

## **The year 2019 in the European Heart Journal – Cardiovascular Imaging. Part**

### **I.**

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## **Abstract**

The European Heart Journal – Cardiovascular Imaging was launched in 2012 and has during these years become one of the leading multimodality cardiovascular imaging journals. The journal is now established as one of the top cardiovascular journals and is the most important cardiovascular imaging journal in Europe.

The most important studies published in our Journal in 2019 will be highlighted in 2 reports. Part I of the review will focus on studies about myocardial function and risk prediction, myocardial ischaemia, and emerging techniques in cardiovascular imaging, while Part II will focus on valvular heart disease, heart failure, cardiomyopathies, and congenital heart disease.

European Heart Journal – Cardiovascular Imaging has successfully consolidated as a multimodality journal during its first 8 years. It has now an important role as a significant resource for cardiologists, specialists in all imaging modalities, and other physicians working in the field of cardiovascular imaging. The tradition of highlighting the most important studies that were published in the last year is continued.<sup>1 2</sup> In two articles, we will summarize the most important papers from the journal in 2019. Part I will focus on myocardial function and risk prediction, myocardial ischaemia, and emerging techniques in cardiovascular imaging.

## **Recommendations and expert consensus documents from the European Association of Cardiovascular Imaging**

One important assignment of European Heart Journal – Cardiovascular Imaging is to publish position papers, recommendations and expert consensus papers from the European Association of Cardiovascular Imaging (EACVI). The journal published recommendations and expert consensus papers in the field of cardiac imaging and also the best research presented at our conferences in 2019.<sup>3 4 5 6 7 8</sup> These papers are commented on in more detail elsewhere in the two documents.

The EACVI scientific initiatives committee started their work in 2018 and published the results from their first survey in 2019.<sup>9</sup> This survey explored multimodality imaging training in ESC countries. The interest in multimodality cardiovascular imaging and the enthusiasm for further training in different techniques was high among the responders, but training was restricted by a lack of time and training programs.<sup>10</sup>

### **Myocardial function and risk prediction**

Several papers published by the Journal in 2019 considered the pre-test probability stratification models. One of the most important studies was published by Juarez-Orozco et. al.<sup>11</sup> In a population of 15 815 patients, the authors provided a pooled estimation of contemporary pre-test probabilities (PTP) of significant coronary artery disease (CAD) across clinical patient categories, re-evaluated the utility of the application of diagnostic techniques according to such estimates, and proposed a comprehensive diagnostic technique selection tool for suspected CAD. Pooled CAD prevalence was 14.9% (range = 1–52), clearly lower than that used in current clinical guidelines. Ruling-out capabilities of non-invasive imaging were good overall, even if the greatest ruling-out capacity (i.e. post-test probability <5%) was documented by CCTA, PET, and stress CMR. With decreasing PTP, the fraction of false positive findings rapidly increased, although a lower CAD prevalence partially cancels out such effect. The authors concluded that contemporary PTP of significant CAD across symptomatic patient categories is substantially lower than currently assumed. With a low prevalence of the disease, non-invasive testing can rarely rule-in the disease and focus should shift to ruling-out obstructive CAD. The large proportion of false positive findings must be taken into account when patients with low PTP are investigated.

In line with the previous study, Foldyna et. al. tried to update PTP for obstructive coronary artery disease (CAD >50%) across age, sex, and clinical symptom strata, using coronary computed tomography angiography (CCTA) in a large contemporary population of patients with stable chest pain referred to non-invasive testing (named PROMISE-PTP).<sup>12</sup> Patients enrolled in the Prospective Multicenter Imaging Study for Evaluation of Chest Pain (PROMISE) trial and randomized to CCTA were evaluated. In 4415 patients, the observed prevalence of CAD $\geq$ 50% was 13.9%, only one-third of the average ESC Diamond and Forrester PTP (40.6; P < 0.001 for difference). Initially, 4284/4415 (97%) patients were classified as intermediate-probability by the

ESC score (PTP 15–85%); using the PROMISE-PTP, 50.2% of these patients were reclassified to the low PTP category (PTP < 15%). The ESC score overestimates vastly the actual prevalence of CAD $\geq$ 50%. A new set of PTP, derived from results of non-invasive testing, may substantially reduce the need for non-invasive tests in stable chest pain.

