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EDITORIAL

Cardiovascular imaging 2017 in the International Journal of Cardiovascular Imaging

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Please, find below an overview of the most relevant papers in the International Journal of Cardiovascular Imaging over the year 2017 for the different modalities.

X-ray imaging

Dr Sato and his team investigated the predictors of acute recoil after implementation of everolimus-eluting bioresorbable scaffold (BRS) based on optical coherence tomography (OCT). They studied 39 patients with 56 scaffolds and the acute absolute recoil was assessed by QCA. They concluded that the acute recoil of the current generation of everolimus-eluting BRS seems to be influenced by procedural as well as OCT-derived plaque characteristics, particularly plaque eccentricity and calcified plaque components [1].

The standard angiography, despite being the current gold standard, is limited by its static or fixed acquisitions resulting in underappreciation of tortuous vessels, overlap and foreshortening of coronaries. Jin et al. [2] underwent a study to evaluate the accuracy of dual-axis rotational coronary angiography (DARCA) for coronary lesion assessment by directly comparing to intravascular imaging with IVUS. Evaluating 40 patients and 58 lesions they found significant correlation in lesion length and reference vessel diameter ($r = 0.9$ and 0.81, respectively), and a fair correlation for minimal lesion diameter ($r = 0.65$), but highest agreement for luminal measurement. Authors concluded that DARCA followed by additional standard angiography at the discretion of operator may be more acceptable, however this technology remains to find its way to clinical practice.

Jan Hinrichs and colleagues evaluated a new 2D-perfusion angiography technique (2D-PA) allowing pro- and retrospective flow analysis in patients treated for peripheral arterial disease. It allows quantifying blood flow by post-processing of digital subtraction angiography (DSA). Differences in time-to-peak pre- and post-intervention showed a fair correlation with ankle-brachial-index [3].

A simulator, which incorporates data on scattered ionizing radiation, was built by Katz and colleagues to understand the effects of ionizing radiation in the cardiac catheterization laboratory and to use this simulator also for teaching purposes [4]. The validity of the simulator was confirmed in three catheterization laboratories and tested by 20 interventional cardiologists. It was demonstrated how the use of the simulator increases the knowledge of the interventional cardiologists about radiation protection and lower doses for personnel and patient.

In another study regarding radiation dose, Ray and team studied using a phantom and in a patient population of low BMI, the removal of the anti-scatter grid on the radiation dose and the associated image quality. They found reductions in radiation doses of about 50% with very little effect on image quality. They suggest a larger clinical study to assess procedural outcomes [5].

Kozuma and his team evaluated the agreement between two versions (7.3 and 6.0) of the QAngio XA analytical software solution for QCA analysis in a population of 100 patients. They concluded that there were no major systematic differences in

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the QCA parameters between the two versions, which is of course important for the use in clinical research studies [6].

Shi described an underestimated type of iliac vein compression syndrome (ICVS), also called May–Thurner Syndrome, with dual compression by right and left common iliac arteries simultaneously [7].

The team of Pan optimized the Spider view in coronary angiography using the Taguchi method with a phantom study, later confirmed on a clinical diagnosis of 43 patients [8].

Iwachow and colleagues compared the radiological risks during coronary angioplasty between the transradial and the transfemoral approaches in a retrospective analysis of 1500 patients [9]. They found that the fluoroscopy times, X-ray dose and use of contrast medium was similar between the two approaches, but the mean total procedure time was significantly shorter in the radial approach. However, older patients in the radial group needed longer fluoroscopy and procedure times to complete the PCI.

The feasibility, efficacy and safety of carbon dioxide DSA to guide EVAR procedure was evaluated in a group of 13 patients with chronic kidney disease by De Angelis et al. [10]. No patients suffered major complications.

The aim of the study carried out by Fam was to determine if there are significant differences in curvature of the treated vessels after the deployment of a polymeric BRS or MPS in long lesions. They compared two groups of 32 patients and QCA was used to determine the curvature. The use of the metal platform was an independent predictor of change in diastolic curvature [11].

Ge and colleagues studied a total of 1160 patients with- and 2251 without- diabetes who underwent surveillance angiography 1 year after DES implantation. They found that the 1-year rate of stent-fracture was comparable among the two groups. However, the diabetic patients with stent fracture had a 2.6 fold increase in stent-fracture related cardiac death at the end of the study and three-fold increase of re-repeat of vascularization compared with the non-diabetic patients with stent-fracture [12].

Yesin were interested in the relationship between the coronary no-reflow phenomenon in the Syntax score and the Syntax II score [13]. They studied 193 patients undergoing PCI in whom 42 developed the no-reflow phenomenon. They concluded that the Syntax II score may be a more useful tool that the Syntax score for the prediction of the no-reflow phenomenon after primary PCI in patients with ST elevation myocardial infarction.

Intravascular imaging

The year of 2017 was tremendously successful in publishing high quality papers in the field intravascular imaging. In every issue of *The International Journal of Cardiovascular Imaging*, there is an interesting paper involving all aspects of intravascular imaging.

Evaluation of bioresorbable vascular scaffolds

Highlighting the importance of high resolution intravascular imaging by OCT, Ramalho and colleagues described a case report of disrupted BRS stent integrity during percutaneous intervention. The delineated struts disruption seen on OCT enabled operator to successfully implant DES resulting in optimized stenting and restored vascular integrity [14]. Whereas, in a subgroup analysis of absorb II evaluating plaque volume by IVUS in 501 patients after implantation of either bioresorbable vascular scaffold (BVS) or everolimus-eluting metallic stent (EES). Zeng et al. demonstrated that the difference in device volume and ultrasound backscattering resulted in artifactual measurement of the lumen [15].

In a 5 year follow up with OCT, Tenekecioglu et al. reported three cases of BRS demonstrating in elegant pictures the potential capability of these stents to stretch the non-calcified segment of the vessel lumen while creating a neointimal cap overlying the calcified plaques therefore "refurbishing" the endoluminal lining. Authors described the advantage of biodegradable stents compared to metallic stents is temporary vessel scaffolding which reduces the inflammatory response in treated segments on long-term follow up [16].

Shen et al. evaluated the safety and efficacy of XINSORB bioresorbable (poly-L-lactic acid (PLLA) backbone) sirolimus-eluting scaffold (strut thickness 160 micron) compared to durable Cobalt-chromium sirolimus eluting stent. Using serial OCT imaging and histopathological studies up to 6 months, he demonstrated that XINSORB bioresorbable scaffold effectively suppressed neointimal hyperplasia without obvious late device recoil and comparable late lumen loss (LLL) and diameter stenosis to the durable metallic scaffold stent. We look forward to the clinical trial evaluating the safety and efficacy in patients with coronary artery disease [17].

Sato et al. performed OCT to study the predictors of acute recoil after implantation of everolimus-eluting BRS in 56 scaffolds (39 patients). Acute absolute recoil was assessed by QCA, while plaque eccentricity (PE) and plaque composition (PC) were assessed by OCT. High acute recoil was associated with higher calcium in plaque composition along with increased plaque eccentricity. Authors concluded that acute recoil of BRS is influenced by BRS sizing as well as OCT-derived plaque characteristics [18].

Sato and colleagues studied the neointimal thickness NIT and strut coverage by OCT after everolimus-eluting BRS implantation in bifurcation lesions (BL) in 64 scaffolds. Authors found significant differences in NIT and percent uncovered struts among the three examined regions: the

vessel opposite to the ostium (OO), the vessel wall adjacent to the ostium (AO) and the side-branch ostium (SO). After BRS implantation in BL, neointimal response was pronounced at the vessel wall opposite to the side branch ostium, especially in those with large side branches (128 micron), but with the least amount of uncovered struts (0.4%). Based on OCT characteristics, authors concluded that BRS may be an adequate therapeutic option for bifurcation lesions [19].

Evaluation of metallic stents

Covered struts without excessive neointimal hyperplasia (NIH) are cardinal features of benign healing pattern post coronary stenting. Intravascular imaging is indispensable in evaluating vascular response to newer generation stents. In a sub-group analysis of DESTINY trial, both IVUS and OCT were used to evaluate a novel sirolimus-eluting drug-eluting stent (DES) with biodegradable polymer (Inspiron™) (n = 46) compared to the Biomatrix™ DES (n = 20). At nine months, sirolimus-eluting drug-eluting stent (DES) with biodegradable polymer showed excellent strut coverage by OCT > 99%, minimal neo-intimal formation by OCT (144 μm) and NIH obstruction of 4.9% on IVUS suggesting benign healing response [20].

Ohtani and colleagues elegantly analyzed OCT cross sections in 57 patients without in-stent restenosis 9 months post DES implantation to study normal vascular response to three second generation stents: cobalt–chromium everolimus-eluting stents (CoCr-EES), platinum–chromium EES (PtCr-EES), and resolute zotarolimus-eluting stents (R-ZES). R-ZES had significantly more uncovered struts and less homogenous neointimal growth which may have clinical implication for risk of stent thrombosis [21].

In an attempt to evaluate prevalence and neointimal morphological characteristics of neoatherosclerosis in early versus late in-stent restenosis, Sabbah et al. and colleagues performed optical frequency domain imaging (OFDI) in 46 consecutive patients who received prior second-generation drug eluting stents (Biolimus and everolimus). There was no difference between the two groups in the morphological appearance or tissue characteristics. Platinum–chromium platform stents were more likely to presented with early ISR compared to late ISR in cobalt-chromium or biolimus-eluting stents [22].

Long et al. evaluated neoatherosclerosis in BMS, first-generation and second-generation stents in 274 ISR lesions (average > 4.5 years after stent implantation). Authors identified neoatherosclerosis in 39% of the ISR lesions: 54, 65, and 23%, respectively. More thrombus without plaque rupture, was more commonly seen in first-generation DES stent, whereas underexpansion or fracture/deformation was noted in second-generation DES [23].

Takahara et al. aimed to evaluate neointimal coverage in the very early phase after second-generation drug-eluting stent (DES) implantation using OCT. Study included patients who underwent staged PCI after median time of 21 days. Authors found significantly lower strut coverage stent coverage in the overlapping segments than in the non-overlapping segments (48% vs. 74%), suggesting that very early interruption of dual antiplatelet therapy might result in increased risk of stent thrombosis, even in second-generation DES [24].

