

EuroEcho and other imaging modalities: highlights

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The annual meeting of the European Association of Echocardiography (Euroecho and other Imaging Modalities) was held in Athens, Greece. In the present paper, we present a summary of the 'Highlights' session.

Keywords

Ischaemic heart disease • 3D echocardiography • Cardiac computed tomography • Nuclear cardiology • Cardiovascular magnetic resonance • Congenital heart diseases • Heart valve diseases

Introduction

The first annual scientific meeting of the European Association of Cardiovascular Imaging (Euroecho and other Imaging Modalities) was held in Athens, Greece. The meeting was dedicated to a more comprehensive assessment of the 'clinical scenario' with the objective of focusing on how imaging modalities—based on an integrated cardiovascular imaging approach—affect clinical decision-making and outcome. The total attendance of the meeting was over 2800 participants and 690 abstracts were selected for presentation. The last day of the meeting, the 'Highlights' session wrapped up the event with a summary of the most relevant abstracts presented throughout the congress. A short report of this session is presented below.

Ischaemic heart disease

Vassiliadis *et al.*¹ in a series of 300 patients undergoing non-contrast computed tomography (CT) showed that increased epicardial adipose tissue was related to the presence of coronary artery disease (CAD) (160 mm in CAD vs. 147 mm in non-CAD, $P = 0.012$). In 250 CAD patients with a Gensini Score ranging between 2 and 364, the presence of epicardial adipose tissue was related to the underlying left ventricular (LV) function. In the subset of patients with normal LV function, epicardial adipose tissue was higher than in those with reduced LV function

(<50%).² Ahn *et al.*³ compared in 30 post-acute myocardial infarction patients integrated backscatter with late gadolinium enhancement cardiac magnetic resonance (LGE-CMR) for the identification of myocardial viability, showing a significant correlation between the two parameters. In another study, Liepic *et al.* compared multislice computed tomography (MSCT) and dobutamine stress echocardiography for predicting functional recovery in 72 patients after MI treated by percutaneous coronary intervention. Sensitivities and specificities were comparable between the two techniques with a clear advantage for stress echocardiography in terms of costs and lower radiation exposure risks (61 vs. 68% and 84 vs. 89%, respectively).⁴ A few presentations focused on the use of stress echocardiography for the prediction of response to cardiac resynchronization therapy. Nikcevic *et al.*⁵ showed in 44 patients with idiopathic dilated cardiomyopathy that the improvement of LV ejection fraction (EF) during the stress test was related to a sustained CRT response over time; similar data, but on both ischaemic and non-ischaemic settings were reported by Mizia-Stec *et al.*⁶ in 129 subjects. The improvement of LVEF during dobutamine stress echocardiography was a predictor of response to CRT. Such a response was reported to be more effective in the non-ischaemic subset than in the ischaemic condition. A very novel and simple approach to identify candidates for CRT was proposed by Stankovic *et al.*⁷ who used a simple 2D echo parameter such as apical rocking and demonstrated its ability to predict response in 58 patients with LV dysfunction. Changes in apical rocking were highly predictive for

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CRT outcome while LVEF changes could not predict either response or long-term survival in CRT candidates. Myocardial contractility, identified by stress-induced variation in LV end-systolic pressure–volume ratio (ESPVR), was measured in patients with abnormal LVEF and negative stress echocardiography to assess its prognostic power.⁸ Bombardini *et al.* showed that patients with rest <50% LVEF despite no inducible ischaemia may still experience an adverse outcome related to abnormal contractile reserve, which can be identified by $\Delta\text{ESPVR} < 0.4 \text{ mmHg/mL/m}^2$. In a meta-analysis that pooled data from published series examining the prognostic value of normal stress CMR defined as the absence of inducible perfusion defects and/or the absence of inducible wall motion abnormalities, Gargiulo *et al.*⁹ showed that stress CMR had a high-negative predictive value for primary and secondary cardiac events. The negative predictive value for MI and cardiac death of the absence of myocardial ischaemia was 98.3% [95% confidence interval (CI) 97–98%] over a median follow-up of 24 months, resulting in an estimate event rate after the negative test equal to 1.7% (95% CI: 1.25–2.3%). Doppler-derived coronary flow reserve (CFR) was shown to be significantly impaired in 27 type 1 diabetic patients (mean value 1.1 vs. 2.4 of the control group) despite a normal LV function. The identification of vascular allograft disease in heart transplanted patients was obtained with dipyridamole stress echocardiography in 44 patients: three parameters of wall motion, CFR, and contractility (ESPVR) yielded the highest diagnostic accuracy.¹⁰

