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153 Multilayer radial strain measurements detect reduction in myocardial perfusion before longitudinal, circumferential, radial strain and rotation. An experimental porcine study.

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Background: Tissue Velocity Imaging (TVI) can measure radial strain at several depths of the myocardium. With Speckle Tracking Echocardiography (STE) average strain in two directions and left ventricular rotation can be obtained. Their sensibility to detect regional dysfunction at modest reductions in perfusion is not fully investigated.

Purpose: To investigate the effect of a significant stenosis on myocardial function evaluated by TVI and STE.

Methods: Eight pigs (41±2 kg) were anaesthetised, mechanically ventilated and sternotomized. An extracorporeal shunt with an inline flowprobe and two pressure ports were installed from the proximal brachocephalic artery to the left anterior descending coronary artery (LAD). The shunt was constricted in steps with gradual reduction of LAD perfusion pressure. HR, LVP and CI were monitored. TVI short-axis of the anterior left ventricular wall along with short and 4 chamber B-mode images for STE were obtained. Microsphere injections and echocardiography were recorded with: (1) Open shunt, (2) 15%, (3) 35%, (4) 50% and (5) 60% reduction of LAD perfusion pressure. TVI images were analysed for radial peak ejection strain using 3 regions of interest (2x6 mm, strain length=2 mm) across the anterior myocardial wall. STE images were used to obtain strain and rotation in the same region as well as rotation in 6 levels of the left ventricle.

Results: With open shunt (1), TVI analysis showed a transmural gradient of peak systolic strain, with low values subepicardially (10.0±2.0%) and high values subendocardially (55.3±3.6%) with no transmural perfusion gradient. At (2) no changes in transmural perfusion and strain were observed, but at (3) perfusion in the mid- and subendocardium were significantly ($p<0.05$) reduced, strain decreased in the midmyocardium (37.9±3.3% vs. 28.8±2.4%) and subendocardium (55.3±3.6% vs. 42.6±3.0%). HR increased, while dP/dtmax, −dP/dtmin and LV-SPmax decreased. At (4), perfusion and strain were reduced in all layers, further decreased at (5). For STE in the anterior wall, significant reduction was not seen until a 50% reduction of perfusion pressure decreasing further at 60% pressure reduction. With open shunt, end systolic rotation gradually increased towards the ventricular apex with torsion less influenced by ventricular level. Rotation and torsion were not affected by reductions in perfusion.

Conclusion: Both TVI and STE analysis detects reduced myocardial ischemia. Multilayer radial strain TVI is more sensitive, also detecting subendocardial ischaemia. Rotation and torsion were not affected.

P318 Immediate improvements in systolic and diastolic left ventricular function after transcatheter aortic valve implantation (TAVI) in high risk patients

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Purpose: TAVI has emerged as treatment option in high risk patients with severe aortic stenosis (AS) where LV function often is severely impaired. The aim in this study was to investigate the magnitude of immediate per procedure changes in LV systolic and diastolic performance during TAVI in high risk patients.

Methods: Seven (2 women) consecutive patients aged (mean±SD) 80±6 years treated with the transapical aortic valve replacement technique in general anesthesia were studied after induction

of anesthesia (BL) and 15 min post valve delivery (PVD). All had severe symptomatic AS (valve area 0.65±0.18 cm2, transvalvular mean gradient 53±9 mmHg). In all, surgical treatment was declined due to high risk (Euroscore 34±11). None had coexisting coronary artery disease. Transoesophageal echocardiography was used to obtain mitral ring systolic velocities and the diastolic mitral inflow deceleration (E DT). Invasive pressures and continuous cardiac output monitoring were obtained by LiDCO pulse power analysis facilitating estimates of pulse pressure, stroke volume index (SVI) and systemic vascular resistance (SVRI).

Results: The TAVI procedure was successful in all patients and induced an immediate improvement in global LV systolic function, demonstrated by an increase in mitral ring peak systolic velocity from 22.7 at BL to 23.4 cm s-1 at PVD (p = 0.003). E DT decreased from 317±132 to 189±77 ms (p = 0.027), indicating improved diastolic relaxation. There was a marked increase in pulse pressure (44±4 mmHg 60±9 mmHg, p =0.005), despite unchanged SVRI (1775±716 to 1583±359 d.s.cm-5m-2, p = 0.43). No significant changes were observed in heart rate (92±14 to 78±19 min-1), central venous pressure (9±3 to 11±3 mmHg), mean arterial blood pressure (64±14 to 71±5 mmHg) or SVI (36±14 to 39±16 mL m-2).

Conclusion: This pilot echocardiographic and pulse pressure study demonstrates an immediate improvement in both systolic and diastolic LV function following the TAVI. Further studies needs to focus on the prognostic value of these results.

P337 Mitral annular tissue Doppler velocities are associated with cardiac risk factors in a healthy population

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Purpose: To study the associations of peak systolic (S') and early diastolic (e') mitral annular velocities with common cardiovascular risk factors.

Methods: 1266 persons (20-89 years), without known heart disease, hypertension and diabetes, which participated in the 3rd HUNT Study were randomised to echocardiographic examination. Anthropometrics and non-fasting blood samples were collected. Serum analyses were performed at an accredited laboratory. S' and e' was analyzed online by commercial pulsed wave tissue Doppler. S' and e' was measured in the base of the lateral, septal, anterior and inferior left ventricular wall, and the average of these four myocardial walls is presented as a global measure of systolic LV function. The measurement was performed at the outer clear edge of the Doppler spectrum at low gain settings. Feasibility was ≥96%. Associations were tested in multivariable analyses adjusted for age, and with regard to the lipids 'time since last meal' was also included as a covariate.