Evaluation of plaque and tissue characteristics

Evaluating vulnerability of atherosclerotic plaques has clinical and therapeutic implications. In an effort to evaluate plaque characteristics, Li and colleagues studied the elastic mechanical properties of atherosclerotic plaque with different morphological properties by using intravascular ultrasound elastography IVUSE to predict plaque vulnerability. In a preclinical study, authors evaluated shear strain (SS) and area strain (AS) of 30 New Zealand rabbits fed high fat diet and subjected to balloon-injury of the abdominal aorta. They concluded that eccentric plaques with high plaque burden and negative remodeling showed greater strain which may predict elastic stability of the plaque [25].

Continuing the theme of evaluating plaque characteristics and complexity in order to predict plaque stability, Minami et al. serially imaged 44 non-culprit plaques with OCT in patients treated with statin therapy. Authors performed OCT bright spot density analysis as surrogate for inflammation and macrophage infiltration within 250 micron thickness of vessel wall. They found statistically significant reduction of bright spot density at 12 months of 0.5% signaling a potential reduction in vessel wall/plaque inflammation [26].

Her et al. performed pre-intervention virtual histology IVUS (IVUS–VH) of culprit lesions in 172 STEMI patients aiming to predict MACE during follow up period of 41 months (median). The incidence of MACE did not significantly differ among patients with or without all 3 high-risk plaque features (MLA ≤ 4 mm^2, plaque burden ≥ 70% or the presence of VH-derived thin-cap fibroatheroma (TCFA)) on IVUS–VH (15.1 vs. 16.2%), and therefore had no incremental value in predicting future MACE. However, elevated inflammatory markers hs-CRP and neutrophil-to-lymphocyte ratio levels were significantly associated with poorer outcomes and had incremental predictive values over conventional risk factors [27].

Timmins et al. demonstrated a stable and validated algorithm to automatically circumferentially co-register serial VH–IVUS imaging data for the focal quantification of coronary atherosclerosis progression. Authors studied thirty-three patients with an abnormal non-invasive cardiac stress test or stable angina who underwent IVUS–VH at baseline

and 6–12 months follow-up. This automated algorithm is proposed to allow for greater understanding of the natural history of coronary atherosclerosis, and may provide superior evaluation of the regional effects of therapies aimed for plaque regression [28].

Erythrocyte-rich thrombi contain more inflammatory cells and reflect high thrombus burden, leading to impaired myocardial reperfusion in myocardial infarction. Shiratori et al. aimed to charachterize erythrocyte-rich thrombus by quantified frequency domain optical coherence tomography (FD-OCT). In an ex-vivo study on 54 thrombi specimen aspirated during thrombetomy from eight patients during primary PCI, the cut-off point for prediction of erythrocyte-rich thrombus was defined as mean signal intensity (MSI $\leq$ 4.56, sensitivity: 87.5%, specificity: 82.9%, area under the curve: 0.836, respectively). This study suggested that quantified FD-OCT signal analysis can be used to detect of erythrocyte-rich thrombus. We look forward to in-vivo study to validate the clinical utility of this approach [29].

Gnanadesigan et al. compared index of plaque attenuation (IPA), a local quantitative measure of attenuation, to the labor-intensive manually measured lipid score on OCT images, and to the plaque characterization ex-vivo in cadaveric hearts. Authors found significant correlation between IPA and lipid scores of >0.7 which enables automation of the coronary plaque lipid assessment by OCT [30].

Stent profile and endothelial shear stress

In a swine model, Tenekecioglu et al. implemented angiographic and OCT data to reconstruct three-dimensional (3D) geometry of the right coronary artery (RCA) stented with ArterioSorb (Arterius, UK) with 95 micron (μm) strut thickness and ArterioSorb with 120 μm strut thickness in mid-segment of the vessel. After excluding other factors, authors hypothesized that lower ESS in ArterioSorb-120 μm is presumably ascribed to the thicker struts [31].

Tenekcioglo et al. investigated in vivo (8 pigs) the protrusion status of everolimus-eluting Bioresorbable Vascular Scaffold (Absorb, Abbott Vascular) (n = 6) compared to sirolimus-eluting Bioresorbable Microfiber Scaffolds (Mirage, Manli Cardiology) (n = 11), and their relationship with endothelial shear stress (ESS) distributions. Authors found significant difference in protrusion distances (156 vs. 139 micron) between the two stents, respectively. However, noted that the protrusion of the thick quadratic struts of Absorb has a tendency to lower shear stress in the close vicinity of struts, opposite to Mirage stent where less thick struts where associated with increase shear stress. Authors propose that protrusion analysis may contribute to predicting hemodynamic performance of the bioresorbable scaffolds [32].

Chronic total occlusions

Ostial or stumpless chronic totally occluded arteries represent a technical challenge due to difficulty defining and penetrating the proximal cap, and retaining wire within the vessel structure. Ryan and colleagues reported single center experience of 22 cases of systematic IVUS-guided PCI with ostial/stumpless cases and J-CTO score >3. Authors reported 77% success rate with no complications of death, coronary artery bypass grafting or myocardial infarction requiring intervention. he IVUS catheter is positioned at the ostium of the CTO and a CTO wire is advanced into the true lumen of the CTO using microcatheters and a wire escalation strategy as necessary. IVUS is used to confirm wire position within the true lumen, as well as stent sizing (diameter and length) [33].

Side branches and bifurcations lesions

In an elegant serial 3D OCT imaging study of 48 jailed side branch SB (in 25 patients) aimed at understanding SB restenosis in relation to complexity, Nakamura et al and colleagues classified the configuration of overhanging struts at the SB orifice into three groups according to the 3D aspect of the jailing configuration: no-jail, simple and complex-jail type (described as a link at the carina). 3D-OCT images showed that some of the compartments (formed by stent struts) were filled with tissue. In the complex-jail type group, the side-branch flow area (area of SB ostium minus area of jailing struts) was significantly decreased and small compartments were filled with tissue, therefore is associated with progression of SB ostial stenosis [34].

Taking into account vessel tapering and major side branches, Nakamura and colleagues proposed a novel volumetric assessment of vessel profile for more accurate estimation of stent expansion minimum expansion index (MEI) compared to conventional single cross-section minimum stent area (MSA). MEI was calculated as [(actual lumen area/ideal lumen area) $\times$ 100] in all frames. Authors included 44 patients with bifurcation lesions, and found that MEI more accurately identified cases with under-expansion compared to MSA (48% vs. 25%) [35].

Nuclear cardiology

In 2017 different excellent paper in the field of nuclear cardiology were published in the journal. In this review we selected a few papers on technical advances, assessment of coronary artery disease, FDG/PET imaging in atrial fibrillation and FDG PET/CT imaging in infective endocarditis.

Cadmium–zinc telluride cameras for myocardial SPECT imaging

Recently, cadmium–zinc telluride (CZT) cameras have introduced significant progress in myocardial perfusion SPECT imaging, offering high-quality images despite lower doses and scan time. Ishihara et al. [36] evaluated whether pre-installed normal databases for quantitative perfusion SPECT software with conventional SPECT scans can also be used for CZT scans. They studied 81 consecutive Japanese patients with Thallium-201 SPECT and compared the summed stress score (SSS), summed rest score (SRS) and summed difference score (SDS) for the two SPECT devices using two normal databases from different ethnic groups (one pre-installed normal database and one new Japanese normal database constructed in their own institution). Compared with conventional SPECT, CZT SPECT showed significantly lower SSS, SRS and SDS using the pre-installed SPECT database. In contrast, CZT SPECT showed no significant difference from conventional SPECT in QPS analysis using the normal database from their institution. The authors conclude that myocardial perfusion analyses by CZT SPECT should be evaluated using normal databases based on the ethnic group being evaluated.

Lima et al. [37] studied a large cohort of 2930 patients who underwent CZT-SPECT and were then followed for 30.7 ± 7.5 months for hard events including death or non-fatal myocardial infarction as well as late revascularization. Mean dosimetry was 6 mSv and mean total study time 48 ± 13 min. The annual hard events and late revascularization rates were higher in patients with greater extension of defect and ischemia. Summed stress scores and summed difference scores were significantly higher in patients with hard events compared to those without hard events. Similar findings were noted for patients with or without late revascularization. The authors conclude that the faster, low-radiation myocardial perfusion SPECT protocol in a CZT camera maintains the ability to risk stratify patients referred for myocardial perfusion imaging, as compared to conventional SPECT imaging. These kind of studies are important to define the net clinical benefit of this new technology in daily practice.

PET imaging and FFR-CT versus SPECT for the assessment of coronary artery disease

Noninvasive evaluation of coronary artery disease is still a challenging tasks in daily practice. Driessen et al. [38] wrote an excellent review on the use of cardiac positron emission tomography for myocardial perfusion imaging. After a brief discussion on the principles of PET imaging, PET perfusion tracers are discussed including 82Rb which is produced by a 82Sr/82Rb generator, obviating the need for a cyclotron and therefore more convenient to implement in daily practice and the newer fluorine-labeled tracers such as 18F-flurpiridaz. The latter has a longer physical half-life of 110 min allowing for off-site production and can be used in physical exercise protocols whereby the tracer is administered during maximal exertion. The authors also discuss the potential incremental value of hybrid PET/CT as compared to either one of the standalone modalities.

Fractional flow reserve (FFR) derived from coronary computed tomography angiography (CCTA) (FFR-CT) is a newer technique allowing functional assessment of CAD. Nakanishi et al. [39] compared SPECT-MPI and FFR-CT for assessing functional significance of CAD in 62 patients, included in the ACCURACY and VCT001 studies, with suspected CAD who underwent ≥ 64 slice CCTA and SPECT-MPI within 3 months. On a per-vessel analysis, accuracy, sensitivity and specificity of SPECT-MPI to predict FFR-CT ≤ 0.80 was 74, 45 and 77% respectively. The AUC curve analysis for SPECT-MPI demonstrated a modest performance for predicting FFR-CT ≤ 0.80 (AUC 0.56). The authors conclude that SPECT-MPI has an only modest concordance with FFR-CT. Clearly, further studies are needs, also with direct comparison with FFR derived from invasive coronary angiography.