Moreover, Winther and Coll aimed to compare the ability of risk factors and different PTP stratification models to predict haemodynamically obstructive CAD with fractional flow reserve (FFR) as reference in low to intermediate probability patients.<sup>13</sup> All patients (n=1675) showed low to intermediate risk and had been referred to CCTA. Patients with coronary stenosis were subsequently investigated by invasive coronary angiography (ICA) with FFR measurement if indicated. Discrimination and calibration were assessed for four models: the updated Diamond–Forrester (UDF), the CAD Consortium Basic, the Clinical, and the Clinical plus Coronary artery calcium score (CACS). The authors concluded that CAD Consortium models improve PTP stratification compared with the UDF score, mainly due to superior calibration in low to intermediate probability patients. Thus, adding the coronary calcium score to the models substantially increases discrimination.

Finally, CACS was used by Welton and Coll to evaluate the association of CACS with CVD vs. cancer mortality.<sup>14</sup> The CACS consortium is comprised of 66 636 scans performed in asymptomatic patients without known CVD. Among the 3158 deaths, cancer was the leading cause of death when CAC= 0 (50%) with CVD overtaking cancer when baseline CAC >300. These results argue for a focused approach for patients at the extremes of CAC scoring while suggesting that combined CVD and cancer primary prevention strategies for patients with intermediate CAC scores may significantly decrease mortality from the two leading causes of death.

Amzulescu and colleagues contributed a timely review concerning myocardial strain. As its availability and proposed utility as a prognostic tool above and beyond ejection fraction grows both within the CMR and echocardiography communities, understanding how the technique is validated and the potential pitfalls in cross-comparison was presented.<sup>15</sup> Contributors from the Multi-ethnic Study of Atherosclerosis (MESA) explained how individuals with prior cardiovascular events had a greater burden of diffuse myocardial fibrosis when compared with event-free individuals – an unsurprising yet important observation.<sup>16</sup>

The prognostic value of LV global longitudinal strain (GLS) in patients with chronic obstructive pulmonary disease after STEMI was evaluated by Goedemans et al.<sup>17</sup> In all, 143 STEMI patients with chronic obstructive pulmonary disease were retrospectively analyzed. They found that impaired LV GLS was independently associated with worse long-term survival and had incremental prognostic value over LVEF.

Beela et al determined if assessment of mechanical dyssynchrony could improve the prognostic value of patient selection for cardiac resynchronization therapy (CRT) based on current guidelines.<sup>18</sup> They performed echocardiography in 1060 patients before and  $12 \pm 6$  months after CRT implantation. Mechanical dyssynchrony, defined as the presence of apical rocking or septal flash was visually assessed at the baseline examination. Presence of mechanical dyssynchrony predicted long-term outcome better than guideline Classes I, IIa, IIb and in patients with no guideline recommendation. The authors concluded that current guideline criteria for CRT candidate selection could be improved by incorporating assessment of mechanical asynchrony. The same group of authors investigated to which extent sex-specific difference in CRT outcome could be explained by differences in baseline characteristics between both sexes.<sup>19</sup> They retrospectively analyzed data from 1058 patients who received CRT and who were examined by echocardiography before and  $12 \pm 6$  months after implantation. Female sex was no independent

predictor of neither volumetric response nor survival. The authors concluded that the repeatedly observed better outcome in women after CRT is mainly due to the lower rate of ischaemic cardiomyopathy and smaller scars. The response of both sexes CRT was similar when comparing patients with similar baseline characteristics.