Age-adjusted percentage difference (standard error) in mitral annular velocities per standard deviation difference in covariates

Covariate	S' (women)	S' (men)	e' (women)	e' (men)
Age	-8.0 (0.6)	-5.9 (0.6)	-22.2 (0.8) -	20.6 (0.9)
BMI	-1.3 (0.6)	-2.6 (0.6)	-4.4 (0.8)	-6.7 (0.9)
Systolic blood pressure	-1.4 (0.6)	-1.2 (0.7)*-	5.9 (0.8) -	5.4 (0.9)
Diastolic blood pressure	-1.6 (0.6)	-2.9 (0.7)	-6.0 (0.8)	-9.0 (0.8)
Non-HDL cholesterol	0.0 (0.7)#	-2.0 (0.7)	-2.1 (0.9)	-4.4 (0.9)
HDL cholesterol	0.7 (0.6)#	2.0 (0.7)	1.5 (0.8)*	4.4 (0.9)
Smoking	-2.5 (1.1)	-0.3 (1.3)	-4.8 (1.5)	-1.0 (1.8)

All p , 0.05, except; p , 0.10 and #; non-significant.*

Results: Results are shown in table. Higher age, higher body mass index (BMI), higher blood pressure, higher non-HDL cholesterol and lower HDL cholesterol were significant associated with reduced mitral annular velocities. Smoking was associated with reduced mitral annular velocities in women, but not in men. (Table)

Conclusions: Unfavorable levels of conventional risk factors were clearly associated with reduced systolic and diastolic mitral annular velocities; suggesting the possibility of subclinical cardiac dysfunction among healthy individuals. The findings suggest that these risk factors influence cardiac function many years prior to clinical detection.

P390 TAPSE and RVFAC describe early reduction in right ventricle function in an experimental model of sepsis

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Purpose: The tricuspid annular systolic velocity (TAPSE) and RV fractional area change (RVFAC) are easily obtainable and simple echocardiographic measures of right ventricular function. We studied RV function in a model of sepsis in pigs. We hypothesised that TAPSE and RVFAC could accurately express changes in RV function during sepsis.

Methods: In an experimental model, 10 anaesthetised open-chest pigs, mean weight 53 ± 2.9 kg, were given an infusion of heat-inactivated E coli (60°C, 60 min) in incremental doses to induce a septic response. Pulmonary artery pressure was measured by a pulmonary artery catheter and cardiac output (CO) calculated by thermodilution to obtain pulmonary vascular resistance (PVR). A micromanometer catheter was placed in the right ventricle to monitor right ventricular peak systolic pressure (RVP). An epicardially placed miniaturized ultrasound sensor was used to obtain regional recordings of diastolic wall thickness. Standard echocardiography was performed intermittently to calculate RVFAC and TAPSE. The hearts were paced atrially to 130 beats/min for 5 min to obtain comparable readings.

Results: After a mean of 204 min (165 to 240 interquartile range) of E coli infusion, there were significant increases in PVR (140.7 ± 64.4 to 518.5 ± 266.1 dynes*sec/cm5, p = 0.003) and RVP (29.2 ± 2.9 to 39.5 ± 12.1 mmHg, p = 0.007). The RVFAC decreased (0.65 ± 0.05 to 0.43 ± 0.15 %, p = 0.001) and TAPSE decreased (1.4 ± 0.3 to 0.8 ± 0.4 cm, p = 0.005). The RV diastolic wall thickness decreased (5.6 ± 1.3 to 4.9 ± 1.2 mm, p = 0.02). There were significant correlations between the rise in PVR and the decrease in RVFAC (r = -0.75, p = 0.05) and between the rise in RVP and decrease in RV diastolic wall thickness (r = 0.84, p = 0.01), whilst there was no significant correlation between TAPSE and PVR.

Conclusions: Induction of E coli sepsis in pigs caused significant pulmonary hypertension and subsequent rise in RVP. These hemodynamic alterations caused significant decrease in RV function as demonstrated by the decrease in TAPSE and RVFAC. In our study, TAPSE was not significantly influenced by PVR and might better describe RV failure in pulmonary hypertension than RVFAC.

P657 Novel high frame rate sparse tissue Doppler imaging

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Purpose: Standard tissue Doppler imaging (TDI) is recorded as a swept scan continuously covering a sector of some size. However, when imaging the left ventricle (LV) apically, the objects of interest are the walls positioned at the edges of the sector. We suggest a new tissue Doppler acquisition scheme with only two transmit beams; one transmit beam is automatically directed at the base of each of the LV walls. Thus a frame rate close to 1000 FPS can be achieved. One use of such high frame rates is to image how mechanical events propagate around the LV. We have used it to quantify the delay from the aortic valve closure (AVC) event occurs in the septal base till it is visible in the basal lateral wall.

Method: A deformable non-uniform rational B-spline (NURBS) model was automatically fitted to the LV in a 4CH view in real-time on the scanner. Based on the model position, the tissue Doppler acquisition scheme was set up to fire one transmit beam in the direction of basal septum and one in the direction of basal lateral wall. In post processing, a velocity curve was extracted from the basal part of each wall. In TDI curves, the time-point of peak positive acceleration after protodiastole has previously been shown to be a good marker of AVC visible in curves from all LV walls. We thus identified the time-point of this marker in the septal curve and the lateral curve and calculated the delay between the events. Eight healthy normal subjects were examined using a Vivid E9 scanner with an M5S probe.

Results: The recording from one subject was discarded due to inability to get sufficient quality velocity curves. Mean achieved frame rate was 880 FPS. This corresponds to a temporal resolution of 1 ms. The AVC event as visible in TDI curves occurred mean ± st.d. 8±3 ms later in the lateral wall than in the septal wall where it originates.

Conclusions: We have implemented a tissue Doppler imaging acquisition approach that can be used for very high frame rate imaging of the LV walls. Usability of the method has been demonstrated by the ability to detect the propagation time of the shear wave starting with aortic valve closure. This new TDI method might be beneficial in allowing more temporal smoothing and more advanced Doppler processing than regular TDI. Based on estimated shear wave velocities, it can potentially also be used for characterizing tissue properties.

P658 4D strain: validation of new 3D speckle tracking and left ventricular function tool in simulated echocardiographic data

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In this study, a newly developed 4D quantitative tool of LV function is applied on simulated datasets.

