Journal of the American College of Cardiology
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Published by Elsevier Inc.

Vol. 50, No. 25, 2007
ISSN 0735-1097/07/$32.00
doi:10.1016/j.jacc.2007.09.018

MEETING HIGHLIGHTS

Highlights of the 18th Annual Scientific Sessions of the American Society of Echocardiography

Seattle, Washington, June 16–20, 2007

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An exceptional view of the heart through quality ultrasound imaging of the cardiovascular system was the theme of the 18th Annual Scientific Sessions of the American Society of Echocardiography, which took place in Seattle, Washington, from June 16 to 20, 2007. This meeting showcased how the latest advances in cardiovascular ultrasound technology play a vital role in enhancing the comprehensive evaluation of the cardiovascular patient. Furthermore, this meeting also highlighted that with the use of novel ultrasound technologies, echocardiography plays a critical role in "translational research." This highly successful 5-day conference chaired by Dr. Roberto M. Lang attracted more than 3,000 attendees and 300 faculty from all over the world. Among the highlights of the conference was the Edler Lecture, named after the father of echocardiography, Inge Edler, MD, entitled "The Future of Echocardiography: What Follows the Tipping Point?" In this lecture, Dr. Michael H. Picard, president of the Society, discussed the possible pathways that echocardiography can use in its continued evolution so that it does not become an obsolete technology. He pointed out several strengths and new applications of echocardiography including: 1) its use as a tool to understand mechanisms of heart failure and influence treatment; 2) its interface with personalized genetic medicine; and 3) its role in global health as we fight the epidemics of obesity, diabetes, and metabolic syndrome and aim for earlier detection of subclinical heart disease. Also, Dr. Picard discussed the subtle balance between appropriate and potential over-use of cardiac ultrasound technology. The Feigenbaum Lecture by Dr. Marielle Scherrer-Crosbie was entitled "Echocardiography in Translational Medicine: Of Mice and Men." In this lecture she discussed the power of echocardiography both at the bench and in clinical practice to help understand the genetic and molecular controls on cardiovascular physiology, cardiac structure, and function.

This year the National Board of Echocardiography honored its founder by sponsoring the Arthur E. Weyman Young Investigator Award competition. This competition featured the most innovative research from young investigators. This year the finalists' presentations spanned the use of a variety of novel ultrasound technologies to investigate a wide range of cardiac physiological mechanisms. Among the 4 finalists, Dr. Beat Kaufmann from Oregon Health and Science University was the winner. His interesting work described the utility of molecular imaging of inflammation in atherosclerotic lesions with ultrasound (1). The other finalists' work included: 1) the use and validation of Lagrangian strain and left ventricular (LV) rotation using a new algorithm based on speckle tracking (2); 2) the evaluation of load dependency of mitral annulus velocities and strain rates in humans in a microgravity environment created during parabolic flights (3); and 3) the impact of intraventricular blood flow vorticity on LV function (4). These last investigators presented a novel quantitative approach based on contrast echocardiography using vector particle image velocimetry (4).

The conference concluded with a mid-day session, hereby summarized, which highlighted the most innovative and provocative presentations on systolic function, resynchronization therapy, valvular heart disease, 3-dimensional echocardiography (3D echo), stress echocardiography, contrast

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Manuscript received August 10, 2007; revised manuscript received September 14, 2007, accepted September 17, 2007.

echocardiography, pediatric and adult congenital heart disease (CHD), vascular disease, and atherosclerosis detection.

Echocardiography in the Evaluation of Systolic Function and Resynchronization Therapy

Advances in technology have recently allowed the quantitation of regional LV function with myocardial velocity, strain, and strain rate using tissue Doppler or speckle tracking. Several studies were presented at the American Society of Echocardiography Scientific Sessions investigating and refining the role of echocardiography and Doppler in global and regional function. Using speckle tracking from 4-dimensional imaging, Ashraf et al. (5) validated the quantitation of cardiac twist in an in vitro model of mechanical cardiac rotation of explanted pig hearts. In the area of cardiac synchrony assessment, Sengupta et al. (6) demonstrated that regional differences in cardiac longitudinal stretch during early systole correlated with events that define LV synchrony. This pathway may provide new insights into cardiac muscle mechanics and synchrony.