Klaeboe et al investigated how TAVI procedure related conduction abnormalities influence ventricular mechanics and prognosis, with particular focus on new-onset persistent left bundle branch block (LBBB).<sup>20</sup> They included 140 consecutive patients with severe aortic stenosis undergoing TAVI in a single tertiary center. Classical dyssynchronous LBBB contractions were absent in most patients with new-onset post-TAVI LBBB, even when applying strict ECG criteria. Patients with and without new-onset LBBB experienced similar prognosis with regards to mortality. (Figure 1)

The prognostic utility of LV global function index from young adulthood into middle age for incident heart failure and cardiovascular disease in comparison to LVEF was evaluated by Nwabuo et al. in 4107 participants.<sup>21</sup> LV global function index was defined as LV stroke volume/LV global volume\*100. Results showed that LV global function index was a strong, independent predictor of incident heart failure and CVD that provided incremental prognostic value compared with LVEF. Male sex, black race, obesity, hypertension, and smoking are associated with worse LV global function index in the early adult lifespan.

Lavine et al hypothesized that indexing  $E/e'$  to a measure of LV filling volume may enhance the correlation with LV filling pressures and LVFP changes.<sup>22</sup> They summarized previously obtained haemodynamic and Doppler echo data in 137 dogs with coronary microsphere embolization induced-chronic LV dysfunction prior to and following haemodynamic induced alterations in LV filling pressures. They found that indexing  $E$  to both LV relaxation and filling volume resulted in



a more robust relation with LV filling pressures and with LV filling pressures changes. Dr. Gillebert commented the paper in an editorial comment.<sup>23</sup>

Rozenbaum et al explored the association between small left atria (LA) and outcome in a relatively large heterogeneous population of hospitalized patients. The cohort consisted of 17 343 inpatients who had an available LAVI measurement. Small left atria were independently associated with poorer short- and long-term mortality. Left atrial volume should be referred to as J-shaped in terms of mortality.<sup>24</sup>

Santoro et al assessed the impact of the strain-guided therapeutic approach on cancer therapy-related cardiac dysfunction and rate of cancer therapy interruption in breast cancer. They enrolled 116 consecutive female patients with HER2-positive breast cancer undergoing a standard protocol by EC (epirubicine + cyclophosphamide) followed by paclitaxel + trastuzumab (TRZ). The results showed usefulness of ‘strain oriented’ approach in reducing the rate of overt cancer therapy-related cardiac dysfunction and cancer therapy interruption by a timely cardioprotective treatment initiation.<sup>25</sup> The study was commented by Dr Bergler-Klein, emphasizing the use of strain echocardiography in cardio oncology.<sup>26</sup>

Jørgensen et al investigated which echocardiographic parameters best predicted cardiovascular disease and sex differences in patients with type 2 diabetes.<sup>27</sup> They performed comprehensive echocardiography in 933 patients with type 2 diabetes. Several echocardiographic parameters predicted cardiovascular disease, however, mean  $E/e'$  was the strongest predictor and had the highest model performance. The study identified a gender interaction as mean  $E/e'$  performed best in men, whereas in women this was global longitudinal strain.

Wu et al evaluated the impact of obesity on longitudinal cardiac structural and functional changes in patients with type 2 diabetes.<sup>28</sup> This study comprised of 274 patients. Echocardiographic parameters including LV geometry, systolic, and diastolic functions were measured at baseline

and follow-up. Being obese at baseline was associated with greater longitudinal increase in LV mass and greater deterioration in LV systolic function.

Several papers published by the Journal in 2019 considered inherited cardiovascular diseases. In hypertrophic cardiomyopathy (HCM), Raman et al. undertook interval CMR examinations in HCM patients across an average of five years and identified that progression of myocardial fibrosis was associated with adverse cardiac remodelling and increased risk of cardiovascular events.<sup>29</sup> In MYBPC3 HCM patients, Grover and colleagues described how myocardial deoxygenation during stress (BOLD technique) was observed despite normal LV diastolic function, LV global longitudinal strain and LV wall thickness – an important insight into how standard imaging phenotypes may not paint the whole picture.<sup>30</sup> Marty et al. described important information regarding changes observed in cardiac structure, function and tissue characterisation in patients with Becker muscular dystrophy.<sup>31</sup> Te Rijdt and colleagues analysed CMR data from phospholamban p.Arg14del mutation carriers with preserved ejection fraction and identified that CMR with LGE was an important tool in the diagnostic work-up of these patients.<sup>32</sup>