Methods: Using 22 simulated meshes representative of LV shape and motion, 4D synthetic echocardiographic datasets were simulated using a validated ultrasound simulator with acquisition parameters representative of an high-end scanner (44 frames during cardiac cycle). Those data were then analyzed by a 4D speckle tracking method with semi-automatic placement of region of interest. Global (n = 22) and segmental (17 segment model, n = 384) end systolic strains were computed in the longitudinal and circumferential directions. Area strain (mid-wall) was also computed.

Analysis were performed blinded to the simulation parameters and by a different operator.

Results: For a wide range of longitudinal and circumferential strains (−26 to -1%) the results from 4D strain were similar to the known simulated values, see table 1 (limit=1.96SD).

LV ED and ES volumes (−3.70±4.97ml, r = 0.999, range: 7-295ml) and LV masses (2.84±14.92g, r = 0.994, range 26-300g) were also very similar to simulated values.

Summary: 4D strain was computing global and segmental strains with very high precision and accuracy on simulated datasets. Volumes and Masses were also highly correlated⇓.

Age-adjusted percentage difference (95% CI) in left ventricular end-systolic global longitudinal strain per standard deviation difference in covariates

Covariate	Women	Men	p-value (Women/Men)
Age	−3.9 (-4.9 to -2.9)	−3.1 (-4.3 to -1.9)	both p < 0.001
BMI	−3.1 (-4.1 to -2.1)	−3.9 (-5.1 to -2.8)	both p < 0.001
Systolic blood pressure	−3.0 (-4.1 to -1.8)	−2.4 (-3.7 to -1.1)	both p < 0.001
Diastolic blood pressure	−2.5 (-3.6 to -1.4)	−5.2 (-6.4 to -4.0)	both p < 0.001
Non-HDL cholesterol	−2.2 (-3.4 to -1.0)	−2.3 (-3.6 to -1.0)	both p < 0.001
HDL cholesterol	2.1 (1.0 to 3.2)	3.5 (2.2 to 4.7)	both p < 0.001
Smoking	−0,8 (-2,8 to 1,3)	−1.0 (-4,5 to 2.6)	p=0.47/p=0.43

Abbreviations as in text. Age was not adjusted for other covariates; all other data are age-adjusted. Lipids adjusted for time since last meal as well. Smoking is difference between ever vs. never smokers.

P786 Longitudinal left ventricular strain is associated with cardiac risk factors in a healthy population

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Purpose: To study the associations of systolic longitudinal left ventricular (LV) strain with common risk factors.

Methods: 1266 persons (20-89 years), without known heart disease, hypertension and diabetes, which participated in the 3rd HUNT study were randomised to echocardiographic examination including deformation imaging. Anthropometrics and non-fasting blood samples were collected. Serum analyses were performed at an accredited laboratory.

End-systolic strain was analyzed by a combination of tissue Doppler for tracking along the ultrasound beam and speckle tracking for tracking perpendicular the ultrasound beam. Segments with poor data quality were discarded. A 16 segment model of was used. Global strain was obtained in 98% of the subjects and mean 10.9 (SD 3.8) number of segments were the base for the analyses.

Results: Results are shown in Table.

In both sexes, higher age, higher body mass index (BMI), higher blood pressure, higher non-HDL cholesterol and lower HDL cholesterol were significant associated with reduced LV strain. Smoking was not significant associated with reduced LV strain.

Conclusions: Unfavorable levels of conventional risk factors were clearly associated with reduced LV systolic global strain; suggesting the possibility of subclinical cardiac dysfunction. The findings suggest that these risk factors influence cardiac function many years prior to clinical detection.

P967 Subclinical impairment of LV function in patients with obstructive sleep apnea

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Aims: Obstructive sleep apnea (OSA) is associated with obesity, hypertension and heart failure. The aim of the present study was to assess LV function in patients with OSA of mainly mode-

rate severity and no previous diagnosis of heart disease.

Methods: 40 consecutive patients with OSA verified by polysomnography (apnea-hypopnea-index) were compared with 41 voluntary healthy controls. OSA patients were divided into lean (BMI, body-mass-index ≤ 28; "OSA-lean", n = 16) or obese (BMI >28; "OSA-fat", n = 24). LV systolic function was determined using 2D echo including 2D longitudinal global strain recorded from three apical views. LV diastolic function was assessed by the ratio between early diastolic-transmitral Doppler velocity (E) and the septal mitral tissue Doppler imaging velocity (e`). All analyses were performed by one investigator blinded to the study groups.

Results: Healthy controls and "OSA-lean" were identical for height and body weight, while "OSA-fat" had greater body weight. "OSA-fat" had lower minimal nocturnal oxygen saturation and greater apnea-hypopnea-index than "OSA-lean". While systolic blood pressure (mmHg) was similar in "OSA-lean" and controls (130±3 and 128±3), it was significantly elevated in "OSA-fat" (141±3). LV dimensions were similar in all three groups, while LV ejection fraction (Simpson) was slightly but significantly lower in both OSA groups. Septal, posterior, and relative wall thickness were all increased in "OSA-lean", and further augmented in "OSA-fat". Peak longitudinal global LV strain values were significantly and similarly reduced in "OSA-lean" (−16.0±0.4%) and OSA-fat (−15.5±0.5%) compared to controls (−18.0±0.3%). Moreover, LV global strain was inversely correlated with apnea-hypopnea-index (R = 0.55; P < 0.00001). E/é ratio was significantly increased in "OSA-fat" (10.1±0.8) as compared to "OSA-lean" (8.4±0.7) and controls (7.7±0.3).

Conclusion: The present study demonstrates subclinical impairment of LV systolic and diastolic function in obese asymptomatic patients with OSA as compared to lean OSA patients and controls. Although increased blood pressure might have an impact on our findings, the strong association between systolic 2D strain and the apnoea-hypnoea index indicates decreased oxygen saturation to be of importance for the impairment of LV function in patients with OSA of moderate severity.

P1005 Feasibility and accuracy of transthoracic coronary Doppler for coronary flow velocity reserve measurements in the three major coronary arteries: a comparison with quantitative coronary angiography

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Objective: The purpose of this study was to evaluate the potensial of combined use of transthoracic Doppler echocardiographic (TTE) coronary flow velocity reserve (CFVR) measurements and findings of retrograde coronary flow in all 3 coronary arteries for the assessment of borderline (angiographic diameter stenosis 50-75%) and high-grade (diameter stenosis 76-100%) coronary stenoses.