Imaging in atrial fibrillation

Atrial fibrillation is the most frequent cardiac arrhythmia seen in daily practice. Increasing evidence supports a role of inflammation in the development of atrial fibrillation and some recent, small studies suggest that persistent inflammatory activity can be detected in the left atrial wall by FDG-PET/CT imaging in these patients. Lange et al. [40] studied 37 patients with a history of atrial fibrillation who were referred for routine FDG PET/CT. Standardized uptake values were obtained in the walls of the left and right atrium and were compared to the measurements in 37 age and sex matched control group patients without a history of atrial fibrillation. Contrary to previous reports, no significant differences in inflammatory activity in the left or right atrium between patients with and without atrial fibrillation could be detected. Clearly, further studies are needed. As pointed by the authors, these studies should be prospective clinical imaging studies of a larger homogeneous cohort of atrial fibrillation patients in the absence of systemic disease and relevant comorbidities, and using dedicated techniques for the suppression of physiological myocardial glucose uptake.

FDG PET/CT and WBC SPECT/CT imaging in infective endocarditis

Recent studies have shown promising results using (18) F-FDG PET/CT and white blood cell (WBG) SPECT/CT

for the diagnosis of prosthetic valve endocarditis (PVE) and the use of these nuclear imaging techniques have recently been advocated in American and European guidelines on the management of endocarditis. Lauridsen et al. [41] evaluated the use of these nuclear imaging techniques in the extra-cardiac work-up in 55 patients with infective endocarditis. In total 91 pathological extra-cardiac foci were found by FDG-PET/CT and 37 foci by WBC-SPECT/CT ($p < 0.001$). A clinical utility score was higher for FDG-PET/CT as well as the inter-observer reproducibility. These data seem to suggest that FDG-PET/CT is potentially superior to WBC-SPECT/CT for the detection of extra-cardiac pathology in patients with infective endocarditis. However, these findings needs confirmation in larger studies, especially in patients with prosthetic valve endocarditis. Also, the impact of routine assessment of extra-cardiac infective foci on the management and clinical outcome of these patients needs further study.

Echocardiography

In the 2017 issue of the International Journal of Cardiovascular Imaging, echocardiographic techniques were able to provide an answer to some interesting questions.

Does left ventricular myocardial contractile function change during gestation?

Sengupta et al. [42] evaluated the impact of pregnancy and labor on left ventricular myocardial mechanics using speckle tracking echocardiography in 35 pregnant women undergoing serial clinical and echocardiographic evaluation during each trimester and labor compared to 20 nulliparous age-matched women and controls. There was a progressive increase in heart rate, systolic and diastolic blood pressure, cardiac output and left ventricular stroke-work during pregnancy. Left ventricular end-diastolic and end-systolic volumes also increased progressively but left ventricular ejection fraction remained unaltered, except for slight reduction during the second trimester. Compared to the controls, global longitudinal strain and global circumferential strain were reduced in the first trimester itself and remained so throughout the pregnancy and labor. In contrast, global radial strain showed an increase during pregnancy which peaked during the second trimester. These counterbalancing changes serve to maintain overall left ventricular ejection performance within a normal range and enable the maternal heart to meet the hemodynamic demands of pregnancy and labor.

Does deformation imaging allow evaluation of the negative effects of trastuzumab on cardiac mechanics after anthracycline chemotherapy?

Trastuzumab has been shown to be extremely effective in breast cancer patients over-expressing HER-2, but careful cardiac monitoring is required when Trastuzumab is administered with anthracyclines, since the combination can increase its toxicity. An observational, prospective study was designed to assess Trastuzumab-induced cardiac damage using speckle tracking in 45 patients with HER-2 positive breast cancer who had been sequentially treated with Trastuzumab following Epirubicin [43]. Conventional echocardiographic parameters and deformation indexes were analyzed at baseline, after each Epirubicin treatment, and 1 week after every other dose of Trastuzumab administration until 1 year follow up. A reduction in subendocardial function after Epirubicin treatment was observed by a significant impairment of the global longitudinal strain/strain rate, while a significant increase in the activity of the subepicardial fibers was highlighted by an increase in apical rotation. After the second Trastuzumab dose, a sudden reduction of the apical rotation was seen, together with circumferential and radial strain/strain rate. Most importantly, the extent to which the apical rotation increased and decreased was found to strictly correlate with the global longitudinal strain reduction at follow up.

Does chronic training affect right ventricular dimensions and function?

The significance and spectrum of reduced right ventricular deformation, reported in endurance athletes, is unclear. Sitges et al. [44] studied 100 professional male athletes and 50 sedentary healthy males of similar age. Conventional echocardiographic parameters of all four chambers were obtained, as well as two dimensional echo-derived strain in the left and in the right ventricular free wall with separate additional analysis of the right ventricular basal and apical segments. Left and right-sided dimensions were larger in athletes than in controls, but with a disproportionate right atrial enlargement. Right ventricular global strain was lower in sportsmen due to a decrease in the basal segment resulting in a marked gradient of deformation from the right ventricular inlet towards the apex. Cardiac remodelling in athletes is more pronounced in the right heart cavities with specific regional differences within the right ventricle, but with a wide variability among individuals. The large inter-individual differences, as well as its acute and chronic relevance warrant further investigation.

Is there a role for 3D transesophageal echocardiography in the evaluation of left atrial appendage function and thrombi in patients with atrial fibrillation?

The detection of embolic sources in patients with atrial fibrillation is important to guide anticoagulant therapy. Dentamaro et al. [45] hypothesized that real time 3D transesophageal echocardiography is superior to 2D transesophageal echocardiography in detecting and/or excluding left atrial appendage thrombi and studied 93 patients with non-valvular atrial fibrillation referred for electric cardioversion with transthoracic, 2D transesophageal echocardiography and real time 3D transesophageal echocardiography. Before cardioversion, transthoracic echocardiography allowed a confident measurement of emptying velocity of left atrial appendage in only 63% of subjects. On the contrary a good quality transesophageal echocardiography emptying velocity of left atrial appendage was obtained in all patients. Besides to several additional findings, 2D transesophageal echocardiography managed to detect thrombi with certainty in 8/93 patients. In other five cases with diagnostic doubts for thrombi with 2D transesophageal echocardiography (5/93 patients: 5.4%), the addition of the real time 3D transesophageal echocardiography mode allowed to discriminate with certainty the presence of just pectinate muscles in four patients. Real time 3D transesophageal echocardiography in patients with atrial fibrillation at risk of embolism is feasible, accurate and showed an additional diagnostic capability in the differential diagnosis of selected cases with suspected left atrial appendage thrombi.

Does a combined analysis of tissue Doppler-derived Tei index and two-dimensional speckle tracking imaging derived longitudinal strain predict outcome of patients with light-chain cardiac amyloidosis?

Prognosis of patients with light-chain cardiac amyloidosis (AL-CA) is poor. Speckle tracking imaging derived longitudinal deformation parameters and Doppler-derived left ventricular Tei index are valuable predictors of outcome in patients with AL-CA. Liu et al. [46] estimated the prognostic utility of Tei index and deformation parameters in 58 comprehensively phenotyped patients with AL-CA after a median follow-up of 365 days. The primary end point was all-cause mortality. During follow-up, 19 (33%) patients died. Tei index and E to global early diastolic strain rate ratio ($E/GLSR_{dias}$) were higher while global longitudinal systolic strain (GLS_{sys}) was lower in non-survivors than in survivors. Tei index, NYHA functional class, GLS_{sys} and $E/GLSR_{dias}$ were independent predictors of all-cause mortality risk, and Tei index ≥ 0.9 was the best predictor of poor outcome. Combining Tei index and GLS_{sys} yielded the best results on predicting death within 1 year (100% with Tei index ≥ 0.9 and $GLS_{sys} \leq 13\%$) or survival (95% with Tei index ≤ 0.9 and $GLS_{sys} \geq 13\%$). The authors concluded that 1-year mortality risk in AL-CA patients can be reliably predicted using Tei index or deformation parameters, with combined analysis offering best performance.

Does machine learning of the spatio-temporal characteristics of echocardiographic deformation curves allows infarct classification?

Tabassian et al. [47] set up a study to analyze the whole temporal profiles of the segmental deformation curves of the left ventricle and describe their interrelations to obtain more detailed information concerning global left ventricular function in order to be able to identify abnormal changes in left ventricular mechanics. The temporal characteristics of the segmental left ventricular deformation curves were compactly described using an efficient decomposition into major patterns of variation through a statistical method, called Principal Component Analysis. In order to describe the spatial relations between the segmental traces, the principal component analysis-derived temporal features of all left ventricular segments were concatenated. The obtained set of features was then used to build an automatic classification system. The proposed methodology was applied to a group of 60 MRI-delayed enhancement confirmed infarct patients and 60 controls in order to detect myocardial infarction. An average classification accuracy of 87% with corresponding sensitivity and specificity rates of 89% and 85%, respectively was obtained by the proposed methodology applied on the strain rate curves. This classification performance was better than that obtained with the same methodology applied on the strain curves, reading of two expert cardiologists as well as comparative classification systems using only the spatial distribution of the end-systolic strain and peak-systolic strain rate values. This study shows the potential of machine learning in the field of cardiac deformation imaging where an efficient representation of the spatio-temporal characteristics of the segmental deformation curves allowed automatic classification of infarcted from control hearts with high accuracy.

Is it possible to use transthoracic contrast echocardiography for the diagnosis of a patent foramen ovale?

He et al. [48] investigated 125 patient with unexplained cerebral infarction and migraine. All patients underwent contrast transthoracic echocardiography using vitamin B6 and sodium bicarbonate as contrast agents, after which they underwent transoesophageal examinations. Evidence of patent foramen ovale was found in 39% of patients with

contrast transthoracic echocardiography, more than were detected with transoesophageal echocardiography (31%). Contrast transthoracic echocardiography had a sensitivity of 92% and a specificity of 85% for diagnosing patent foramen ovale, showing high concordance with transoesophageal echocardiography for patent foramen ovale recognition ($\kappa = 0.72$). No significant adverse reaction was discovered during contrast transthoracic echocardiography examination. Using vitamin B6 and sodium bicarbonate as contrast agents to perform contrast transthoracic echocardiography can be recommended for detecting and diagnosing the patent foramen ovale due to its simplicity, non-invasive character, low cost, and high feasibility.

