovolumetric intervals contribute significantly to cardiac long axis movement. Even the new generation of improved echocardiographic equipments can still produce random noise disturbing the Doppler signal. Therefore, it is a need for smoothing of velocity curves e.g. with application of temporal smoothing procedures. The aim of this study was to evaluate the influence of such smoothing procedures on measured values.
Methods: Basal septal velocity recordings from 10 healthy individuals (HR 60-85 beats/min) were analysed. All recordings were acquired at a frame rate over 105 Hz. Timing of systolic, diastolic and isovolumetric events as well as velocity values during respective phase were calculated without and with a temporal filtering smoothing procedure during 20, respectively 30, 40, 50 and 60 ms. The unfiltered timing and velocity curves were used to evaluate the influence of inter-individual differences. The % value of the initial measured variable was then calculated for the different filter steps.
Results: A temporal smoothing up to 20ms did not significantly compromised the values. Longer temporal smoothing procedures influenced timing of systolic and pure diastolic variables with 20% and isovolumetric events were sometimes impossible to detect with high filter settings. The peak systolic velocity was decreased with more than 20% in filter settings over 40 ms, the same finding during E and A. The isovolumetric velocities were reduced with more than 50% already at a filter-setting of 30 ms.
Conclusion: Temporal filter smoothing factors should be used with caution. 20ms temporal smoothing could be used without risk. Fore peak systolic and diastolic variables 30ms filter setting could possibly be used. Higher filter values can completely eliminate isovolumetric information.

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An analysis of the angle dependence in strain imaging of the left ventricle.
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Background: In conventional strain Doppler Echocardiography, strain is measured in the beam direction by integrating strain rate estimates obtained from the tissue Doppler (TDI). For a 2D analysis, a new ultrasound imaging system, the Doppler accuracy tool (DIA), is essential for interpretation of myocardial function by tissue Doppler imaging (TDI). A new software algorithm for online identification of cardiac timing events, such as systolic ejection (S) and diastole (DIA), was developed to facilitate the quantification of regional myocardial function by TDI. This study describes validation of TDI systolic (S') and diastolic (E') velocity waves, defined by the zero-crossings. Timing of cardiac events, such as systolic ejection (SYS) and dias-

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SPEQLE: software package for echocardiographic quantification Leuven.
An integrated approach for ultrasound based cardiac deformation quantification.
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Introduction: Ultrasound strain and strain rate imaging have been introduced as new tools for the assessment of regional myocardial function. Unfortunately, the current methodology is labor intensive as a significant amount of post-processing of the Doppler Myocardial Imaging (DMI) data sets is required. The aim of this study was to develop a software package that helps standardizing and speeding up the process.
Methods: A software package called Speqle, was developed to integrate the offline analysis of ultrasound based deformation imaging build on four integrated components (data organization, data extraction, timing/parameter extraction and data visualization). The data-organizing component takes care of organizing the ultrasound data and creating project based structure which is stored in a database. At acquisition, digital DMI data sets are stored in a manufacturer-dependent format, when added this format is converted into a standardized format. The data-extraction component takes care of extracting velocity and strain rate traces based on manually tracking of an anatomical region of the myocardium through the 2D echo image. Moreover, it provides tools to represent the data sets in different ways such as anatomical and curved M-modes. The timing/parameter extraction component allows to define the timing of the cardiac mechanical events based on the simultaneous presentation of different synchronous datasets such as blood pool Doppler, M-mode images and pressure traces. It also takes care of user-defined parameter extraction during the different events of the cardiac cycle (various values quantifying velocity, displacement, strain and strain-rate). At each step in the analysis, processing parameters are saved with the analysis, allowing for re-entering the analysis chain to double check aberrant findings. Finally, the visualization component allows the synchronous representation of different curves on the patient and group level.
Conclusions: SPEQLE is a software package providing an integrated offline approach to ultrasound based cardiac deformation imaging. It offers manufacturer-independent, documented, controlled and editable parameter extraction in a project oriented structure, features that are indispensable in a research environment. Therefore, it contributes to speeding up and standardizing DMI/SRI research. The package is open source and freely available for research purposes.