Methods: We studied 108 patients scheduled for diagnostic coronary angiography because of chest pain or acute coronary syndrome. CFVR was measured in mid-to-distal segments of left anterior descending (LAD), marginal branch from left circumflex (CxMb) and posterior descending (PDA) arteries, with CFVR <2,0 implying hemodynamic significant stenosis. Findings were compared with quantitative coronary angiography (QCA), with stenosis severy in the left main and 3 major coronary arteries divided into 3 groups: (1) diameter stenosis 0-49%; (2) diameter stenosis 50-75%; (3) diameter stenosis 76-100%.

Results: QCA confirmed retrograde flow in 7 of the 9 arteries found by TTE. Among patients not found with retrograde flow in the relevant coronary artery segment, CFVR was successfully measured in mid-to-distal LAD, CxMb and PDA in 97%, 63% and 75% of patients, respectively. CFVR was significantly different among the stenosis groups, with peak CFVR (pCFVR) 2,79±0,77 in group 1, 2,02±0,72 in group 2, and 1,60±0,76 in group 3 (p < 0,009 between groups). Combined use of a damped CFVR (pCVFR <2,0) or findings of retrograde coronary artery flow correctly identified 42 of 49 arteries with stenoses in group 3, with sensitivity, specificity, positive and negative predictive value of 86%, 70%, 70%, and 85%, respectively. Group 2 showed no preponderance to either above or below the defined CFVR cut-off value.

Conclusions: CFVR measurement in mid-to-distal LAD was feasible in almost all patients, and in CxMb and PDA in 2/3 and 3/4 of patients, respectively. Use of the combined echocardiographic criteria had high precision for diagnosing severe coronary stenoses (diameter stenosis 76-100%). The functional significance of borderline coronary stenoses (diameter stenosis 50-75%) may be further differentiated by use of CFVR measurements, as suggested in other studies. (ClinicalTrials.gov number NTC00281346.)

P1055 Quantification of aortic regurgitation using high pulse repetition frequency 3D color Doppler

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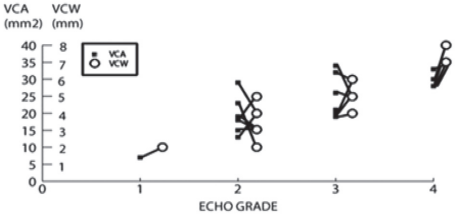
Purpose: To measure the vena contracta area (VCA) in patients with aortic regurgitation with a recently described method using high pulse repetition frequency 3D color Doppler, (MULDO).

Method: We isolated the Doppler signal from the aortic regurgitant jet in 18 patients using MULDO. The Nyquist limit was near the peak jet velocity of the regurgitant jet. The VCA was found by summing the backscattered Doppler power from multiple beams within the vena contracta region and compensating for the attenuation and geometry by a reference beam within the jet.

The VCA was measured by MULDO while the vena contracta width (VCW) and the echo grade of the severity of aortic regurgitation were assessed by 2D echocardiography. To assess kappa agreement the VCA was divided into groups 1: 0-9 mm2; 2: 10-19 mm2; 3: 20-29mm2; 4: ≥30 mm2. The VCW was divided into 1: 0-2mm; 2: 3-4mm; 3: 5-6mm; 4: >6 mm. The echo grade was similarly divided into 1: mild; 2: mild to moderate; 3: moderate to severe; 4: severe.

Results: The Spearman correlation between VCA and echo grade was 0.72 (p = 0.001) and kappa agreement was 0.44 (p = 0.004). Between VCA and VCW the Spearman correlation was 0.67 (p = 0.003) and kappa agreement was 0.45 (p = 0.002). The results are shown in the figure.

Conclusion: MULDO calculates the VCA semi-automatically from the backscattered Doppler power, requiring no manual tracing and making no geometric assumptions. As expected, there was only moderately good agreement between VCA and both the echo grade of the severity of aortic regurgitation and VCW. We believe that MULDO will be a useful tool in quantification of aortic regurgitation, and we have planned further validation with magnetic resonance imaging.



Aortic regurg. VCA vs VCW vs ECHO GRADE

P1069 Diagnostic accuracy of pocket-sized ultrasound with b-mode and color flow imaging. A comparison with a high-end scanner

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Purpose: The use of pocket-sized ultrasound may improve hospital workflow and in this study we wanted to study the reliability of echocardiographic evaluation with pocket-sized ultrasound in patients admitted to a cardiology department.

Methods: 51 persons (33-89 years, median 70 years), admitted to the Cardiological Department, at a regional hospital were screened with b-mode and color flow imaging with pocket-sized ultrasound (size of unit: 135x73x28 mm) at admission. The examinations were performed bed-side by two experienced cardiologist. Time used for echocardiographic screening was median 4.3 (range 2.3-13.0) minutes.

Complete echocardiographic examinations for comparison were performed by three experienced cardiologist with high-end scanners with a time delay of median 17 hours.

The variables were categorized and agreement assessed with kappa statistics. Left (LV) ventricular function was categorized as normal/near normal, moderate dysfunctional or severe dysfunctional, in addition to LV regional dysfunction. Right ventricle (RV) was categorized as normal or dilated. Valvular function was categorized as normal, insignificant pathology, moderate dysfunction or severe dysfunction. The most dysfunctional valve is used in the analyses. Left atrial diameter (LAd) was categorized as normal/near normal or dilated. Pericardial effusion was categorized as absent or present. The size of the abdominal aorta (AA) were categorized as no present aneurysm or present aneurysm (>35mm).

Results: The agreement between pocket-sized ultrasound and a high-end scanner are shown in the table below.

Conclusions: Semi quantitative evaluation of cardiac anatomy and function with pocket-sized ultrasound showed substantial to almost perfect agreement with reference echocardiographic examination for most indices. A bedside examination with pocket-sized ultrasound of 4 minutes length might improve patient care and workflow in cardiology departments. However, how this corresponds to non-expert users has to be proven.