Is a smart phone good enough to film stress echocardiography and share the images with a remote expert?

To evaluate the reliability of stress echocardiography based on smart-phone filming and reading, a set of 20 video-clips were read in random sequence with a multiple choice six-answer test by ten readers from five different countries of the "SE2020" study network [49]. The gold standard to assess accuracy was a core-lab expert reader in agreement with angiographic verification. The same set of 20 stress echocardiography studies were read, in random order and > 2 months apart, on a desktop workstation and via smartphones by ten remote readers. The image quality was comparable in desktop workstation versus smartphone. The average reading time per case was similar for desktop versus smartphone. The overall diagnostic accuracy of the ten readers was similar for desktop workstation versus smartphone. Intra-observer agreement was good. Inter-observer agreement was good and similar via desktop or smartphone. The diagnostic accuracy and consistency of stress echocardiography reading among certified readers was high and similar via desktop workstation or via smartphone.

Magnetic resonance imaging

There were a number of interesting advancements in cardiovascular MRI (CMR) in 2017. A number of these were related to the use of T1 and T2 mapping methods. Nadjiri et al. compared T1 mapping to Lake Louis Criteria in patients with suspected myocarditis and found that native T1 values performed at least as well as established imaging biomarkers [50]. In related work Mayr et al. found increased T2 values in acute myocarditis patients in myocardial segments with and without late gadolinium enhancement (LGE) compared with controls [51]. In an observational study of cardiac thrombi and masses, Casper et al. found that T1 and T2 mapping were useful for tissue characterization [52]. The mean native T1 was found to be significantly higher in hypertrophic cardiomyopathy (HCM)patients than controls with a subset having increased extracellular volume (ECV) in areas exhibiting LGE [53]. Bolus versus infusion protocols were compared in congenital heart disease patients finding no significant difference in ECV [54]. SHAHA and ShMOLLI pulse sequences were found to provide significant differences in T1 both with and without gadolinium contrast at 3T for dilated cardiomyopathy patients and healthy controls but both methods could discriminate between controls and dilated cardiomyopathy [55]. Patient-adaptive dual-source and conventional single source radio frequency transmission for T1 mapping at 3 T with MOLLI were compared by Rasper et al. [56] who found improved image homogeneity with dual-source transmission.

The effects of caffeine intake prior to cardiac magnetic resonance perfusion imaging were compared using regadenoson verses adenosine induced hyperemia measured by T1 mapping by van Dijk et al. [57]. These workers found T1 reactivity was significantly reduced following coffee intake with adenosine induced hyperemia compared with regadenoson. The accuracy of stress perfusion CMR for stenosis following percutaneous coronary intervention of the left main coronary artery by Nanni et al. who suggest that stress perfusion CMR could reduce the need for elective coronary angiography [58]. Stress perfusion CMR in combination with LGE and wall motion analysis was found to be accurate and feasible for diagnosing coronary artery disease in children [59]. Ungated perfusion CMR using regadenoson was found to be accurate for the diagnosis of obstructive coronary artery disease in patients with atrial fibrillation [60]. Yin et al. found that abnormal perfusion can be identified in non-LGE and non-hypertrophic segments in patients with hypertrophic cardiomyopathy [61].

Gadobutrol was found to be superior compared with gadopentetate dimeglumine for assessing myocardial fibrosis in patients with hypertrophic cardiomyopathy by Liu et al. [62]. Stiermaier et al. compared myocardial salvage and infarct size between patients with early and late reperfusion following ST-elevation myocardial infarction (STEMI) by CMR and found that the myocardial salvage index was significantly smaller in patients with late reperfusion [63]. Nevertheless, CMR parameters was not found to provide incremental predictive value beyond the assessment by a conventional echocardiography-based risk model in patients with STEMI.

Garg et al. studied strain parameters measured by CMR in STEMI patients to correlate with microvascular obstruction (MVO) or intramyocardial hemorrhage (IMH) and found that global longitudinal strain had the strongest association with MVO or IMH and was the best predictor for adverse left ventricular remodeling [64]. Fent et al. examined global longitudinal strain measured with CMR in patients

with preserved left ventricular ejection fraction and history of prior myocardial infarction and found it to be reduced compared with controls [65]. Accelerated myocardial strain measurements by CMR was shown to be feasible and reliable in patients who require short acquisition [66]. Gho et al. found that the full width at half maximum technique for quantification of LGE revealed 60% of myocardial fibrosis in a chronic porcine infarct model whereas cine derived wall thickness could explain 16–36%, peak circumferential strain 15% and radial strain 10% of myocardial fibrosis [67]. The natural variations of heart deformation analysis myocardial segments of normal volunteers was demonstrated by Lin et al. [68].

The helical distribution of hypertrophy in patients with HCM was studied by Viliani et al. who found a higher estimation of risk of sudden cardiac death in HCM patients exhibiting a helical pattern [69]. A bicuspid aortic valve classification scheme for CMR was proposed by Murphy et al. to aid in better understanding the relationship of valve morphology, flow derangement and aortopathy [70]. Children with repaired tetralogy of Fallot prior to and following pulmonary valve replacement were studied by Yim et al. who found that patients with larger pre-operative right ventricular volumes had lower right ventricular strain postoperatively [71].

Age-stratified normal values of regional cardiac valve plane displacement were provided by Ochs et al. [72]. Quantification of left atrial volume and phasic function were compared using biplane area-length to the Simpson's method finding the latter to be more accurate [73]. A 3D T2-weighted pulse sequence was compared to 2D T2-weighted turbo spin echo imaging found comparable results for carotid artery plaque characterization [74]. The incremental value of CMR for the evaluation of cardiac tumors in adults was provided by Giusca et al. [75]. Incidental findings were better seen with greater confidence with a balanced steady state free precession pulse sequence than T1-weighted half Fourier single shot turbo spin-echo [76].

Computed tomography

Cardiovascular computed tomography has an established clinical role across a wide spectrum of cardiac indications. Based on existing literature, modern multi-modality imaging guidelines lists appropriateness of several imaging modalities including CT for specific clinical scenarios [77]. Beyond these established indications, the scientific literature discusses novel trends and emerging applications. The following selection of articles, covering clinical topics of coronary artery disease, FFR, myocardial perfusion, and interventional guidance provides a glance at developments in 2017.

Appropriate clinical indication for coronary CTA are well defined in clinical practice and are reflected in an article describing data from a large CT registry. Marwan et al. summarize clinical indications, image acquisition parameters as well as results and clinical impact of cardiac CT examinations based on data from 12 clinical centers with extensive expertise in cardiovascular imaging [78]. Between 2009 and 2014, 7061 patients were prospectively enrolled and scanned with 64-slice or newer generation CT systems. Mean patient age was 61 ± 12 years, 63% were males. The majority (63%) of cardiac CT examinations were performed in an outpatient setting, and 91% were elective diagnostic procedures. Cardiac CT limited to assessment of coronary artery calcification, and isolated contrast-enhanced coronary CT angiography was performed in 9 and 16.6%; while combined native and contrast-enhanced coronary CT angiography was performed in 57.7% of patients. Non-coronary cardiac CT examinations constituted 16.6% of all cases. Coronary artery calcification assessment was performed using prospectively ECG-triggered acquisition in 76.9% of all cases, with a median dose length product (DLP) was 42 mGy cm (estimated effective radiation dose of 0.6 mSv). Coronary CT angiography was performed using prospectively ECG-triggered acquisition in 77.3% of all cases. Tube voltage was 120 kV in 67.8% of patients and 100 kV in 30.7% of patients, with a resultant median DLP of 256 mGy cm (estimated effective dose of 3.6 mSv). Based on the results of the coronary CT, invasive coronary angiography was not necessary in 46.8% of the cases, and was recommended only in 16.4%, while ischemia testing was recommended in 4.7% of the cases. Changes in medication were prescribed in 21.6% of the examinations.

CT acquisition and analysis are standardized, but undergo incremental changes based on technical developments [79]. Using a latest generation 320-row Area Detector CT (320-ADCT), Kawaguchi et al. analyze the potential impact of full versus half reconstruction technique, standard versus reduced tube current, and advanced patient motion correction on radiation exposure for coronary CTA. (4) The effective doses ranged between 0.77 ± 0.31 and 1.98 ± 0.68 mSv in 209 selected patients [80].

Cao et al. describe a fully automated algorithm for identification and labeling of the anatomical coronary segments from coronary CT angiographic images [81]. Three-dimensional (3D) models for both right (RD) and left dominant (LD) coronary circulations were built. All labels in the model were matched with their possible candidates in the extracted tree to find the optimal labeling result. In total, 83 CCTA datasets with 1149 segments were included in the testing of the algorithm. The results of the automatic labeling were compared with those by two experts. In all cases, the proximal parts of main branches including LM were labeled correctly. The automatic labeling algorithm was able

to identify and assign labels to 89.2% RD and 83.6% LD coronary tree segments in comparison with the agreements of the two experts (97.6% RD, 87.6% LD). The average precision of start and end points of segments was 92.0% for RD and 90.7% for LD in comparison with the manual identification by two experts while average differences in experts is 1.0% in RD and 2.2% in LD cases.

CT-FFR, myocardial perfusion imaging, and delayed contrast-enhanced imaging (DE) imaging have the potential to expand indications for coronary CTA to populations with higher pre-test probability

Kawaji et al. examined FFR_{CT} in an unselected population of 48 patients who had suspected significant CAD by coronary computed tomography angiography (CCTA) and underwent invasive coronary angiography [82]. Without exclusion of studies based on CTA image quality FFR_{CT} was compared with invasive fractional flow reserve (FFR). FFR_{CT} was measured in a blinded fashion by an independent core laboratory. FFR_{CT} value was evaluable in 89.6% of patients with severe calcification. Per-vessel FFR_{CT} value showed good correlation with invasive FFR value (Spearman's rank correlation = 0.69, $P < 0.001$). The area under the receiver operator characteristics curve (AUC) of FFR_{CT} was 0.87.