Dyssynchrony may be present in both systole and diastole. Nair et al. (7) evaluated diastolic ventricular dyssynchrony in patients with systolic heart failure (ejection fraction <35%). In this study population, 86% of patients had evidence of diastolic dyssynchrony defined as an intraventricular or interventricular delay of >40 ms. Diastolic dyssynchrony was associated with left bundle branch block, larger ventricles, and worse systolic function. One-third of patients, however, did not have concurrent systolic dyssynchrony (SDI). The clinical implication of this finding remains to be determined. While most studies have focused on LV dyssynchrony, Kalogeropoulos et al. (8) evaluated right intraventricular dyssynchrony and its implication in patients with pulmonary hypertension. The standard deviation of time-to-maximal myocardial systolic velocity of 6 segments of the right ventricle (RV) determined a novel index of dyssynchrony for this chamber. Compared with control subjects, patients with pulmonary hypertension had higher standard deviations and thus greater RV dyssynchrony. This index related to the patients' functional class better than conventional parameters of RV systolic function.

In a study on the clinical applicability of automated myocardial strain determination, Lowe et al. (9) evaluated whether on-line determination of regional strain using speckle tracking corroborated visual analysis of regional function. They found that 97% of segments could be tracked, feasibility being lowest for basal segments (76%). A strong correlation was seen between longitudinal strain and visually adjudicated wall motion over a wide range of regional functions. Goland et al. (10) evaluated the changes in LV and RV function in donor hearts during the first year after heart transplantation with the use of tissue Doppler and myocardial performance index. A decrease of systolic and diastolic function parameters was seen in both ventricles and was worse early after transplantation. A gradual improvement in these parameters was observed during the year of follow-up. While LV indexes mostly recovered at 1 year after transplantation, RV function parameters remained depressed.

Echocardiography in the Evaluation of Valvular Heart Disease and 3D Echo

Bicuspid aortic valve. Identification of the presence and magnitude of dilation of the ascending aorta is an important component of the evaluation of patients with bicuspid aortic valves, especially those being considered for valve surgery. Albano and Pape (11) compared the diameters of the ascending aorta by transthoracic echocardiography between patients with bicuspid aortic valves and normals at 1 cm, 2 cm, and 3 cm above the sinotubular junction. The detection rate of aortic dilation in those with bicuspid aortic valves was best when measurements were made at least 2 cm beyond the sinotubular junction. The authors concluded that 3 cm above the sinotubular junction in the parasternal long-axis view is the optimal location for measurement of the ascending aorta.

Variability of 3D echo. Chukwu et al. (12) compared LV volume measurements by real-time 3D echo and 2-dimensional echocardiography (2D echo). They found that there were subtle gender and age differences in ventricular volumes and ejection fraction that were detected by the 3D echo but not by the 2D technique (12). This documentation of the superior accuracy and reduced variability of real-time 3D echo suggests that differences in cardiac size and function can be discriminated with 3D echo with smaller sample sizes than that needed with 2D echo.

RV volumes. Sugeng et al. (13) compared quantification of RV volume with real-time 3D echo with cardiac magnetic resonance imaging (13). As has previously been shown for the LV, the RV volume and ejection fraction measurements by 3D echo were accurate and in agreement with cardiac magnetic resonance.

Stroke volume in children. Lu et al. (14) lead a multicenter investigation of stroke volume measurement by real-time 3D echo in children. Stroke volume measurement was feasible across the mitral, aortic, and pulmonic valves. The 3D echo technique was most accurate for the left-sided valves. This may prove a valuable tool for noninvasive assessment of cardiac function in children with CHD.

Mitral regurgitation (MR). Quantitation of MR by 2D echo continues to be a challenge. In contrast, MR quantitation by 3D echo has proven superior due to the ability to visualize the true vena contracta area and the true volume of the proximal flow convergence region. Kahlert et al. (15) examined 57 patients with MR from a variety of etiologies to compare quantitation of the MR by tracing the proximal jet area en face by real-time 3D echo compared with a proximal jet area calculated from apical 4- and 2-chamber views. As one might expect, the real-time 3D technique confirmed that jet widths measured in 2D failed to accu-

rately represent the severity of MR for all etiologies. This was particularly true for those cases in which the regurgitant jet was eccentrically directed into the left atrium (LA). However, the jet area derived from the two 2D jet widths correlated very well with the 3D echo jet area measurement.