Structure/measure	Kappa statistics	Structure (continues)	Kappa statistics (continues)
LV global function	0.82	LAd	0.36
LV regional function	0.88	Pericardial effusion	0.88
RV function	0.81	Size of the AA	1
Valvular function	0.72		

Abbreviations US; ultrasound, other as in text. Agreement; pocket-sized US vs. reference

P727 Longitudinal strain in patients with coronary artery disease and preserved ejection fraction

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Functional recovery after revascularisation is an important aspect of myocardial viability. However, the majority of studies addressing segmental functional recovery have investigated patients with extensive myocardial scars due to coronary artery disease (CAD). Thus, little is known about functional recovery in patients with segmental myocardial dysfunction and predominantly viable myocardium. Longitudinal strain assessed by tissue Doppler imaging (TDI) is a sensitive parameter for evaluating ischemic lesions. We hypothesized that TDI strain and strain rate (SR) at rest and during dobutamine stress, provide an effective tool to identify myocardial segments with reduced function and with potential functional improvement after revascularization.

Methods: Normal strain and SR values were assessed from TDI measurements in fifteen healthy volunteers. Fifty-seven patients scheduled for coronary artery bypass grafting (CABG), with an average ejection fraction (EF) of 49%, underwent preoperative magnetic resonance imaging with late enhancement (LE-MRI), resting echocardiography and dobutamine stress (DS) echocardiography with assessment of wall motion score index, TDI- strain and SR and post-systolic strain (PSS). Eight to ten months after the CABG procedure, myocardial function was reassessed by resting and DS echocardiography. The predictive value of preoperative resting and DSE parameters in assessing postoperative improvement of segmental strain, was evaluated using uni- and multivariate regression analyses and receiver operating characteristic (ROC)-curves.

Results: Compared to healthy controls, half of all segments in CAD patients displayed preoperatively reduced longitudinal strain despite only 1.4% segments with transmural infarctions. Of these dysfunctional, mainly viable segments, 38% improved resting strain postoperatively. From all tested parameters, resting ejection time (ET)-strain (R = 0.570, P,0.001) and strain from dobutamine-sterss increments (DSE) (R = 0.415, P,0.001) were the most predictive for functional segmental improvement. The area under the curve (AUC) for DSE strain increment in predicting functional improvement was 0.785 (0.685-0.895) in akinetic segments and 0.647 (0.541-0.714) in hypokinetic segments.

Conclusion: Longitudinal strain revealed extensive segmental myocardial dysfunction in CAD patients despite viable myocardium and nearly normal EF. Less than half of these segments demonstrated improved resting longitudinal function after CABG. In viable but dysfunctional segments, resting strain and DS stain-increments are reasonably accurate predictors of functional improvement.

P887 Improved diastolic myocardial function in elderly after high intensity aerobic interval training, compared to old master athletes

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Background: Myocardial diastolic function decreases with age. We hypothesised that aerobic interval training (AIT) improves diastolic function and that endurance training ameliorate age-associated reduction of the myocardial function.

Methods: 16 sedentary subjects (72 +1 years, 13 men) performed AIT (4x4minutes) at 90-95% of maximal heart rate 3 times/week for 12 weeks. Results: were compared with master athletes (74+2 years, 11 men). Echocardiography, including tissue Doppler (TD), was recorded at rest and during submaximal exercise.

AIT effect compared to master athletes

	Elderly, n=16			Master Athletes, n=11		
	Before	After	P-value	Value	P-value before inter-vention	P-value after inter-vention
VO2max(ml/kg/min)	32.5±5.5	37±6.1	<0.001	48.5±5.6	<0.001	<0.001
SBP, mmHg	144±14.8	126±8.2	<0.001	123±16.7	0.003	0.54
DBP, mmHg	80±8.7	73±4.5	0.005	71±9.2	0.02	0.55
Heart rate, beats/min	69±8.6	59±6.6	<0.001	53±6.0	<0.001	0.04
EDV, ml	92.5±16.9	106.5±28.2	0.001	142±21.4	<0.001	<0.001
SV, ml	74.5±13.8	81.5±19.2	0.03	102±25.7	0.005	0.02
EF,%	60.7±6.7	68.7±6.4	<0.001	63.7±4.8	0.20	0.03
E/A	0.89±0.25	1.28±0.67	0.02	1.31±0.7	0.06	0.90
E' , cm/s	7.3±1.7	8.1±1.8	0.02	9.0±2.1	0.04	0.32
A' cm/s	11.1±1.7	9.7±1.5	0.007	10.3±2.6	0.43	0.54
E/E'	8.9±1.9	8.8±1.4	0.78	6.6±1.5	0.005	0.001
S' submax exercise cm/s	8.0±1.4	10.1±2.1	0.001	11.9±1.2	<0.001	0.01

VO2max–maximal oxygen uptake, SBP-systolic blood pressure, DBP-diastolic blood pressure, EDV- end diastolic volume, SV-stroke volume, EF-ejection fraction, E/A-early/late diastolic filling, S' -systolic tissue velocity (TV), E'-early diastolic TV, A' - late diastolic TV

Results: Left ventricular diastolic function measured by traditional Doppler and TD, increased significantly after AIT, with no effect on systolic TD velocity (S') at rest, but a 26% increase during exercise (p , 0.001). Compliance to intervention was 100%. Conclusion: AIT improved left ventricular diastolic function in an elderly population almost to the same level as master athletes, although both remained below reference values for younger people. Stroke volume and end-diastolic volume increased, but was still superior among master athletes, compensating for the reduced diastolic function.

P888 Reduced left ventricular global strain and ejection fraction during normal pregnancy

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Purpose: During pregnancy, the cardiovascular systemadapts to the metabolic needs of mother and foetus in order to sustain adequate tissue perfusion. The effects on left ventricular (LV) function have not been well documented in larger patient groups. Thus, we used serial echocardiography with tissue Doppler and strain measurement to obtain a comprehensive analysis of LV systolic, and diastolic function during normal pregnancy.