Bischoff et al. analysed CT single-phase perfusion using high-pitch helical image acquisition technique in 36 patients with prior myocardial revascularization (28 with coronary stents, 2 with coronary artery bypass grafts and 6 with both) [83]. All patients were examined on a 2nd generation dual-source CT system. Stress CT images were obtained using a prospectively ECG-triggered single-phase high-pitch helical image acquisition technique. During stress the tracer for myocardial perfusion (MP) SPECT imaging was administered. Rest CT images were acquired using prospectively ECG-triggered sequential CT. MP-SPECT imaging and invasive coronary angiography served as standard of reference. CCTA alone showed a low overall diagnostic accuracy for detection of hemodynamically relevant coronary artery stenosis of only 31% on a per-patient base and 60% on a per-vessel base. Combining CCTA and CTMPI allowed for a significantly higher overall diagnostic accuracy of 78% on a per-patient base and 92% on a per-vessel base ($p < 0.001$). Mean radiation dose for stress CT scans was 0.9 mSv, mean radiation dose for rest CT scans was 5.0 mSv.

Feger et al. evaluated the feasibility of four-dimensional (4D) whole-heart computed tomography perfusion (CTP) of the myocardium and the added value of temporal averaging of consecutive 3D datasets from different heartbeats for analysis [84]. Out of 30 patients with suspected or known CAD who underwent 320-row coronary CT angiography (CTA) and myocardial CTP, 15 patients underwent magnetic resonance myocardial perfusion imaging (MR MPI). All CTP examinations were initiated after 3 min of intravenous infusion of adenosine (140 µg/kg/min) and were performed dynamically covering the entire heart every heart beat over a period of 20 ± 3 heart beats. Temporal averaging for dynamic CTP visualization was analysed for the combination of two, three, four, six, and eight consecutive 3D datasets. Input time attenuation curves (TAC) were delivered from measurement points in the center of the left ventricle. In all 30 patients, myocardial 4D CTP was feasible and temporal averaging was successfully implemented for all planned combinations of 3D datasets. Temporal averaging of three consecutive 3D datasets showed best performance in the analysis of all CTP image quality parameters: noise, signal-to-noise ratio (SNR), contrast-to-noise ratio (CNR), subjective image quality, and diagnostic accuracy with an improvement of SNR and CNR by a factor of 2.2 ± 1.3 and 1.3 ± 0.9. With increasing level of temporal averaging, the input TACs became smoother, but also shorter. Out of the 11 perfusion defects detected with MR MPI, 9 defects were also visible on the 4D CTP images.

Pelgrim et al. examined the accuracy of quantification of myocardial perfusion imaging (MPI) using computed tomography (CT) in 5 ex-vivo perfused porcine models [85]. An inflatable cuff was placed around the circumflex (Cx) artery to create stenosis grades which were monitored using a pressure wire, analysing perfusion at several fractional flow reserve values of 1.0, 0.7, 0.5, 0.3, and total occlusion. Second-generation dual-source CT was used to acquire dynamic MPI in shuttle mode with 350 mAs/rot at 100 kVp. CT MPI was performed using VPCT myocardium software, calculating myocardial blood flow (MBF, ml/100 ml/min) for segments perfused by Cx artery and non-Cx myocardial segments. Microspheres were successfully infused at three stenosis grades in three of the five hearts. Heart rate ranged from 75 to 134 beats per minute. Arterial blood flow ranged from 0.5 to 1.4 l min and blood pressure ranged from 54 to 107 mmHg. MBF was determined in 400 myocardial segments of which 115 were classified as 'Cx-territory'. MBF was significantly different between non-Cx and Cx segments at stenosis grades with an FFR ≤ 0.70 (Mann–Whitney U test, $p < 0.05$). MBF showed a moderate correlation with microsphere MBF for the three individual hearts (Pearson correlation 0.62–0.76, $p < 0.01$).

Symons et al. describe feasibility of dual-contrast agent imaging of the heart using photon-counting detector (PCD) computed tomography (CT) to simultaneously assess both first-pass and late enhancement of the myocardium [86]. An occlusion-reperfusion canine model of myocardial infarction was used. Gadolinium-based contrast was injected 10 min prior to PCD CT. Iodinated contrast was infused immediately prior to PCD CT, thus capturing late gadolinium enhancement as well as first-pass iodine enhancement. Gadolinium and iodine maps were calculated using a linear material decomposition technique and compared

to single-energy (conventional) images. PCD images were compared to in vivo and ex vivo magnetic resonance imaging (MRI) and histology. For infarct versus remote myocardium, contrast-to-noise ratio (CNR) was maximal on late enhancement gadolinium maps (CNR 9.0 ± 0.8, 6.6 ± 0.7, and 0.4 ± 0.4, $p < 0.001$ for gadolinium maps, single-energy images, and iodine maps, respectively). For infarct versus blood pool, CNR was maximum for iodine maps (CNR 11.8 ± 1.3, 3.8 ± 1.0, and 1.3 ± 0.4, $p < 0.001$ for iodine maps, gadolinium maps, and single-energy images, respectively). Combined first-pass iodine and late gadolinium maps allowed quantitative separation of blood pool, scar, and remote myocardium. MRI and histology analysis confirmed accurate PCD CT delineation of scar. Simultaneous multi-contrast agent cardiac imaging is feasible with photon-counting detector CT. The authors hypothesize that this initial proof-of-concept results may provide incentives to develop new k-edge contrast agents, to investigate possible interactions between multiple simultaneously administered contrast agents, and to ultimately bring them to clinical practice.

Lee et al. evaluated the feasibility of cardiac CT for the evaluation of myocardial delayed enhancement (MDE) in the assessment of patients with cardiomyopathy, compared to cardiac MRI in 37 patients (mean age 54.9 ± 15.7 years, 24 men) with suspected cardiomyopathy [87]. A Dual-energy ECG-gated cardiac CT was acquired 12 min after contrast injection. Two observers evaluated cardiac MRI and cardiac CT at different kV settings (100, 120 and 140 kV) independently for MDE pattern-classification (patchy, transmural, subendocardial, epicardial and mesocardial), differentiation between ischemic and non-ischemic cardiomyopathy and MDE quantification (percentage MDE). Kappa statics and the intraclass correlation coefficient were used for statistical analysis. Among different kV settings, 100-kV CT showed excellent agreements compared to cardiac MRI for MDE detection ($\kappa = 0.886$ and 0.873, respectively), MDE pattern-classification ($\kappa = 0.888$ and 0.881, respectively) and differentiation between ischemic and non-ischemic cardiomyopathy ($\kappa = 1.000$ and 0.893, respectively) for both Observer 1 and Observer 2. The Bland–Altman plot between MRI and 100-kV CT for the percentage MDE showed a very small bias (-0.15%) with 95% limits of agreement of -7.02 and 6.72.

Tanabe et al. evaluated the image quality and diagnostic performance of late iodine enhancement computed tomography (LIE-CT) with knowledge-based iterative model reconstruction (IMR) for the detection of myocardial infarction (MI) in comparison with late gadolinium enhancement magnetic resonance imaging (LGE-MRI) in 35 patients with suspected coronary artery disease [88]. The CT protocol consisted of stress dynamic myocardial CT perfusion, coronary CT angiography (CTA) and LIE–CT using 256-slice CT. LIE–CT scans were acquired 5 min after CTA without additional contrast medium and reconstructed with filtered back projection (FBP), a hybrid iterative reconstruction (HIR), and IMR. The signal-to-noise ratio (SNR) and contrast-to-noise ratio (CNR) were assessed. Sensitivity and specificity of LIE–CT for detecting MI were assessed according to the 16-segment model. Image quality scores, and diagnostic performance were compared among LIE–CT with FBP, HIR and IMR. Among the 35 patients, 139 of 560 segments showed MI in LGE-MRI. On LIE–CT with FBP, HIR, and IMR, the median SNRs were 2.1, 2.9, and 6.1; and the median CNRs were 1.7, 2.2, and 4.7, respectively. Sensitivity and specificity were 56 and 93% for FBP, 62 and 91% for HIR, and 80 and 91% for IMR. LIE-CT with IMR showed the highest image quality and sensitivity ($p < 0.05$).

Because of its superior ability for 3D reconstruction, CT is extensively used for planning of interventional procedures in structural/valvular heart disease (e.g. LAA occlusion) and post-interventional assessment, e.g of coronary stents

Goitein et al. examined the role of cardiac CT angiography (CCTA) in predicting optimal left atrial appendage (LAA) occluder size and procedure outcome in 36 patient [89]. Pre-procedural CCTA and TEE LAA orifice diameters and perimeters were compared with the implanted device size. CCTA 3D configuration was correlated with procedure outcome. Watchman™ device (N = 18): diameters were 21 ± 4, 26 ± 5 and 25 ± 3 mm for TEE, CCTA and inserted device, respectively. Average perimeters were 61 ± 10, 74 ± 8 and 78 ± 11 mm for TEE, CCTA and inserted device, respectively. Better agreement with the device size was found for CCTA compared to TEE (Bland–Altman). ACP™ device (N = 15): diameters were 20 ± 5, 25 ± 4 and 23 ± 4 for TEE, CCTA and inserted device, respectively. Average perimeters were 58 ± 11, 72 ± 15 and 72 ± 13 mm for TEE, CCTA and inserted device, respectively. Excellent correlation and agreement with the device size was found for CCTA compared to TEE. CCTA perimeter > 100 mm and "cactus" 3D configuration had a specificity of 96 and 81% respectively for procedure failure.

Collett et al. analyzed data from 101 patient with non-complex lesions who were treated with the fully biodegradable vascular scaffold in the ABSORB Cohort B trial [90]. Patients who underwent coronary CTA at 18 months and OCT within ± 180 days were included. Coronary CTA and OCT data were analyzed at an independent core laboratory for quantitative cross-sectional luminal dimensions. The primary objective was the accuracy and precision of coronary CTA for in-scaffold minimal lumen area assessment, with OCT as a reference. Among the 101 patients of the ABSORB Cohort B trial, 35 underwent both OCT and coronary CTA. The feasibility of quantitative

evaluation was 74%. In the scaffolded segment, coronary CTA underestimated minimal lumen area by 9.8% (accuracy 0.39 mm^2, precision 1.0 mm^2, 95% limits of agreement − 1.71–2.50 mm^2). A similar level of agreement was observed in the non-scaffolded segment.