In Takotsubo syndrome, in their three-month longitudinal study Aikawa and colleagues propose that characterisation of the myocardium with native T1 mapping is a promising method of predicting LV wall motion restoration in this disease.<sup>33</sup> Focusing on the atria in Takotsubo patients, Backhaus et al. explain how there is transient impairment in left atrial reservoir and conduit function and enhanced biatrial active booster pump function.<sup>34</sup>

The assessment of cardiovascular disease in pregnancy can be fraught with anxiety both for patient and clinician. Herrey and colleagues describe data from a decade's worth of pregnant patients across four centres and conclude that CMR in pregnancy frequently changes management and that CMR should be offered to pregnant women when indicated, including the administration of contrast as per current guidelines.<sup>35</sup>

## **Ischaemic heart disease**

The diagnostic approach in a patient with suspected obstructive coronary artery disease (CAD) includes basic testing and assessment of LV function. A resting transthoracic echocardiogram is recommended in all patients for exclusion of alternative causes of angina, identification of regional wall motion abnormalities suggestive of CAD, determination of left ventricular ejection fraction (LVEF) for risk-stratification purposes as well as evaluation of diastolic function. Then, functional imaging includes myocardial perfusion imaging with single photon emission computed tomography (SPECT) or positron emission computed tomography (PET), stress echocardiography, or stress CMR imaging assessing myocardial perfusion and/or wall motion can be performed according to the local expertise and availability of the exams. A normal functional test is associated with a low ( $\leq 1\%$  per year) subsequent rate of cardiac death and myocardial infarction. The 2019 ESC-guidelines on chronic coronary syndromes and their key messages for imagers have been published.<sup>36 37</sup> Also, the contemporary pre-test probability of significant CAD across symptomatic patient categories is substantially lower than currently assumed.<sup>11</sup> Ruling out an ischaemic origin is important for the diagnosis of dilated cardiomyopathy and this is the object of a recommendation made by the EACVI this year. Considering the new scientific works performed with echocardiographic techniques, the potential value of the global and regional myocardial work indices could be stressed. They have been described as sensitive markers of myocardial global and regional function.<sup>38</sup> No study dedicated to ischaemic heart disease have been published in 2019 specifically for CAD detection but the concept and the value of myocardial work is underscored for instance by Przewlocka-Kosmala et al.<sup>39</sup> Also, longitudinal strain and strain rate, (without the use of this new concept of myocardial work with pressure/strain loops), have been reported relevant to overcome the limits of the

qualitative and observer dependent analysis of the left ventricular segmental wall motion.

Schuster et al did a nice prognostic study about 1235 patients with myocardial infarction. They demonstrated the incremental value of additional longitudinal strain assessment for optimized event prediction compared with left ventricular ejection fraction and a combination of established clinical and imaging parameters.<sup>40</sup> Strain analyses allow, as demonstrated nicely by Verdugo-Marchese et al, to report on the electro-mechanical coupling and its clinical value.<sup>41</sup>

Stress echocardiography is used in many laboratories. But still, up to 33% of the patients referred for stress echocardiography could have suboptimal image quality. Echo contrast improves the visualization of regional wall motion analysis and the use of 3D echocardiography will overcome foreshortening. 3D provides fast acquisition of the exact tomographic planes than can be advantageous for the robustness of the assessment of regional wall motion. With 3D acquisitions, the assessment of apical and mid-segments at rest and peak stress is improved as compared to 2D-conventional echocardiography. Thus, in 2019, no revolution occurs in the use of echocardiography for CAD but adding to the visual assessment, contrast, 3D strain and its new application combining pressure and strain (myocardial work) could be stressed.