Methods: 65 women (age 33.0 + 1.2 years) with normal pregnancies, were studied with transthoracic echocardiography (GE Vingmed Vivid 7) including grey scale imaging, Doppler, tissue Doppler, and global strain (by 2D speckle tracking echocardiography) at gestational weeks 14-16, 22-24, 36, and 6 months postpartum.

Results: During normal pregnancy, cardiac output (CO) and LV end-diastolic volume (LVEDV) increased significantly by 20% and 23 %, respectively, whereas LV EF and global strain (GS) decreased by 11% and 8 %. The increase in CO was caused by an increase in both heart rate (14 %, p , 0.001) and stroke volume (18 %, p , 0.001). Although left atrium (LA) dimensions increased by 18 %, E/e' was unchanged indicating stable LV filling pressures.

Conclusions: During normal pregnancies in healthy, asymptomatic women, CO increased due to adaptive dilatation of LV and increased HR. The reduced LV EF and GS is likely a result of this adaptation, particularly since filling pressures were unchanged.

Results

	14-16 weeks	22-24 weeks	36 weeks	6 mo postpartum	ANOVA p
CO (L/min)	5.7 ± 1.1	6.0 ± 1.0	6.0 ± 0.9	4.8 ± 1.0# ¤ §	<0.001
LV EDV (mL)	92 ± 22	97 ± 23	101 ± 26	78 ± 19# ¤ §	<0.001
LV EF biplane (%)	61 ±6	59±9	54± 8 # ¤	60 ± 7 §	<0.001
GS (%)	219.0±3.2	219.6±2.2	218.1±2.4¤	219.2±2.7	0.015
Mitral E (m/s)	0.80 ± 0.15	0.78 ± 0.13	0.66 ± 0.15# ¤	0.67 ± 0.12# ¤	<0.001
LA Area (cm2)	16.0 ± 2.5	16.7 ± 2.3	17.5 ± 2.1#	14.6 ± 2.3 # ¤ §	<0.001
E/e'	6.7 ± 2.2	7.0 ± 2.4	6.6 ± 3.0	6.6 ± 1.8	0.780
e'(m/s)	0.14 ± 0.03	0.13 ± 0.03	0.12 ± 0.03 #	0.13 ± 0.02 #	<0.001

Mean ± SD. p , 0.05 vs #14-16 w, ¤22-24 w, §36 w. E = peak early transmitral flow velocity and e' = mean peak lateral and septal mitral annulus velocity.

P337 Mitral annular tissue Doppler velocities are associated with cardiac risk factors in a healthy population

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Purpose: To study the associations of peak systolic (S') and early diastolic (e') mitral annular velocities with common cardiovascular risk factors.

Methods: 1266 persons (20-89 years), without known heart disease, hypertension and diabetes, which participated in the 3rd HUNT Study were randomised to echocardiographic examination. Anthropometrics and non-fasting blood samples were collected. Serum analyses were performed at an accredited laboratory. S' and e' was analyzed online by commercial pulsed wave tissue Doppler. S' and e' was measured in the base of the lateral, septal, anterior and inferior left ventricular wall, and the average of these four myocardial walls is presented as a global measure of systolic LV function. The measurement was performed at the outer clear edge of the Doppler spectrum at low gain settings. Feasibility was ≥96%. Associations were tested in multivariable analyses adjusted for age, and with regard to the lipids 'time since last meal' was also included as a covariate.

Results: Results are shown in table. Higher age, higher body mass index (BMI), higher blood pressure, higher non-HDL cholesterol and lower HDL cholesterol were significant associated with reduced mitral annular velocities. Smoking was associated with reduced mitral annular velocities in women, but not in men.

Conclusions: Unfavorable levels of conventional risk factors were clearly associated with reduced systolic and diastolic mitral annular velocities; suggesting the possibility of subclinical cardiac dysfunction among healthy individuals. The findings suggest that these risk factors influence cardiac function many years prior to clinical detection.

Age-adjusted percentage difference (standard error) in mitral annular velocities per standard deviation difference in covariates				
Covariate	S' (women)	S' (men)	e' (women)	e' (men)
Age	-8.0 (0.6)	-5.9 (0.6)	-22.2 (0.8)	-20.6 (0.9)
BMI	-1.3 (0.6)	-2.6 (0.6)	-4.4 (0.8)	-6.7 (0.9)
Systolic blood pressure	-1.4 (0.6)	-1.2 (0.7)*	-5.9 (0.8)	-5.4 (0.9)
Diastolic blood pressure	-1.6 (0.6)	-2.9 (0.7)	-6.0 (0.8)	-9.0 (0.8)
Non-HDL cholesterol	0.0 (0.7)#	-2.0 (0.7)	-2.1 (0.9)	-4.4 (0.9)
HDL cholesterol	0.7 (0.6)#	2.0 (0.7)	1.5 (0.8)*	4.4 (0.9)
Smoking	-2.5 (1.1)	-0.3 (1.3)	-4.8 (1.5)	-1.0 (1.8)

All p , 0.05, except; p , 0.10 and #; non-significant.*

P910 Echocardiography without ECG

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Purpose: Automatic detection of the QRS complex on ECG is used on most cardiac ultrasound scanners to separate recordings into cardiac cycles for continuous playback and storage of single cardiac cycles. On small hand-held scanners it is unpractical to connect ECG cables. We aim to do automatic cardiac cycle separation by estimating the length of the cardiac cycle using B-mode data only.

Method: The parameters of the algorithm were tuned using a data set of 214 apical B-mode recordings with 3 cardiac cycles and ECG. Testing the algorithm against ECG was done on a separate data set of 315 apical B-mode recordings (105 normal subjects, 55 female, age 23-83, mean frame rate 44). Both data sets were randomly extracted from the HUNT3 study. The lower 80% of the image was partitioned in 20 boxes. For each box and at each frame, the spatial mean B-mode intensity was calculated, resulting in 20 intensity/time curves. Then, an interval at the start of each curve was extracted and compared to the rest of the curve by a sum of absolute differentiated differences (SADD) algorithm. The minimum of the SADD function then represents the location at which the shape of the intensity

curve repeats itself, the cycle length. The median of cycle lengths from all boxes was used as the cycle length estimate. The number of cycle length estimates that were less than 50 ms different from the median was also calculated. If less than 8 of the 20 cycle length estimates were within this limit, the process was repeated up to two more times by restarting the SADD algorithm 200 ms later. If the number of accepted estimates was still below 8, the test case was discarded. To emulate a real-world situation, several test cases with start points at each of the different time points within the first cardiac cycle were run for each recording. Each test case was 2.15 s long. Test cases within a recording are not independent of each other, thus non-parametric statistics was used.