Cardiac resynchronization therapy (CRT). Three-dimensional echocardiography has been applied to various aspects of CRT for heart failure. Soliman et al. (16) compared quantification of mechanical dyssynchrony on real-time 3D echo to the position of the LV pacing lead on fluoroscopy. When the LV lead was positioned at the site of latest mechanical activation as determined on the 3D echo maps, a greater improvement in 6-min walk, LV volumes, and LV ejection fraction were noted at 6 months. Sixty percent of the subjects were noted to have this concordance in lead placement to the site of latest mechanical activation. Solis et al. (17) used real-time 3D echo to assess changes in mitral valve remodeling after CRT (17). This group showed that in addition to favorable changes in LV volume, a variety of 3D markers of mitral valve geometry and function improved after CRT.

Stress Echocardiography and Contrast Echocardiography

The highlight presentations related to stress echocardiography and contrast echocardiography focused on our ever-growing clinical experience with these modalities and the development of robust safety, efficacy, and cost-benefit data.

Safety of stress echocardiography. Kane et al. (18) examined the safety of stress echocardiography in over 15,000 patients when supervised by a registered nurse rather than by a physician. In this retrospective review from the Mayo Clinic, approximately 8,600 patients had an exercise echocardiogram and 6,800 had a dobutamine stress echocardiogram. The overall complication rate was 0.36% (1 in 280), with most adverse events being arrhythmic (0.24% were supraventricular tachycardia or atrial fibrillation requiring treatment and 0.04% were ventricular tachycardia). As expected, patients with a positive stress test (with new regional wall motion abnormalities during stress) were more likely to have a complication ($p < 0.001$). These complication rates are comparable to previously reported studies that assessed the safety of physician-supervised stress echocardiography.

New imaging techniques. Several studies demonstrated the feasibility and incremental value of new imaging techniques used during stress testing. Examples of these are the use of strain imaging or contrast echocardiography during stress testing. Ishii et al. (19) demonstrated that strain imaging derived from 2D speckle tracking can be applied immediately after cessation of exercise echocardiography to detect post-ischemic regional LV diastolic dyssynchrony in patients with stable effort angina. Since diastolic dysfunction occurs before systolic dysfunction in the ischemic cascade, this technique has the potential to improve the sensitivity of stress echocardiography.

Physicians performing stress echocardiography on a regular basis understand the benefits of contrast in improving LV opacification and endocardial border delineation. Bernier et al. (20) have shown that the addition of contrast to a stress echocardiogram is cost-effective when 2 or more segments cannot be adequately visualized. In over 16,000 consecutive stress patients, 3,637 patients with suboptimal noncontrast images received contrast. This group was compared with 912 patients with suboptimal echocardiograms who did not receive contrast. All patients were followed for 21 days and the end point was the need for additional testing. A total of 16% of patients in the noncontrast group required additional tests (e.g., single-photon emission computed tomography or computed tomography angiogram) as compared with 5.8% in the contrast group ($p < 0.001$). This represents a net risk reduction of 10.2%, with a weighted average savings of $2,421 per patient requiring repeat testing.

Echocardiography in Vascular Disease and Atherosclerosis

Highlights on vascular disease and atherosclerosis focused on measures of plaque and intimal-medial thickness (IMT) in the carotid and femoral arteries, as well as endothelial function measured by flow-mediated dilation (FMD) of the brachial artery.

Pre-clinical atherosclerosis. Postley et al. (21), in their study of pre-clinical atherosclerosis, recruited from 14 internal medicine practices 398 adults (age range 33 to 79 years) with no previous history of angina, myocardial infarction, stroke, or claudication and no previous lipid therapy. In each patient, Framingham risk score (FRS) was calculated and ultrasound recordings performed in the carotid and femoral arteries. The authors reported that the largest numbers of men with pre-clinical atherosclerosis were found in the intermediate FRS group, whereas the largest number of women was found in the low-risk FRS group. Of additional interest, among patients with plaques, 21% were localized only in the femoral arteries, while 43% were localized solely to the carotid arteries. These findings suggest that both carotid and femoral ultrasound measurements of plaque (and IMT) are of value, in addition to FRS, in identifying pre-clinical atherosclerosis. Strain rate might provide additional mechanical insights into the atherosclerotic process.