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Software-aided identification of global cardiac events for the quantification of regional myocardial function by tissue Doppler imaging: validation in normal subjects.
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Timing information of cardiac events, such as systolic ejection (S) and diastole (DIA), is essential for interpretation of myocardial function by tissue Doppler imaging (TDI). A new software algorithm for online identification of cardiac timing events was tested in 10 healthy subjects (mean age: 28.8±8.6 yrs (System7, GE Vingmed, Horten, Norway)). Aortic and mitral valve opening (AVO, MVO) and closure (AVC, MVC) were identified by CW-Doppler to define isovolumic contraction (IVC, MVC-AVO) and relaxation interval (HR, AVC-MVO). SYS (AVO-AVC) and DIA (MVC-AVO). Valvular opening/closure clicks were marked in 3 consecutive cardiac cycles, the time difference to the triggered preceeding QRS complex was automatically measured and averaged. Timing information was then superimposed on separately recorded velocity tracings of the basal septum by colour-coded TDI (frame rates >110 frames/sec) and compared to start and end of regional systolic (S'), early (E') and late diastolic (A') velocity waves, defined by the zero-crossings. Timing of SYS and DIA was compared to TDI velocity echo (Echoc Pac PC SW-only v3.0.0.1336 beta, GE Vingmed, Horten, Norway). Results are mean values ±SD.
Results: Timing of regional motion correlated closely to SYS and DIA, identified by Dopper AVO (mean delay 4±8ms after S' onset and AVC 3±9ms after S' end). MVC was closely correlated to peak IVC velocity (mean delay 4±8ms) and MVO to E' onset (mean delay 9±17ms).
Conclusion: Global timing information can be reliably identified online by CW-Doppler and displayed on the TDI velocity trace. This allows a visual comparison between global and regional events and may help to identify regional abnormalities such as post-systolic shortening and to quantify TDI more objectively and semi-automatically.
935 Modelling the effect of incorrect transducer placement on tissue Doppler measurements.

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Introduction: Correct placement of the ultrasound transducer during echocardiography is recognized as an important and difficult skill for the sonographer to master. The difficulties are apparent both in quantitative Doppler analysis, and when performing myocardial contrast echocardiography where it is required that the transducer is kept in the same position as when sending the high energy flash throughout the examination.

Methods: The left ventricle was modeled as one half of an ellipsoid with myocardial velocities starting from zero in apex and increasing linearly towards the base. Parameters and velocities for the model were taken from a healthy volunteer. In the model the offset of the transducer, i.e. the distance on the skin surface away from the ideal transducer placement, and the insonation angle could be set freely. The angle was defined as positive when pointing outward from the ventricle and negative when pointing towards the center of the ventricle. When the transducer is misplaced the shape of the ventricle does not necessarily alter much, but the apex seen in the image will not be the true apex, rather a point on the more basal wall. Velocities in the found, erroneous apex were compared to velocities of the true apex which were assumed to be 0.

Results: Although the image of the heart could look satisfactory in one scan plane, an orthogonal plane reveals a severely skew image as shown in the figure to the left. The figure to the right shows the velocities of what was interpreted as the apex at different offsets and angles.

Conclusions: The figures show that a severe offset can be compensated for by pointing the transducer more inwards, however, if always including two orthogonal scan planes, an misaligned transducer can easily be detected.

936 Spatial and temporal resolution influences the results and signal quality of strain rate imaging during dobutamine echocardiography.

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Background: Strain rate imaging (SRI) remains a research more than a clinical tool, reflecting technical problems which compromise signal quality. We sought to assess the efficacy of a number of steps to improve SRI quality during dobutamine echo.

Methods: We assessed signal quality (QUAL - blinded assignment into pre-defined categories of waveform quality ranging from 1-poorly defined peak ranging to 5-excellent signal with clearly defined, single peak), a quantitative measure of signal noise (ERROR - degree of scatter in the velocity regression line used to measure SRI), and measurement of SRI in 34 normal pts at both baseline and peak DSE. Imaging chambers were - standard fundamental (STD), harmonic (HR) - including use of harmonic tissue Doppler acquisition, parallel beam-forming to increase frame-rate from 120 to 200 fps and improved temporal filtering, high temporal resolution (SR - narrow sector with increased resolution to x mm) and both (TS).

Results: Normal time to peak SRI (0.21±0.04 at rest and 0.10±0.03 with stress) were similar although the standard deviation was less with HR and SR. STD showed significantly lower QUAL and ERROR particularly at peak stress (Table). Better spatial resolution also improved QUAL and ERROR. Use of >1 focal zone had a small impact on SRI quality.

Conclusions: SRI quality can be improved with harmonic imaging and higher temporal resolution but optimization of spatial resolution is critical.