Results: Due to inconsistent ECG trigging as visible when reviewing ECG traces and trig points, 58 recordings were discarded from the test set before any processing was done. In the remaining 257 recordings, totally 9678 test cases were run. A cycle length estimate was achieved in 97% of the cases. Median difference to corresponding cycle length by ECG was 0.6 ms. 15% percentile was -14.9 ms, 85% percentile was 15.1 ms.

Conclusions: Automatic detection of cardiac cycle length is feasible based on B-mode only. Thus continuous playback and storage of one cardiac cycle is possible on a handheld ultrasound scanner without ECG.

P758 The influence of juvenile neuronal ceroid lipofuscinosis on the left ventricle

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Background: Juvenile neuronal ceroid lipofuscinosis (JNCL), also known as Spielmeyer-Vogt-Sjögren-Batten disease, is a rare autosomal recessive neurodegenerative disorder characterized pathologically by accumulation of lipopigments in various tissues. It manifests in early childhood as a variable yet progressive neurological disease with blindness, epilepsy and dementia as dominating symptoms. Autopsy studies have indicated a prominent progressive involvement of the heart in JNCL; storage material is found in the myocardium, valves and the conduction system. Storage is associated with hypertrophy, dilation of the ventricles, degenerative myocardial changes, interstitial fibrosis and fatty replacement. Despite severe myocardial damage, hemodynamic symptoms are reported to remain inconspicuous. The discrepancy between the pathology and the clinical condition is thought to be related to the highly limited activity of JNCL-patients. Systematic echocardiographic studies in patients with JNCL are lacking. We therefore aimed to study a cohort of these patients with respect to LV function and structure.

Methods: We conducted for the first time a systematic study of 13 consecutive patients (mean age 20 yrs, range 15 to 35 yrs; 8 male and 5 female patients) with known JNCL. All patients were studied by transthoracic echocardiography (TTE) and ECG. Data were compared with 13 age matched healthy controls. Results: None of the patients had symptoms of heart failure or were taking medication related to the cardiovascular system. Systolic and diastolic blood pressure was (mean±SD) 112±21 mmHg and 61±11 mmHg, respectively. Two patients (15 %) had mild LV systolic dysfunction with reduced ejection fraction (47% and 48 %) and reduced global longitudinal strain (216.5% and 215.8 %, respectively). None of the patients in the control group had EF below 55% or global longitudinal strain values above 218 %. Left ventricular hypertrophy (LVH) was found in 4 other patients (31 %), but LV was not dilated in any of the patients. There were significantly more patients with abnormal LV function and structure compared with the control group (P,0.01). Two patients showed mild mitral valve regurgitation. ECG analysis revealed one patient with T-inversions and LVH, but with normal TTE. One patient had right bundle branch block with mild LVH on TTE. All other patients presented with normal ECGs. Conclusion: In 13 patients diagnosed with JNCL, without cardiac symptoms, TTE revealed two patients with LV dysfunction and four other patients with LVH. Our findings suggest that these patients should be followed with echocardiography.

P689 Gender difference in angiographic disease severity in non-ST elevation myocardial infarction is not reflected by contrast echocardiography hypoperfusion

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Background: Significant gender differences in angiographic severity of coronary artery disease in patients with non-ST elevation myocardial infarction (NSTEMI) has been demonstrated. However, less is known about gender differences in the extent of myocardial hypoperfusion by contrast echocardiography.

Methods: We assessed segmental myocardial wall motion and perfusion by contrast echoc-

ardiography in 110 patients (34 women and 76 men) with NSTEMI prior to scheduled coronary angiography. Number of hypoperfused segments using a 17 segment left ventricular model was compared to angiographic coronary artery disease by quantitative coronary angiography (QCA).

Results: Age (70+12 vs. 66+12 years), troponin T level (0.53+0.66 vs. 0.75+1.32 mg/l), Thrombolysis In Myocardial Infarction (TIMI) risk score (3.2+1.4 vs. 3.5+1.4), left ventricular ejection fraction (58+12 vs. 55+11 %), diabetes (21 vs. 18%) and hypertension (44 vs 45 %, all ns) did not differ between women and men in the study. However, proportionally more women were ≥65 years of age (74% vs. 51%, p , 0.05). More women had angiographically normal coronary arteries and fewer women had multivessel disease (both p , 0.05) (Table). However, neither the number of segments with wall motion abnormality nor the number of segments with hypoperfusion by contrast echocardiography differed between genders (Table). Conclusion: Compared to men, women with NSTEMI had angiographically less severe coronary artery disease, but similar extent of myocardial hypoperfusion by contrast echocardiography. These findings suggest that microvascular disease may be more common in women than in men with NSTEMI.

	Women (n = 34)	Men (n = 76)
No significant stenosis by QCA (%)	27*	9
Multivessel disease by QCA (%)	35*	57
Wall motion abnormality (segments)	4.1±0.7	3.5±0.4
Hypoperfusion (segments)	7.0±3.7	7.3±3.4

** p , 0.05 compared to men*

P718 Is tissue Doppler based- and speckle tracking based strain and strain rate comparable at high heart rate?

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Aims: Compare strain and strain rate by tissue Doppler (TDI) and 2D-Strain (2DS), during stress.