Using a big cohort study of consecutive patients (n = 48 731) registered in the Western Denmark Cardiac Computed Tomography Registry from 2008 to 2016, Olesen et. al. examined whether severity of CAD, measured by CCTA, can predict rates of myocardial infarction (MI) and death in patients with and without diabetes.<sup>42</sup> Patients were stratified by diabetes status and CAD severity (no, nonobstructive, or obstructive). Endpoints (median follow-up was 3.6 years) were MI and death. Diabetes patients had higher death rates than non-diabetes patients, irrespective of CAD severity. In patients without CAD, diabetes patients have a low risk of MI similar to non-diabetes patients. Further, MI rates increase with CAD severity in both diabetes and non-diabetes patients; with diabetes patients with obstructive CAD having the highest risk of MI.

Diabetic patients were evaluated also in the study published by Zobel et. al.<sup>43</sup> The authors evaluated myocardial flow reserve (MFR) and coronary artery calcium (CAC) in persons with Type 1 diabetes with or without albuminuria and in non-diabetic controls. MFR (pharmacological stress flow/rest flow) was evaluated by cardiac rubidium-82 (82Rb) PET. MFR was comparable in patients with diabetes and simplex or no retinopathy, but lower in proliferative compared with simplex retinopathy. The CACS was comparable between groups of retinopathy. The authors concluded that myocardial microvascular function was comparable in non-diabetic controls and patients with Type 1 diabetes and normo-albuminuria, but impaired in the presence of microvascular complications (macroalbuminuria and proliferative retinopathy). Coronary calcification was elevated in diabetes, however, not explained by albuminuria.

Nappi et. al. used 82Rb PET to evaluate, in 270 patients with suspected CAD and normal myocardial perfusion at stress–rest, the relationship between epicardial adipose tissue (EAT) and coronary vascular function.<sup>44</sup> CACS and EAT volume were measured. In patients with CACS 0 (n = 114), a significant relation between EAT volume and MPR (P = 0.014) was observed, while the relationship was not significant (P = 0.21) in patients with CAC score >0 (n = 156).

The authors concluded that in patients with suspected CAD and normal myocardial perfusion, EAT volume predicts hyperaemic MBF and reduced MPR, confirming that visceral pericardium fat may influence coronary vascular function. Thus, EAT evaluation has a potential role in the early identification of coronary vascular dysfunction.

Finally, Lee et. al. evaluated whether CACS progression represents compositional plaque volume (PV) progression differently according to statin use. whether the association between CAC progression and compositional plaque volume progression differed between non-statin and statin-taking individuals, in a subset of patients from the PARADIGM registry, who underwent serial CCT.<sup>45</sup>

The analysis indicated that in the statin-taking group, CACS increase was positively associated with calcified PV change, but was negatively associated with non-calcified PV change. In the non-statin group, CACS progression indicates the progression of both non-calcified and calcified PV progression. However, under the effect of statins, CACS progression indicates only calcified PV progression, but not noncalcified PV progression. Thus, the result of serial CACS should be differently interpreted according to the use of statins.

Demirkiran et. al. provided a helpful review of the role of CMR in tissue characterization after acute myocardial infarction (AMI) with an important reminder of the utility of CMR in detected microvascular injury in AMI.<sup>46</sup> Park et al. also reported on left ventricular remodelling and functional impairment in women with non-obstructed coronary arteries using data from the WISE-CVD study.<sup>47</sup>

Kanaya et. al. provided an interesting insight into the composition of high-intensity coronary plaques observed by CMR compared to non-high intensity plaques using optical coherence tomography.<sup>48</sup> In Luu's study assessing transmural gradient of myocardial perfusion, they observed that compared to controls, those with risk factors for (but no overt) coronary artery disease exhibited an inducible transmural oxygenation gradient indicating perhaps a novel imaging phenotype of subclinical cardiovascular disease.<sup>49</sup>

### **Emerging techniques**

The applications of artificial intelligence in cardiac imaging have increased during the last year and the machine learning algorithm can assist measuring cardiac chambers' volumes, ejection fraction and filling parameters. Data obtained by Narang et al from a machine learning algorithm, conventional 3D echocardiography volumetric analysis, and CMR images (slice-by-slice, frame-by-frame manual tracing) were similar, with significantly shorter analysis time. This machine

learning algorithm based on 3D echocardiographic images may soon be very useful in clinical practice.<sup>50</sup>