Endothelial function. Sugimoto et al. (22) demonstrated that endothelial function, as measured from FMD in the brachial artery, could predict the development of restenosis or coronary ischemic events in patients who underwent percutaneous coronary intervention. Specifically, among 49 patients (age range 28 to 76 years), those with FMD $\geq$5% had a significantly higher rate of event-free survival, over approximately 4 years of follow-up, compared with those

patients exhibiting an FMD <5%. Finally, in a fascinating study, de las Fuentes et al. (23) demonstrated that the common osteopontin OPN-66TT genotype may be associated with increased carotid IMT compared with the OPN-66GG and TG genotypes, consistent with increased OPN promoter activity in this genetic variant in mice. Of further interest, in a study of 140 Caucasian adults, 70 with metabolic syndrome and 70 without the metabolic syndrome, these authors showed that this effect of the OPN genetic polymorphism appeared blunted (i.e., was not significant) in patients with, as opposed to patients without, the metabolic syndrome (in whom the difference was significant ($p < 0.02$).

Pediatric Cardiovascular and Adult CHD

The session on pediatric cardiovascular and adult CHD highlighted potential applications of many recent developments in ultrasound technology to children and adults with CHD.

Quantification of LV dyssynchrony. Baker et al. (24) quantified intraventricular LV dyssynchrony using 3D echo evaluation of segmental LV volumes in 9 children with LV dysfunction (2D fractional shortening <28%) and compared them with that in 9 controls subjects. They hypothesized that children with LV dysfunction have increased intraventricular dyssynchrony, which has been demonstrated in an adult population (24). Dyssynchrony was assessed by subdividing the LV into 16 segments. Time from end-diastole to minimal systolic volume for each subvolume was measured and expressed as a percent of the R-R interval to control for heart rate. The standard deviation of these times provides an SDI, as proposed by Kapetanakis et al. (25). Compared with control subjects, the dysfunction group exhibited significantly increased SDI. The median SDI was 4.37% in the dysfunction group and 2.1% (0.71% to 2.78%) in control subjects ($p = 0.008$). The SDI was negatively correlated with 3D LV ejection fraction. Of particular interest in this study were the different SDI results when compared with those reported in a similar study performed with an adult population (in which normal patients had a mean SDI of 3.5%). An arbitrary SDI cutoff for significant dyssynchrony was set at 8.3%. Thus, SDI values may vary with age and body size, and reference values may need to be established for each age group. Systolic dyssynchrony may provide insight into management options for children with LV dysfunction, such as selection of candidates who may respond to resynchronization therapy.

Quantification of LV rotation and torsion. Takahashi et al. (26) evaluated LV rotation and torsion (difference in rotation between the apex and base of heart) using speckle tracking echocardiography in 114 subjects (ages 0 to 41 years) with normal cardiac anatomy and function. For analysis, results were divided then into 5 groups based on age. After analysis of basal and apical rotation for each age group, values were normalized for differences in heart rate and heart size, and then intergroup comparisons were performed. This study determined that the heart maintains a constant torsion across ages (after normalization). Younger hearts tend to twist and untwist faster than older hearts; thus, age appears to have an impact on the rotational and torsional properties of the myocardium.

Velocity vector imaging. Kutty et al. (27) evaluated the utility of velocity vector imaging in the assessment of RV function in 30 normal children. Manual endocardial tracing and automatic software tracking displayed peak longitudinal systolic and diastolic myocardial velocities, peak systolic strain, maximal longitudinal displacement, and times to peak for these parameters from 6 RV segments. The intraobserver and interobserver as well as intersubject variability of these measures were assessed. Basal longitudinal displacement was a very robust measure (interobserver error <10%), with mean longitudinal displacement of free wall and septal basal regions $>12 \pm 2$ mm. Peak systolic strain values were much less consistent, both between segments and between observers. Since RV function appears to have a dominant longitudinal component, longitudinal displacement is an excellent measure of systolic function analogous to LV shortening fraction.