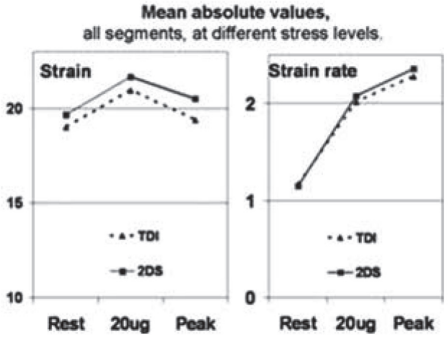
Methods and results: Dobutamine stress echo was performed on 20 patients with normal coronary angiography. TDI and B-mode were recorded at rest, at 20 µg/kg/ min, and peak stress. Segmental peak strain and -strain rate were analyzed by TDI and 2DS. 71% of segments were available for paired analysis. 2DS measured significantly higher absolute peak systolic Strain- and strain rate values in apical segments, and lower absolute Strain- and strain rate basally, than TDI. All segments analyzed together showed no differences between 2DS and TDI, at any stress level. Both methods showed a parallel increase in strain rate with increasing stress level, and biphasic response in strain.

Peak stress results

	Basal segm.	Mid segm.	Apical segm.	All segm.
TDI Strain	-19	-19	-20	-19
2DS Strain	-17	-19	-27	-20
p-value	<0.01	0.74	<0.001	0.13
TDI strain rate	-2.4	-2.1	-2.4	-2.3
2DS strain rate	-2.1	-2.2	-3.0	-2.3
p-value	<0.01	0.40	<0.001	0.28

Mean Strain- and strain rate values at peak stress (mean HR 134/min).

Conclusion: TDI and 2DS are comparable in expressing global information at low-, medium- and high heart rates. 2DS shows a significant basal to apical gradient, which is not evident for TDI. Thus there is a need for method- and level specific reference values if 2DS is to be used in stress echo.



Stress response Strain and strain rate

P747 Regional three-dimensional strain measurements in the left ventricle: a comparison with wall motion score

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A new 3D strain tool for measuring segmental three-dimensional strains (longitudinal, circumferential and radial) in the left ventricle (LV) has

been developed. Our aim was to compare these measurements to visual assessment of segmental wall motion score.

Methods: Three-dimensional recordings of the LV were obtained in 11 healthy subjects and 10 patients with coronary artery disease (frame rate 25-30/s, stitching 4-6 cycles). The region of interest was semi-automatically positioned, and midmyocardial longitudinal (L), circumferential (C) and radial (R) strains were measured in 16 segments of the LV by 3D speckle tracking. Segments were discarded after visual inspection of the tracking result in long- and short-axis slices. Wall motion score was visually assessed by experienced observers in B-mode 2D recordings.

Results: Acceptable tracking was achieved in 84% of the segments. Strain results are shown in table 1. Strain was lower in hypokinetic- and akinetic segments compared to normal segments in all dimensions (p , 0.001). There was a significant difference between hypo- and akinetic segments only for the circumferential strain measurements (p , 0.05 vs. p ¼ 0.6 & p ¼ 0.3 for C, L and R strains, respectively). Average values in normal subjects were 222+6%, 220+5% and 61+18%, for L, C and R-strains, respectively.

Conclusions: Three-dimensional strain measurements are feasible, and can differentiate between segments with normal and reduced function. Only circumferential measurements were able to differentiate between hypokinetic and akinetic segments. This might be due to difficulties in tracking the basal segment motion in the longitudinal direction and epicardial tracking in the radial direction.

	NormalWMS = 1, n = 269	Hypokinetic WMS = 2, n = 43	Akinetic, WMS = 3, n = 20
Longitudinal (%)	-20±6	-10±6 *	-9±5 *
Circumferential (%)	-20±6	-9±5 *	-6±6 * #
Radial (%)	59±18	23±11 *	18±13 *

**p <0.001 vs. normal segments. #p <0.05 vs. hypokinetic segments.*

P487 Professional soccer players display enhanced and earlier peak diastolic untwisting rate but lower left ventricular peak systolic twisting rate

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Purpose: Left ventricular (LV) torsional function contributes to cardiac function and may increase during exercise. LV torsional function depends on LV size, morphology, and inotropic state. This study aimed to systematically assess LV torsional function at rest in a large cohort of highly trained athletes.

Methods: Male professional Norwegian soccer players (n=103) from the two top national leagues underwent mandatory pre-participation echocardiographic screening at our institution prior to the 2008 season, and were compared with age-matched healthy controls (n=46). LV rotation was obtained at basal and apical short axis levels using speckle-tracking imaging (STI) by an experienced investigator blinded to study groups. LV torsion was defined as the net difference between apical and basal LV rotation, while rotational rates and twisting rates were derived from integrating rotation or torsion over time.Time-to-peak (TTP) data were normalized to systole duration (i.e. the time from QRS onset to aortic valve closure =100%).

Results: Body mass index, body surface area, blood pressure, and LV ejection fraction were comparable in both groups. Soccer players had lower heart rates (50±1 vs 63±2 min-1), greater computed LV mass (173±3 vs 150 ±5 g) and LV enddiastolic volumes (LVEDV, 158±3 vs 125±4 mL); all P,0.001 vs controls. Peak basal and apical rotation was not different between groups. Peak systolic torsion was comparable in magnitude (14.3±0.5 vs 15.2±0.9 deg; players vs controls, respectively), and occurred at similar time points (TTP, 93.5 ±0.8 vs 94.4±1.4%). However, when indexed to LVEDV, torsion was significantly lower in players (P,0.01). Moreover, peak basal rotational rate was lower(255.9±2.1 vs 265.1±3.7 deg/s, P,0.02) and occurred earlier in players (TTP, 57.5±1.0 vs 62.1±2.2%, P,0.05), while magnitude and timing of apical rotational rate was similar in both groups. Peak systolic twisting rate was significantly lower in players (86.4±2.8 vs 101.9±5.2 deg/s, P,0.01) with unaltered timing. Peak diastolic untwisting rate was enhanced in players (2124.5±4.2 vs 2106.9±6.7 deg/s, P,0.05) and occurred significantly earlier (TTP, 112.7±0.8 vs 117.4±2.4%, P,0.02).

Conclusions: Male elite soccer players display lower resting LV peak systolic twisting rate, but similar LV torsion compared to controls. However, normalized for LVEDV, lower torsion values suggest to take into account LV size when comparing torsional function between different cohorts. Diastolic untwisting rate was increased and may contribute to enhanced LV early diastolic function in athletes.