Heart valve diseases

Multi-modality imaging has a place of choice in the diagnosis, management, and risk stratification of patients with valvular heart disease. The CFR was quantified using Doppler echocardiography before and after isolated aortic valve replacement (AVR) in 17 patients with moderate to severe aortic regurgitation.¹¹ After AVR, there was a significant early and sustained postoperative improvement in the CFR. Moreover, the early improvement predicted positive changes in LV volume and LV filling pressure estimation (E/e') at the 6-month follow-up. Dulgheru *et al.*¹² reported that ~50% of asymptomatic patients with moderate/severe aortic stenosis (AS) and preserved LV function may have reduced maximal exercise capacity, which is mainly determined by the level of global LV haemodynamic afterload, as assessed by valvulo-arterial impedance. In severe AS, the role of LV diastolic function in the presence of elevated systolic pulmonary arterial pressure (SPAP) was underlined by the study of Cardoso *et al.*¹³ They reported a close correlation ($r^2 = 0.45$) between E/Ea ratio and SPAP. Interesting results including patients with low-gradient severe AS and preserved LVEF were reported by Valbuena *et al.*¹⁴ Patients undergoing AVR had better mid-term survival rate than those under conservative management. However, no significant rates of clinical events were observed between both strategies. The measurement of aortic annulus size and shape is crucial to select appropriate size and type of prosthesis before transcatheter aortic valve implantation (TAVI). In 177 patients scheduled for TAVI and having undergone both transesophageal echocardiography (TOE) and MSCT, Sordi *et al.*¹⁵ found that disagreement regarding aortic annulus size measurements between both

imaging modalities occurred in one-third of patients. In addition, they showed that TOE-based strategy tended to be associated with a higher rate of significant paravalvular regurgitation (PVR). In contrast, MSCT-based strategy was associated with a higher rate of annulus rupture. In 208 patients with primary mitral regurgitation (MR) assessed with preoperative LV and right ventricular (RV) radionuclide angiography, RV dysfunction ($\text{EF} \leq 35\%$) was frequent (30%) and depended weakly on SPAP but mainly on LV remodelling and septal LV function.¹⁶ Furthermore, concomitant LV and RV impairment seemed to be a powerful predictor of both cardiovascular events and overall survival. Despite preserved LV function, as assessed by LVEF, Malev *et al.*¹⁷ showed that primary MR due to Barlow's disease was significantly associated with reduced preoperative LV longitudinal, circumferential and radial strains, and strain rates, when compared with fibroelastic deficiency. These differences could be explained by intramyocardial extracellular matrix damage frequently encountered in Barlow's disease. Left atrial (LA) volume has been included in the current ESC guidelines for the management of patients with primary MR. Cameli *et al.*¹⁸ reported that in patients with severe MR referred for cardiac surgery, the preoperative peak atrial longitudinal strain was strongly correlated with LA fibrosis extent and remodelling. In secondary MR, Theron *et al.* aimed to assess early and mid-term outcome following valve replacement of 47 symptomatic patients with LVEF <40%.¹⁹ Surgery was associated with significant positive reverse LV remodelling, no worsening of LVEF and improvement in SPAP. Early and mid-term outcome was reasonable. In 416 consecutive patients with long-term follow-up, the concomitant presence of functional tricuspid regurgitation in patients with heart failure and secondary MR has been shown to be associated with a higher incidence of renal failure, heart failure episodes, and death.²⁰

3D Echocardiography

At EuroEcho 2012, three-dimensional echocardiography (3DE) has been very popular among the original abstract submissions. Seventy-two (10%) of all accepted abstracts were ~3DE with a stable percentage compared with abstracts accepted at EuroEcho 2011. Muraru *et al.*²¹ reported reference values for mitral valve (MV) annulus and leaflet size and morphology in 81 consecutive healthy volunteers (43 ± 13 years, range 18–70; 33 men) in whom MV data sets were acquired using transthoracic approach. Feasibility of MV analysis was 94%. The average analysis time of one dataset (including manual editing) was 2 min. The possibility to perform a quantitative analysis of mitral annulus using transthoracic echocardiography may support its assessment in clinical routine. Three-dimensional echocardiography has also been used to assess the effects of intervention on adjacent valvular structures, offering a new way to assess the results of surgical or interventional procedures and opening the path for refinement of mitral reparative techniques and prosthesis design. Tsang *et al.*²² used 3DE to study aortic-mitral coupling in AS patients undergoing TAVI and compared them with patients without AS. Before TAVI, patients had significantly reduced mitral annulus area, mitral annulus displacement, and maximum aortic annulus area compared with controls. After TAVI, all these parameters remained reduce.