The role of 3D ultrasound is important not only for cardiac analysis, but also for vascular assessment. Some echocardiographic parameters (e.g. peak wall stress, aortic stiffness) based on non-invasive 3D ultrasound can have an important role in differentiating stable from high risk abdominal aortic aneurysms. A significant increase in stiffness or a high peak wall stress can represent additional criteria for high risk abdominal aortic aneurysm.<sup>51</sup>

Although myocardial work efficiency is already known as a new, promising parameter of left ventricular function, its role in daily clinical practice is still unclear. Van der Bijl et al showed in a study including patients with a Class I indication for cardiac resynchronization therapy (CRT) that this parameter, derived from speckle tracking echocardiography and noninvasive blood pressure measurement, can predict the response to CRT. Lower myocardial work efficiency before the procedure (global left ventricular wasted work ratio <75%) is associated with improved long-term outcome.<sup>52</sup>

In another study, Chan et al analysed myocardial work in patients with hypertension, and with dilated cardiomyopathy. Myocardial work was significantly higher in moderate to severe hypertension patients as a compensatory mechanism to preserve LV function against an increased afterload, while it was significantly reduced in cardiomyopathy. Therefore, myocardial work is a new technique that allows better understanding of the relationship between LV remodelling and increased wall stress under different loading conditions.<sup>53</sup> This study was discussed by Otto Smiseth in an editorial comment, underlining that myocardial work is ready for clinical testing.<sup>54</sup>

Another new echocardiographic parameter is peak cardiac power output to mass. This parameter is calculated as the product of a constant ( $K = 2.22 \times 10^{-1}$ ) with cardiac output and the mean blood pressure, divided by LV mass, and expressed in the unit of W/100g. In a recent study

including 159 patients with heart failure (mean ejection fraction: 30%) this new parameter and the cardiopulmonary exercise test (peak VO<sub>2</sub> ≤14 mL/min/kg) showed independent and incremental prognostic value. Sixty-month survival free from the combined endpoint (all-cause death, ventricular assist device implantation, and heart transplantation) was 85% in those exhibiting oxygen consumption (VO<sub>2</sub>) >14 mL/min/kg and peak cardiac power output to mass >0.6 W/100 g.<sup>55 56</sup>

The applications of nuclear imaging have also expanded during the last year. A study analysing a rat model showed that longitudinal 2-Deoxy-2-<sup>18</sup>F-fluoro-D-glucose (<sup>18</sup>F-FDG) positron emission tomography (PET) can differentiate between active and post inflammatory reaction in autoimmune myocarditis.<sup>57</sup>

An emerging method - pulse indexed contour cardiac output (PICCO) can estimate preload by global end-diastolic volume (GEDV) and congestion as extravascular lung water (EVLW) content. Nielsen et al have evaluated EVLW and GEDV by PET in a porcine model of pulmonary congestion and have also applied this in 35 heart failure patients and 9 healthy volunteers. They demonstrated that <sup>15</sup>O-H<sub>2</sub>O-PET can assess pulmonary congestion and preload quantitatively, but the prognostic information provided by this parameter should be further evaluated.<sup>58</sup>

The applications of cardiovascular magnetic resonance (CMR) imaging in electrophysiology have increased constantly. In a recent study including 31 patients, CMR-guided radiofrequency ablation of cavo-tricuspid isthmus proved to be safe and efficient for the treatment of typical right atrial flutter with fluoroscopy-guided ablation.<sup>59</sup>

The role of hybrid imaging modalities was tested in different clinical settings. Using <sup>18</sup>F-fluorodeoxyglucose PET and CMR (hybrid PET-MR cardiac imaging) in the early cardiac involvement in Anderson Fabry patients allows to identify different stages of disease progression. Focal <sup>18</sup>F-FDG uptake with a trend towards a pseudo-normalization of abnormal T1 mapping



values, may represent an intermediate stage before the development of myocardial fibrosis, allowing an early and more effective therapeutic approach, thus preventing the development of irreversible myocardial damage and fibrosis.<sup>60</sup>