Prenatal ultrasound. On a completely different note, Friedberg et al. (28) highlighted the need for education in imaging CHD in the fetus in a study investigating factors affecting the prenatal diagnosis of CHD in Northern California. Over a 1-year time period, parents of an infant under 6 months of age with CHD requiring an intervention were interviewed. Most (99%) mothers who had a child with CHD had a prenatal ultrasound; only 30% of these studies identified CHD in the fetus. Anomalous pulmonary venous return, d-transposition of great vessels, and left-sided obstructive lesions other than hypoplastic left heart syndrome had the lowest prenatal detection rates. Maternal socioeconomic factors were not different between infants with and without a prenatal diagnosis and did not predict prenatal diagnosis. Chances of prenatal diagnosis were higher at a university versus a community-based prenatal practice (relative risk 3.1, 95% confidence interval 2 to 4.9, $p = 0.001$). Prenatal diagnosis of CHD remains low despite universal prenatal ultrasound with profound impact on the post-natal course. Improved education of prenatal care providers for prenatal diagnosis of CHD is required.

Systemic Diseases, Outcomes, Cardiomyopathy, and Pericardial Disease

Several abstracts extended the literature on the role of hand-carried ultrasound (HCU) in screening for cardiovascular disease. Kenny et al. (29) screened 423 elderly adult outpatients with an HCU device to assess whether LV mass and ejection fraction as well as LA volume and the ratio of peak early to late atrial mitral inflow velocities (E/A) could be used to predict the combined cardiac outcome of first myocardial infarction, stroke, atrial fibrillation, congestive

heart failure, coronary revascularization, or cardiovascular death. In a multivariate analysis, HCU-determined E/A ratio and LA volume were significant predictors of the combined cardiac end point.

The power of echocardiography as a predictive tool was demonstrated in 2 studies. The first looked at the clinical and echocardiographic predictors of readmission in 191 patients with recent myocardial infarction (30). At 1 year, the readmission rate was 58%, and severe diastolic dysfunction during the hospitalization was the most powerful echocardiographic predictor of readmission. Kumar et al. (31) evaluated whether echocardiography could predict intracardiac defibrillator (ICD) discharges among patients with LV systolic dysfunction. Interestingly, LV ejection fraction did not predict ICD discharge, but specific measures of LV remodeling (mass and volume) as well as diastolic filling parameters were associated with an increased incidence of ICD firing.

Using echocardiography, several studies provided new insights into cardiovascular physiology. Chen et al. (32) evaluated radial function using tissue Doppler imaging in obese patients with preserved LV ejection fraction. The authors demonstrated that in addition to the previously demonstrated reduction in longitudinal function, peak radial strain and strain rate were reduced in obese patients without cardiac disease. Saha et al. (33) used a novel echocardiographic technique to assess aortic pulse wave velocity as a measure of aortic stiffness and compared the results to different coronary flow patterns in diabetic patients. Aortic stiffness was increased in the diabetic patients and correlated positively with the systolic fraction of total coronary flow. Finally, researchers at the Mayo Clinic assessed LV regional deformation using speckle tracking in patients with constrictive pericarditis (34). This novel work demonstrated the existence of segmental contractile dysfunction due to significantly reduced peak longitudinal and radial strains in the LV apex with a loss of the apex-to-base gradient of LV deformation in constrictive pericarditis subjects.

Conclusions

This conference showcased how echocardiography and Doppler methods continue to be critical for the diagnosis and quantification of disease, for the determination of serial responses to therapy and clinical decision making, even at a time when the care of the cardiovascular patient is rapidly changing. Dr. Mani A. Vannan, next year's program chair, and Dr. Thomas J. Ryan, American Society of Echocardiography president, are preparing a cutting-edge program filled with new teaching methods from June 7 to 11, 2008, in Toronto, Canada, for the 19th Annual Scientific Sessions of the American Society of Echocardiography.

Acknowledgment

The authors gratefully acknowledge the valuable help of Ms. Andrea Van Hoever in preparing this manuscript.

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