Looi *et al.*²³ used 3DE to study the impact of mitral annuloplasty on aortic-mitral coupling in patients with mitral valve prolapse. Compared with controls, patients with mitral valve prolapse had dilated mitral and aortic annuluses while reciprocal aortic-mitral coupling and systolic contraction of aortic-mitral angle were preserved. After annuloplasty, both mitral and aortic annulus areas were reduced and became adynamic throughout cardiac cycle, and systolic contraction of aortic-mitral angle was significantly restricted.

Many investigators focused their attention on the RV. Muraru *et al.*²⁴ reported reference data for 3DE RV size and function derived from a multicentre study, which enrolled 533 healthy volunteers between 18 and 78 years. Three-dimensional echocardiography has also been used to assess RV function in patients with chronic obstructive pulmonary diseases with and without pulmonary hypertension,²⁵ carcinoid disease,²⁶ pulmonary artery hypertension,²⁷ and pulmonary embolism.²⁸ Huttin *et al.*²⁹ reported that, in the acute phase of MI, 3D area strain—a parameter combining both longitudinal and circumferential strains—seemed the most valuable parameter for assessing LV function. It represents a global marker of LV dysfunction and a regional marker of transmural scar extent.

Nuclear cardiology and cardiac computed tomography

Vancraeynest *et al.*³⁰ showed that the integrin-specific tracer ^{99m}Tc-NC100692 can be used for *in vivo* imaging inflamed atherosclerotic lesions in mice. The animals were imaged with a μ SPECT (single-photon emission computed tomography) and a multidetector (MD) CT system. Images from both modalities were fused. A significantly higher tracer uptake was observed in the ApoE^{-/-} hyperlipidaemic mice that correlated well with the presence of macrophages into atherosclerotic lesions of ApoE^{-/-} mice using immunostaining. Alqaseer *et al.*³¹ demonstrated that the risk of major cardiac events after a normal nuclear cardiac scan is low and in agreement with the international statistics available in a Saudi Arabia population with a high prevalence of diabetes, hypertension, and dyslipidaemia. This single-centre retrospective observational registry included 290 patients and the mean follow-up was 14.8 months. Obase *et al.*³² showed considerable individual variability in the aortic root angle, using multidetector computerized tomography (MDCT) and a 3D quantitative software, in patients with AS and aortic regurgitation. The information provided is important because in the procedure of TAVI, the increasing angle of the LV outflow tract to the ascending aorta was associated with a higher likelihood of PVR. Hrynchshyn *et al.*³³ evaluated the potential contribution of cardiac MDCT to assess prosthetic valve (PV) dysfunction, also assessed by Doppler echocardiography. MDCT provided additional information about the mechanism of PV dysfunction in 10 patients. MDCT demonstrated significant lesions confirmed by surgery on PV considered as normal according to Doppler echocardiographic data in three patients. Does *et al.*³⁴ demonstrated the usefulness of cardiac CT in the assessment of CAD, intramyocardial bridging and different patterns of LV hypertrophy in 20 patients with hypertrophic cardiomyopathy. Mor-Avi *et al.*³⁵ compared quantitative 3D

analysis of myocardial perfusion from regadenoson stress MDCT images with SPECT perfusion in 17 patients referred for CT coronary angiography and showed good agreement with SPECT (sensitivity 82%, specificity 83%, accuracy 82%). Al-Mallah *et al.*³⁶ determined the prevalence of CAD and atherosclerosis in 102 asymptomatic patients with type II diabetes, using coronary CT angiography. Nearly 25% of asymptomatic diabetics had normal coronaries and 18% of diabetics had obstructive CAD. The majority of asymptomatic diabetic patients had evidence of atherosclerosis, but not obstructive CAD. Qureshi *et al.*³⁷ assessed gender differences among 916 symptomatic patients referred for coronary CT angiography. Symptomatic women had less often-obstructive CAD, and were less likely to have mixed coronary plaque compared with symptomatic men. Mckavanagh *et al.*³⁸ in a randomized study compared cardiac CT with the exercise stress test in 500 patients with stable chest pain. CT assessment involved calcium score and CT coronary angiogram. Patients in the CT arm had a lower rate of hospitalization and CAD events, showed a significant improvement in perception of angina stability and quality of life, and were diagnosed and managed earlier.