The identification of coronary plaque vulnerability is an important goal of noninvasive cardiovascular imaging. Kolossvary et al compared 25 patients (44 plaques) who underwent coronary angiography, sodium-fluoride PET, intravascular ultrasound, and optical coherence tomography.<sup>61</sup> The best radiomic parameters significantly outperformed the best conventional CT parameters in identifying attenuated plaques by intravascular ultrasound, thin-cap fibroatheroma by optical coherence tomography and NaF18-positivity. Coronary CTA radiomics may provide a more accurate tool to identify vulnerable plaques compared with conventional methods, but further studies are warranted to assess the true potential of radiomics to aid precision phenotyping of coronary disease.

Nkoulou et. al. validated a 1-day myocardial perfusion imaging (MPI) protocol using an ultra low-dose equal for stress and rest on a cadmium zinc telluride in 56 patients, using a CZT camera (DNM 570c, GE Healthcare).<sup>62</sup> Presence and extent of perfusion defect were analysed as well as function analysis. An excellent correlation between standard dose and ultra-low dose was found for all the analysed variables. This study indicates that CZT cameras may enable reliable MPI scanning in patients with known or suspected coronary artery disease using protocols with about a factor 4-decrease in radiation dose exposure compared with traditional protocols, increasing the safety of nuclear cardiology technique, without losing accuracy.

Recent CT camera and software allow the analysis of plaque volume and tissue composition. de Knecht et al. aimed to test the hypothesis that clinical patient presentation is associated with distinct morphological features of coronary atherosclerosis.<sup>63</sup> A total of 1652 participants,

representing a spectrum of clinical risk profiles underwent multidetector computed tomography (CT).

The presence of vulnerable plaques, defined by plaque volume and tissue composition, was examined. Coronary plaque volume increased significantly with worsening clinical risk profile and plaque composition differed significantly across cohorts ( $P < 0.0001$ ). Significant differences in plaque composition persisted after multivariable adjustment for all examined variables. The authors concluded that coronary atherosclerotic plaque volume and composition are strongly associated to clinical presentation.

At the mitral valve, Faletta et al. provide an important reminder of the complex anatomy of the mitral valve annulus and how non-invasive imaging techniques have helped us understand this structure in a significantly more comprehensive fashion.<sup>64</sup> Further, Liu and colleagues pose an interesting question in CMR's utility in the care of patients with mitral regurgitation (MR); they conclude that they would wish CMR to have a greater role in the surveillance and surgical decision making for those with moderate-severe MR and that more comparative research (vs echocardiography) is required.<sup>65</sup> At the aorta, Dux-Santoy and colleagues utilised CMR with 4D flow to provide novel insights into proximal arch dilatation in patients with bicuspid aortic valves.<sup>66</sup> Again, using 4D flow CMR, Kamphuis et al. describe complex flow patterns in patients with Fontan procedure and the differences compared to healthy controls.<sup>67</sup>

In patients with HCM, Ricci and colleagues describe the utility of pulmonary blood volume index as a quantitative marker for assessment, grading and monitoring of haemodynamic congestion.<sup>68</sup>

## **Figure legends**

**Figure 1.** Echocardiographic 2D strain analysis obtained from the apical four-chamber view of aortic stenosis patients with pre-existing (left) and post-TAVI new-onset strict LBBB (right) with

corresponding ECGs below. Yellow arrows illustrate the opposing wall motion of early septal contraction and lateral wall stretch. White arrow illustrates the late peak contraction of the lateral wall occurring after aortic valve closure (AVC). From Klæboe LG, Brekke PH, Lie ØH, Aaberge L, Haugaa KH, Edvardsen T. Classical mechanical dyssynchrony is rare in transcatheter aortic valve implantation-induced left bundle branch block. *Eur Heart J Cardiovasc Imaging* 2019;**20**:271–278. (ref #20)

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Figure 1