Tu et al. examined visualization of polymeric bioresorbable scaffolds (BRSs) by micro-computed tomography (mCT), including 3-dimensional reconstruction of BRS images by contrast-enhanced mCT and optimal imaging settings [91]. BRSs, made of poly-L-lactic acid (PLLA), were implanted in coronary bifurcation models. Five treatments were conducted to examine an optimal condition for imaging BRSs: Baseline treatment, samples were filled with normal saline and scanned with mCT immediately; Treatment-1, -2, -3 and -4, samples were filled with contrast medium and scanned with mCT immediately and 1, 2 and 3 h thereafter, corresponding to soaking time of contrast medium of 0, 1, 2 and 3 h. Compared to Baseline, mCT scanning completely discriminate the scaffold struts from the vascular lumen immediately after filling the samples with contrast agent but not from the vascular wall until the contrast agent soaking time was more than 2 h (Treatment-3 and -4). By setting 10–15 HU as a cut-point of CT values, the scaffold strut detectable rate at Baseline and Teatment-1, -2, -3 and -4 were 1.23 ± 0.31, 1.65 ± 0.26, 58.14 ± 12.84, 97.97 ± 1.43 and 98.90 ± 0.38%, respectively (Treatment-3 vs. Treatment-2, $p < 0.01$); meanwhile, the success rate of 3D BRS reconstruction with high quality images at Baseline and Teatment-1, -2, -3 and -4 were 1.23, 1.65, 58.14, 97.97 and 98.90%, respectively (Treatment-3 vs. Treatment-2, $p < 0.01$).

An emerging application of CT is 3D printing. Clinical applications are pursued in pediatric and adult cardiovascular medicine

Cantinotti et al. discuss technical considerations and current applications of three-dimensional (3D) printing in congenital heart disease (CHD) [92]. Steps involved in the building of 3D models, including image acquisition and selection, segmentation, and printing and their operator dependency are discussed. Current 3D models may be rigid or flexible, but unable to reproduce the physiologic variations during the cardiac cycle. Furthermore, high costs and long average segmentation and printing times limit a more extensive use. The authors concluded that there is a need for better standardization of the procedure employed for collection of the images, the segmentation methods and processes, the phase of cardiac cycle used, and in the materials employed for printing. More studies are necessary to evaluate the diagnostic accuracy and cost-effectiveness of 3D printed models in congenital cardiac care.

Hernández-Enríquez et al. describe a case of 3D printing of an aortic model for transcatheter aortic valve implantation and discuss possible clinical applications [93].

It is an important role of the journal to publish articles about novel technology and applications at an early investigational stage. However, excitement about early results should not replace careful evaluation in clinical trials and adherence to appropriate use criteria as the basis for clinical use [77].

Topical issue on emerging concepts on invasive and noninvasive coronary physiological assessment

In July 2017 the Topical issue on Emerging concepts on Invasive and Noninvasive Coronary Physiological Assessment was published with a great overview over the various imaging modalities with a total of 15 scientific papers by the experts in this field on invasive and non-invasive flow reserve, flow-pressure relationships, microvascular dysfunction, perfusion imaging and wall shear stress [94–108].

References

1. Sato T, Jose J, El-Mawardy M, Sulimov DS, Tölg R, Richardt G, Abdel-Wahab M (2017) Predictors of acute scaffold recoil after implantation of the everolimus-eluting bioresorbable scaffold: an optical coherence tomography assessment in native coronary arteries. Int J Cardiovasc Imaging 33:145–152
2. Jin Z-G, Zhang Z-Q, Jing L-M, Wei Y-J, Zhang J, Luo J-P, Liu Y, Han W, Yang Y, Liu H-l, Yang S-l, Ma D-X (2017) Correlation between dual-axis rotational coronary angiography and intravascular ultrasound in a coronary lesion assessment. Int J Cardiovasc Imaging 33:153–160
3. Hinrichs JB, Murray T, Akin M, Lee M, Brehm MU, Wilhelmi M, Wacker FK, Rodt T (2017) Evaluation of a novel 3D perfusion angiography technique independent of pump injections for assessment of interventional treatment of peripheral vascular disease. Int J Cardiovasc Imaging 33:295–301
4. Katz A, Shtub A, Solomonica A, Poliakov A (2017) Roguin A Simulator training to minimize ionizing radiation exposure in the catheterization laboratory. Int J Cardiovasc Imaging 33:303–310
5. Roy JR, Sun P, Ison G, Prasam AM, Ford T, Hopkins A, Ramsay DR, Weaver JC (2017) Selective anti-scatter grid removal during coronary angiography and PCI: a simple and safe technique for radiation reduction. Int J Cardiovasc Imaging 33:771–778
6. Kozuma K, Kashiwabara K, Shinozaki T, Kozuma K, Oba K, Matsuyama Y (2017) Two-by-two cross-over study to evaluate agreement between versions of a quantitative coronary analysis system (QAngio XA). Int J Cardiovasc Imaging 33:779–787
7. Shi W-Y, Gu J-P, Liu C-J, Lou W-S (2017) He X Dual compression is not an uncommon type of iliac vein compression syndrome. Int J Cardiovasc Imaging 33:1277–1285
8. Pan L-F, Chu KH, Sher H-F, Pan L-K (2017) Optimizing left anterior oblique (LAO) caudal imaging in coronary angiography using the Taguchi method: a phantom study with clinical verification. Int J Cardiovasc Imaging 33:1287–1295
9. Iwachow P, Miechowicz I, Kalmucki P, Dziki B, Szyszka A, Baszko A, Siminiak T (2017) Evaluation of radiological risk during coronary angioplasty procedures: comparison of

transradial and transfemoral approaches. Int J Cardiovasc Imaging 33:1297–1303
10. De Angelis C, Sardanelli F, Peregо M, Ali M, Casilli F, Inglese L, Mauri G (2017) Carbon dioxide (CO_2) angiography as an option for endovascular abdominal aortic aneurysm repair (EVAR) in patients with chronic kidney disease (CKD). Int J Cardiovasc Imaging 33:1655–1662
11. Fam JM, Ishibashi Y, Felix C, Zhang BC, Diletti R, Mieghem N van, Regar E, Domburg R van, Onuma Y, Geuns R-J van (2017) Conformability in everolimus-eluting bioresorbable scaffolds compared with metal platform coronary stents in long lesions. Int J Cardiovasc Imaging 33:1863–1871
12. Ge Z, Liu Z-Z, Kan J, Zhang J-J, Li S-J, Tian N-L, Ye F, Qian X-S, Yang S, Chen M-X, Rab T-S, Chen S-L (2017) Stent fracture is associated with a higher mortality in patients with type-2 diabetes treated by implantation of a second-generation drug-eluting stent. Int J Cardiovasc Imaging 33:1873–1881
13. Yesin M, Cagdas M, Kalcik M, Uluganyan M, Efe SC, Rencuzogullari I, Karabag Y, Gursoy MO, Karakoyun S (2017) Comparison of syntax score and syntax score II to predict "no reflow phenomenon" in patients with ST-segment elevation myocardial infarction. Int J Cardiovasc Imaging 33:1883–1889
14. Ramalho AR, Marques JS, Pêgo GM (2017) Disruption of bioresorbable vascular scaffold struts due to loss of radial integrity: insights from optical coherence tomography. Int J Cardiovasc Imaging 33(3):311–312
15. Zeng Y, Cavalcante R, Tenekecioglu E, Suwannasom P, Sotomi Y, Collet C et al (2017) Comparative assessment of "plaque/media" change on three modalities of IVUS immediately after implantation of either everolimus-eluting bioresorbable vascular scaffold or everolimus-eluting metallic stent in Absorb II study. Int J Cardiovasc Imaging 33(4):441–449
16. Tenekecioglu E, Bourantas CV, Onuma Y, Serruys PW (2017) Sealing of calcified plaques after bioresorbable scaffold implantations: a five-year follow up. Int J Cardiovasc Imaging 33(4):451–452
17. Shen L, Wu Y, Ge L, Zhang Y, Wang Q, Qian J et al (2017) A head to head comparison of XINSORB bioresorbable sirolimus-eluting scaffold versus metallic sirolimus-eluting stent: 180 days follow-up in a porcine model. Int J Cardiovasc Imaging 33:1473–1481
18. Sato T, Jose J, El-Mawardy M, Sulimov DS, Tölg R, Richardt G et al (2017) Predictors of acute scaffold recoil after implantation of the everolimus-eluting bioresorbable scaffold: an optical coherence tomography assessment in native coronary arteries. Int J Cardiovasc Imaging 33(2):145–152
19. Sato T, Jose J, El-Mawardy M, Sulimov DS, Tölg R, Richardt G et al (2017) Neointimal response to everolimus-eluting bioresorbable scaffolds implanted at bifurcating coronary segments: insights from optical coherence tomography. Int J Cardiovasc Imaging 33(2):169–175
20. Costa JR, Chamié D, Abizaid AAC, Ribeiro E, Meireles GC, Prudente M et al (2017) Intravascular imaging comparison of two metallic limus-eluting stents abluminally coated with biodegradable polymers: IVUS and OCT results of the DESTINY trial. Int J Cardiovasc Imaging 33(2):161–168
21. Ohtani H, Kimura S, Sugiyama T, Hishikari K, Misawa T, Mizusawa M et al (2017) Comparison of vascular responses after different types of second-generation drug-eluting stents implantation detected by optical coherence tomography. Int J Cardiovasc Imaging 33(2):177–186
22. Sabbah M, Kadota K, El-Eraky A, Kamal HM, Abdellah A-T, El Hawary A (2017) Comparison of in-stent neoatherosclerosis and tissue characteristics between early and late in-stent restenosis in second-generation drug-eluting stents: an optical coherence tomography study. Int J Cardiovasc Imaging 33:1463–1472
23. Song L, Mintz GS, Yin D, Yamamoto MH, Chin CY, Matsumura M et al (2017) Neoatherosclerosis assessed with optical coherence tomography in restenotic bare metal and first- and second-generation drug-eluting stents. Int J Cardiovasc Imaging 33(8):1115–1124
24. Takahara M, Kitahara H, Nishi T, Miura K, Miyayama T, Sugimoto K et al (2017) Very early tissue coverage after drug-eluting stent implantation: an optical coherence tomography study. Int J Cardiovasc Imaging 33(1):25–30
25. Li Z, Wang L, Hu X, Zhang P, Chen Y, Liu X et al (2017) Intravascular ultrasound elastography analysis of the elastic mechanical properties of atherosclerotic plaque. Int J Cardiovasc Imaging 33(11):1663–1671
26. Minami Y, Hoyt T, Phipps JE, Milner TE, Xing L, Lee H et al (2017) Lipid-lowering therapy stabilizes the complexity of non-culprit plaques in human coronary artery: a quantitative assessment using OCT bright spot algorithm. Int J Cardiovasc Imaging 33(4):453–461
27. Her A-Y, Cho KI, Singh GB, An DS, Jeong Y-H, Koo B-K et al (2017) Plaque characteristics and inflammatory markers for the prediction of major cardiovascular events in patients with ST-segment elevation myocardial infarction. Int J Cardiovasc Imaging 33:1445–1454
28. Timmins LH, Molony DS, Eshtehardi P, Rasoul-Arzrumly E, Lam A, Hung OY et al (2017) Quantification of the focal progression of coronary atherosclerosis through automated co-registration of virtual histology-intravascular ultrasound imaging data. Int J Cardiovasc Imaging 33(1):13–24
29. Shiratori Y, Watanabe M, Suzuki N, Fukusato T, Kozuma K (2017) Quantified coronary frequency domain optical coherence tomography signal analysis for the evaluation of erythrocyte-rich thrombus: ex-vivo validation study. Int J Cardiovasc Imaging 33(5):587–594
30. Gnanadesigan M, Hussain AS, White S, Scoltock S, Baumbach A, Steen AFW van der et al (2017) Optical coherence tomography attenuation imaging for lipid core detection: an ex-vivo validation study. Int J Cardiovasc Imaging 33(1):5–11
31. Tenekecioglu E, Torii R, Bourantas C, Miyazaki Y, Collet C, Al-Lameé R et al (2017) The effect of strut thickness on shear stress distribution in a preclinical model. Int J Cardiovasc Imaging 33(11):1675–1676
32. Tenekecioglu E, Sotomi Y, Torii R, Bourantas C, Miyazaki Y, Collet C et al (2017) Strut protrusion and shape impact on endothelial shear stress: insights from pre-clinical study comparing mirage and absorb bioresorbable scaffolds. Int J Cardiovasc Imaging 33(9):1313–1322
33. Ryan N, Gonzalo N, Dingli P, Cruz OV, Jiménez-Quevedo P, Nombela-Franco L et al (2017) Intravascular ultrasound guidance of percutaneous coronary intervention in ostial chronic total occlusions: a description of the technique and procedural results. Int J Cardiovasc Imaging 33(6):807–813
34. Nakamura T, Okamura T, Fujimura T, Yamada J, Nao T, Tateishi H et al (2017) Serial changes in the three-dimensional aspect of the side-branch ostium jailed by a drug-eluting stent assessed by optical coherence tomography. Int J Cardiovasc Imaging 33(6):797–806
35. Nakamura D, Attizzani GF, Nishino S, Tanaka K, Soud M, Pereira GT et al (2017) New insight to estimate under-expansion after stent implantation on bifurcation lesions using optical coherence tomography. Int J Cardiovasc Imaging 33(11):1677–1684
36. Ishihara M, Onoguchi M, Taniguchi Y et al (2017) Comparison of conventional and cadmium-sinc-telluride single-photon emission computed tomography for analysis of thallium-201 myocardial perfusion imaging: an exploratory study in normal