Cardiovascular magnetic resonance

Several abstracts on CMR focused on tissue characterization using LGE in the diagnosis of CAD and myocardial diseases. Bonanad Lozano *et al.*³⁹ presented in their abstract the combined prognostic value of Grace Score and CMR in patients with ST-segment elevation MI (STEMI). In this study including 461 patients, the authors concluded that independent predictors of events were high risk Grace Score [3.4 (1.4–8.3), $P = 0.007$] and the extent of myocardial scar [1.3 (1.2–1.4), $P < 0.001$]. The risk of events was higher in patients with >5 segments necrosis (23/296, 8 vs. 29/92, 31%, $P < 0.001$). The extent of infarction in 0–5 or >5 segments allowed to discriminate the event risk in patients with low (1 vs. 23%, $P = 0.001$), intermediate (10 vs. 23%, $P = 0.05$), and high (11 vs. 46%, $P < 0.001$) Grace Score risk. Soeholm *et al.*⁴⁰ hypothesized that moderate or severe diastolic dysfunction in the early post-MI was associated with the area at risk and final infarct size as assessed by CMR. This prospective study included 193 patients with STEMI. They concluded that advanced diastolic dysfunction was significantly correlated with larger area at risk ($r = 0.24$, $P = 0.004$), larger final infarct size ($r = 0.29$, $P < 0.001$), and lower salvage index ($r = -0.25$, $P = 0.004$). Marzluf *et al.*⁴¹ presented the assessment of diffuse myocardial fibrosis by CMR T1-mapping in 81 patients with serum NT-proBNP levels >125 pg/mL and preserved LVEF. Myocardial T1-mapping was performed 10 min after a gadolinium bolus and was correlated with NT-proBNP, cardiac function, and symptoms. In patients with NT-proBNP levels >400 pg/mL, mean T1 was significantly shorter than in patients with NT-proBNP <400 pg/mL (383.8 ± 49.8 vs. 408.6 ± 32.0 ms, $P = 0.012$). T1 was also related to the degree of diastolic dysfunction by echocardiography ($P = 0.002$) and NYHA-functional class ($P = 0.021$). The authors concluded that T1-mapping may become a promising tool for the assessment of diffuse myocardial fibrosis and appear to be of a prognostic

value in patients with heart failure. Almeida et al.⁴² studied the impact of atrial fibrosis assessed by CMR in atrial function and dimension in 47 patients pre-ablation of atrial fibrillation (AF). All patients showed atrial fibrosis, which was mild in 17, moderate in 22, and extensive in 8. Considering the three groups, there was a significant difference in the LA volume and LVEF between the mild fibrosis group and the group with extensive fibrosis ($P = 0.04$ and $P = 0.01$). Mohty et al.⁴³ evaluated the prognostic value of LA volumes and function in 45 patients with systemic amyloidosis (SAL) according to the Mayo clinic staging and their impact on survival. In SAL patients, morphological and functional LA alterations were significantly associated with Mayo clinic staging and LAEF appeared to be an independent predictor of 2-year mortality. In 87 patients with hypertrophic cardiomyopathy who underwent LGE-CMR prior to implantable cardioverter-defibrillator (ICD) implantation, Prinz et al.⁴⁴ showed that fibrosis severity correlated with the occurrence of ventricular tachycardia (VT) ($r = 0.4$, $P < 0.001$) and AF ($r = 0.6$, $P < 0.001$). On multivariable regression analysis, an independent association between myocardial fibrosis ($r = 0.6$, $P < 0.01$) and sustained VT was found. The authors concluded that in patients with high clinical risk markers of sudden cardiac death, the severity of myocardial fibrosis was associated with future arrhythmic events and appropriate ICD therapies. In LGE imaging, myocarditis is one of the major indications for CMR. Bonanad Lozano et al.⁴⁵ evaluated the usefulness of CMR during the follow-up in 33 patients with acute myocarditis. They reported a normalization of LVEF in all patients and a disappearance of LGE in more than one-third of them. CMR is a useful tool for the diagnosis and the follow-up after acute myocarditis.

Congenital heart diseases

Assessment of the RV was prominent in the congenital heart disease oral abstracts. Iriart et al.⁴⁶ presented data from their multi-parametric study of adults with repaired tetralogy of Fallot before and after pulmonary valve replacement surgery. They reported no correlation between simple measures such as tricuspid annular plane systolic excursion but confirmed a correlation between RV fractional area change and 3D EF when compared with CMR. Horovitz et al.⁴⁷ reported no correlation between 3D EF and CMR in adults with a systemic RV after atrial redirection surgery (Senning or Mustard), concluding that conventional echocardiographic parameters of RV function was neither reliable nor reproducible. Marinov et al.⁴⁸ used speckle-tracking echocardiography to evaluate regional RV deformation in young adults following the arterial switch operation. They reported reduced global strain, reduced regional strain at the apex, and mid-RV but not at the base and hypothesized a regional microcirculatory aetiology. Van De Bruaene et al.⁴⁹ studied pulmonary vascular distensibility before and after early or late closure of atrial septal defects (ASD). They derived a distensibility coefficient by echocardiography and reported that those with an unrepaired ASD or after late repair had a significantly lower distensibility coefficient, advising that an ASD should be closed early to avoid this complication. Device closure of ASD has hitherto relied on balloon sizing of the defect. Sordi et al.⁵⁰ compared the conventional balloon stretch

diameter (BSD) with 2D and 3D TOE. They demonstrated the variation in ASD size and shape throughout the cardiac cycle. Although both 2D and 3D TOE correlated well with BSD, the 3D TOE provided values closer to the BSD, particularly so for non-circular defects. Schubert et al.⁵¹ used speckle tracking in the foetus at 28 weeks gestation and then in the same neonate soon after birth to evaluate the feasibility and reliability of this technique even from foetal life. Two-dimensional strain and strain rates were lower after birth in both ventricles and throughout the cardiac cycle. The authors argued for wider use of this technique in neonates due to its angle independence. Granja et al.⁵² reported good correlation between 3D speckle tracking with CMR in children and young adults with heart disease, using linear and quadratic regression between 3D speckle tracking and CMR to estimate ventricular volume. Speckle chords were used by Bellsham-Revell et al.⁵³ to assess the difference in regional strain in two morphological variants of hypoplastic left heart syndrome (HLHS). The authors reported differences in septal strain compared with RV free wall strain in both morphologies, more marked in the globular LV type of HLHS. Finally, Gomez et al.⁵⁴ presented a new technique using compounded 3D colour Doppler echocardiographic images to generate 3D intracardiac blood velocity and flow, comparing flow calculations with phase contrast CMR in both the normal heart and HLHS. This technique requires a short-acquisition time, and is angle independent but still has the inherent limitations of Doppler echocardiography. This abstract was awarded the Euroecho Young Investigator Award—Basic Science 2012.

Conflict of interest: none declared.

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IMAGE FOCUS

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Hybrid treatment of a giant coronary artery fistula between the left circumflex coronary artery and the coronary sinus

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A 60-year-old woman with dyspnoea and palpitation underwent computed tomography (CT), which showed a coronary artery fistula (CAF) originating from an aneurysmal left circumflex coronary artery (LCx) (Figure 1A, arrow), draining directly into the coronary sinus (Figure 1B, arrow) and two obtuse marginal branches arising from the CAF. Transthoracic echocardiography (TTE) showed dilatation of both the right atrium and ventricle with moderate tricuspid insufficiency associated with increased systolic pulmonary artery (PA) pressure (59 mmHg). Magnetic resonance measured a 1.9 pulmonary-to-systemic flow ratio. The surgical closure of the CAF was performed with ligation of the proximal aneurysmal LCx and distal CAF. Then, the first and the second marginal branches (M1, M2) were bypassed with the left internal mammary artery (LIMA) and a saphenous vein graft (SVG), respectively. Three days later, CT showed a complete closure of the proximal CAF (Figure 1C, white arrow) and an incomplete closure of the distal CAF (Figure 1C, red arrow) with retrograde flow from the grafts anastomosed to M1 and M2, confirmed by invasive coronary angiography (Figure 1D). A percutaneous closure was performed using a 7-Fr left Amplatzer 3 guiding catheter introduced from the right femoral vein into the distal part of the CAF. Complete CAF occlusion was obtained after deployment of an 8-mm Amplatzer Vascular Plug 4 (AVP) (Figure 1E, circle). Postoperative TTE revealed normal systolic PA pulmonary pressure (31 mmHg) and dyspnoea disappeared.

This case illustrates that incomplete CAF occlusion may be a potential complication associated with surgical treatment. This is the first report of a hybrid surgical and percutaneous treatment of a CAF.