different databases for different ethnicities. Int J Cardiovasc Imaging 33:2057
37. Lima R, Peclat T, Souza A et al (2017) Prognostic value of a faster, low-radiation myocardial perfusion SPECT protocol in a CZT camera. Int J Cardiovasc Imaging 33:2049
38. Driessen R, Raijmakers P, Stuijfzand W et al (2017) Myocardial perfusion imaging with PET. Int J Cardiovasc Imaging 33:1021–1031
39. Nakanishi R, Osawa K, Ceponiene I et al (2017) The diagnostic performance of SPECT-MPI to predict functional significant coronary artery disease by fractional flow reserve derived from CCTA (FFR-CT): subanalysis from ACCURACY and VCT001 studies. Int J Cardiovasc Imaging 33:2067
40. Lange P, Avramovic N, Frommeyer G et al (2017) Routine 18F-FDG PET/CT does not detect inflammation in the left atrium in patients with atrial fibrillation. Int J Cardiovasc Imaging 33:1271–1276
41. Lauridsen TK, Iversen KK, Ihleman N et al (2017) Clinical utility of 18F-FDG positron emission tomography/computed tomography scan vs 99 m TC-HMPA white blood cell single-photon emission computed tomography in extra-cardiac work-up of infective endocarditis. Int J Cardiovasc Imaging 33:751–760
42. Sengupta SP, Bansal M, Hofstra L, Sengupta PP, Narula J (2017) Gestational changes in left ventricular myocardial contractile function: new insights from two-dimensional speckle tracking echocardiography. Int J Cardiovasc Imaging 33:69–82
43. Cadeddu C, Piras A, Dessì M, Madeddu C, Mantovani G, Scartozzi M, Hagendorff A, Colonna P, Mercuro G (2017) Timing of the negative effects of trastuzumab on cardiac mechanics after anthracycline chemotherapy. Int J Cardiovasc Imaging 33:197–207
44. Sitges M, Merino B, Butakoff C, de la Garza MS, Pare C, Montserrat S, Vidal B, Azqueta M, Sarquella G, Gutierrez JA, Canal R, Brugada J, Bijnens BH (2017) Characterizing the spectrum of right ventricular remodelling in response to chronic training. Int J Cardiovasc Imaging 33:331–339
45. Dentamaro I, Vestito D, Michelotto E, De Santis D, Ostuni V, Cadeddu C, Colonna P (2017) Evaluation of left atrial appendage function and thrombi in patients with atrial fibrillation. Int J Cardiovasc Imaging 33:491–498
46. Liu D, Hu K, Herrmann S, Cikes M, Ertl G, Weidemann F, Stork S, Nordbeck P (2017) Value of tissue Doppler-derived Tei index and two-dimensional speckle tracking imaging derived longitudinal strain on predicting outcome of patients with light-chain cardiac amyloidosis. Int J Cardiovasc Imaging 33:837–845
47. Tabassian M, Alessandrini M, Herbots L, Mirea O, Pagourelias ED, Jasaityte R, Engvall J, March LDE, Masetti G, D'hooge J (2017) Machine learning of the spatio-temporal characteristics of echocardiographic deformation curves for infarct classification. Int J Cardiovasc Imaging 33:1159–1167
48. He JC, Zheng JY, Li X, Yang Y, Zhang B-Y, Chen Y, Li X-F, Liu Y-M, Cao Y, Zhao L, Li T-C (2017) Transthoracic contrast echocardiography using vitamin B6 and sodium bicarbonate as contrast agents for the diagnosis of patent foramen. Int J Cardiovasc Imaging 33:1125–1131
49. Scali MC, de Azevedo Bellagamba CC, Ciampi Q, Simova I, Pretto JL, Djordjevic-Dikic A, Dodi C, Caortigiani L, Zagatina A, Trambaiolo P, Torres MR, Citro R, Colonna P, Paterni M, Picano E (2017) Stress echocardiography with smartphone: real-time remote reading for regional wall motion. Int J Cardiovasc Imaging 33:1731–1736
50. Nadjiri J, Nieberler H, Hendrich E et al (2017) Performance of native and contrast-enhanced T1 mapping to detect myocardial damage in patients with suspected myocarditis: a head-to-head comparison of different cardiovascular magnetic resonance techniques. Int J Cardiovasc Imaging 33:539–547. https://doi.org/10.1007/s10554-016-1029-3
51. Mayr A, Klug G, Feistritzer HJ et al (2017) Myocardial edema in acute myocarditis: relationship of T2 relaxometry and late enhancement burden by using dual-contrast turbo spin-echo MRI. Int J Cardiovasc Imaging 33:1789–1794. https://doi.org/10.1007/s10554-017-1170-7
52. Caspar T, Ghannudi El S, Ohana M et al (2017) Magnetic resonance evaluation of cardiac thrombi and masses by T1 and T2 mapping: an observational study. Int J Cardiovasc Imaging 33:551–559. https://doi.org/10.1007/s10554-016-1034-6
53. Parekh K, Markl M, Deng J et al (2017) T1 mapping in children and young adults with hypertrophic cardiomyopathy. Int J Cardiovasc Imaging 33:109–117. https://doi.org/10.1007/s10554-016-0979-9
54. Al-Wakeel-Marquard N, Rastin S, Muench F et al (2017) Cardiac T1 mapping in congenital heart disease: bolus vs. infusion protocols for measurements of myocardial extracellular volume fraction. Int J Cardiovasc Imaging 33:1961–1968. https://doi.org/10.1007/s10554-017-1191-2
55. Costello BT, Springer F, Hare JL et al (2017) SASHA versus ShMOLLI: a comparison of T1 mapping methods in health and dilated cardiomyopathy at 3 T. Int J Cardiovasc Imaging 33:1551–1560. https://doi.org/10.1007/s10554-017-1134-y
56. Rasper M, Nadjiri J, Sträter AS et al (2017) Cardiac MOLLI T1 mapping at 3.0 T: comparison of patient-adaptive dual-source RF and conventional RF transmission. Int J Cardiovasc Imaging 33:889–897. https://doi.org/10.1007/s10554-017-1072-8
57. van Dijk R, Kuijpers D, Kaandorp TAM et al (2017) Effects of caffeine intake prior to stress cardiac magnetic resonance perfusion imaging on regadenoson-versus adenosine-induced hyperemia as measured by T1 mapping. Int J Cardiovasc Imaging 33:1753–1759. https://doi.org/10.1007/s10554-017-1157-4
58. Nanni S, Lovato L, Ghetti G et al (2017) Utility of stress perfusion-cardiac magnetic resonance in follow-up of patients undergoing percutaneous coronary interventions of the left main coronary artery. Int J Cardiovasc Imaging 33:1589–1597. https://doi.org/10.1007/s10554-017-1149-4
59. Vijarnsorn C, Noga M, Schantz D et al (2017) Stress perfusion magnetic resonance imaging to detect coronary artery lesions in children. Int J Cardiovasc Imaging 33:699–709. https://doi.org/10.1007/s10554-016-1041-7
60. Bieging ET, Haider I, Adluru G et al (2017) Rapid rest/stress regadenoson ungated perfusion CMR for detection of coronary artery disease in patients with atrial fibrillation. Int J Cardiovasc Imaging 33:1781–1788. https://doi.org/10.1007/s10554-017-1168-1
61. Yin L, Xu H-Y, Zheng S-S et al (2017) 3.0 T magnetic resonance myocardial perfusion imaging for semi-quantitative evaluation of coronary microvascular dysfunction in hypertrophic cardiomyopathy. Int J Cardiovasc Imaging 33:1949–1959. https://doi.org/10.1007/s10554-017-1189-9
62. Liu D, Ma X, Liu J et al (2017) Quantitative analysis of late gadolinium enhancement in hypertrophic cardiomyopathy: comparison of diagnostic performance in myocardial fibrosis between gadobutrol and gadopentetate dimeglumine. Int J Cardiovasc Imaging 33:1191–1200. https://doi.org/10.1007/s10554-017-1101-7
63. Stiermaier T, Eitel I, de Waha S et al (2017) Myocardial salvage after primary percutaneous coronary intervention in patients with ST-elevation myocardial infarction presenting early versus late after symptom onset. Int J Cardiovasc Imaging 33:1571–1579. https://doi.org/10.1007/s10554-017-1143-x
64. Garg P, Kidambi A, Swoboda PP et al (2017) The role of left ventricular deformation in the assessment of microvascular

obstruction and intramyocardial haemorrhage. Int J Cardiovasc Imaging 33:361–370. https://doi.org/10.1007/s10554-016-1006-x
65. Fent GJ, Garg P, Foley JRJ et al (2017) The utility of global longitudinal strain in the identification of prior myocardial infarction in patients with preserved left ventricular ejection fraction. Int J Cardiovasc Imaging 33:1561–1569. https://doi.org/10.1007/s10554-017-1138-7
66. Langton JEN, Lam H-I, Cowan BR et al (2017) Estimation of myocardial strain from non-rigid registration and highly accelerated cine CMR. Int J Cardiovasc Imaging 33:101–107. https://doi.org/10.1007/s10554-016-0978-x
67. Gho JMIH, van Es R, van Slochteren FJ et al (2017) A systematic comparison of cardiovascular magnetic resonance and high resolution histological fibrosis quantification in a chronic porcine infarct model. Int J Cardiovasc Imaging 33:1797–1807. https://doi.org/10.1007/s10554-017-1187-y
68. Lin K, Meng L, Collins JD et al (2017) Heart deformation analysis: the distribution of regional myocardial motion patterns at left ventricle. Int J Cardiovasc Imaging 33:351–359. https://doi.org/10.1007/s10554-016-1005-y
69. Viliani D, Pozo E, Aguirre N et al (2017) Helical distribution of hypertrophy in patients with hypertrophic cardiomyopathy: prevalence and clinical implications. Int J Cardiovasc Imaging 33:1771–1780. https://doi.org/10.1007/s10554-017-1161-8
70. Murphy IG, Collins J, Powell A et al (2017) Comprehensive 4-stage categorization of bicuspid aortic valve leaflet morphology by cardiac MRI in 386 patients. Int J Cardiovasc Imaging 33:1213–1221. https://doi.org/10.1007/s10554-017-1107-1
71. Yim D, Mertens L, Morgan CT et al (2017) Impact of surgical pulmonary valve replacement on ventricular mechanics in children with repaired tetralogy of Fallot. Int J Cardiovasc Imaging 33:711–720. https://doi.org/10.1007/s10554-016-1046-2
72. Ochs MM, Fritz T, André F et al (2017) A comprehensive analysis of cardiac valve plane displacement in healthy adults: age-stratified normal values by cardiac magnetic resonance. Int J Cardiovasc Imaging 33:721–729. https://doi.org/10.1007/s10554-016-1058-y
73. Wandelt LK, Kowallick JT, Schuster A et al (2017) Quantification of left atrial volume and phasic function using cardiovascular magnetic resonance imaging-comparison of biplane area-length method and Simpson's method. Int J Cardiovasc Imaging 33:1761–1769. https://doi.org/10.1007/s10554-017-1160-9
74. Lv P, Dai Y, Lin J et al (2017) A comparison study between 3D T2-weighted SPACE and conventional 2D T2-weighted turbo spin echo in assessment of carotid plaque. Int J Cardiovasc Imaging 33:395–400. https://doi.org/10.1007/s10554-016-1017-7
75. Giusca S, Mereles D, Ochs A et al (2017) Incremental value of cardiac magnetic resonance for the evaluation of cardiac tumors in adults: experience of a high volume tertiary cardiology centre. Int J Cardiovasc Imaging 33:879–888. https://doi.org/10.1007/s10554-017-1065-7
76. Sohns JM, Menke J, Schwarz A et al (2017) Incidental findings in cardiac magnetic resonance imaging: superiority of bSSFP over T1w-HASTE for extra-cardiac findings assessment. Int J Cardiovasc Imaging 33:1581–1587. https://doi.org/10.1007/s10554-017-1145-8
77. Doherty JU, Kort S, Mehran R, Schoenhagen P, Soman P. (2017) ACC/AATS/AHA/ASE/ASNC/HRS/SCAI/SCCT/SCMR/STS appropriate use criteria for multimodality imaging in valvular heart disease: A report of the American College of Cardiology Appropriate Use Criteria Task Force, American Association for Thoracic Surgery., American Heart Association, American Society of Echocardiography, American Society of Nuclear Cardiology, Heart Rhythm Society, Society for Cardiovascular Angiography and Interventions, Society of Cardiovascular Computed Tomography, Society for Cardiovascular Magnetic Resonance, and Society of Thoracic Surgeons. J Am Coll Cardiol 70(13):1647–1672
78. Marwan M, Achenbach S, Korosoglou G, Schmermund A, Schneider S, Bruder O, Hausleiter J, Schroeder S, Barth S, Kerber S, Leber A, Moshage W, Senges J (2017) German cardiac CT registry: indications, procedural data and clinical consequences in 7061 patients undergoing cardiac computed tomography. Int J Cardiovasc Imaging. https://doi.org/10.1007/s10554-017-1282-0
79. Abbara S, Blanke P, Maroules CD, Cheezum M, Choi AD, Han BK, Marwan M, Naoum C, Norgaard BL, Rubinshtein R, Schoenhagen P, Villines T, Leipsic J. (2016) SCCT guidelines for the performance and acquisition of coronary computed tomographic angiography: a report of the society of Cardiovascular Computed Tomography Guidelines Committee: Endorsed by the North American Society for Cardiovascular Imaging (NASCI). J Cardiovasc Comput Tomogr 10(6):435–449
80. Kawaguchi Y, Fujimoto S, Takamura K, Kato E, Suda S, Matsumori R, Hiki M, Kumamaru KK, Daida H (2017) Submillisievert imaging protocol using full reconstruction and advanced patient motion correction in 320-row area detector coronary CT angiography. Int J Cardiovasc Imaging. https://doi.org/10.1007/s10554-017-1237-5
81. Cao Q, Broersen A, de Graaf MA, Kitslaar PH, Yang G, Scholte AJ, Lelieveldt BPF, Reiber JHC, Dijkstra J (2017) Automatic identification of coronary tree anatomy in coronary computed tomography angiography. Int J Cardiovasc Imaging 33(11):1809–1819
82. Kawaji T, Shiomi H, Morishita H, Morimoto T, Taylor CA, Kanao S, Koizumi K, Kozawa S, Morihiro K, Watanabe H, Tazaki J, Imai M, Saito N, Shizuta S, Ono K, Togashi K, Kimura T (2017) Feasibility and diagnostic performance of fractional flow reserve measurement derived from coronary computed tomography angiography in real clinical practice. Int J Cardiovasc Imaging 33(2):271–281
83. Bischoff B, Deseive S, Rampp M, Todica A, Wermke M, Martinoff S, Massberg S, Reiser MF, Becker HC, Hausleiter J (2017) Myocardial ischemia detection with single-phase CT perfusion in symptomatic patients using high-pitch helical image acquisition technique. Int J Cardiovasc Imaging 33(4):569–576
84. Feger S, Shaban A, Lukas S, Kendziorra C, Rief M, Zimmermann E, Dewey M (2017) Temporal averaging for analysis of four-dimensional whole-heart computed tomography perfusion of the myocardium: proof-of-concept study. Int J Cardiovasc Imaging 33(3):371–382
85. Pelgrim GJ, Das M, van Tuijl S, van Assen M, Prinzen FW, Stijnen M, Oudkerk M, Wildberger JE, Vliegenthart R (2017) Validation of myocardial perfusion quantification by dynamic CT in an ex-vivo porcine heart model. Int J Cardiovasc Imaging 33(11):1821–1830
86. Symons R, Cork TE, Lakshmanan MN, Evers R, Davies-Venn C, Rice KA, Thomas ML, Liu CY, Kappler S, Ulzheimer S, Sandfort V, Bluemke DA, Pourmorteza A (2017) Dual-contrast agent photon-counting computed tomography of the heart: initial experience. Int J Cardiovasc Imaging 33(8):1253–1261
87. Lee HJ, Im DJ, Youn JC, Chang S, Suh YJ, Hong YJ, Kim YJ, Hur J, Choi BW (2017) Assessment of myocardial delayed enhancement with cardiac computed tomography in cardiomyopathies: a prospective comparison with delayed enhancement cardiac magnetic resonance imaging. Int J Cardiovasc Imaging 33(4):577–584
88. Tanabe Y, Kido T, Kurata A, Fukuyama N, Yokoi T, Kido T, Uetani T, Vembar M, Dhanantwari A, Tokuyasu S, Yamashita N, Mochizuki T (2017) Impact of knowledge-based iterative model reconstruction on myocardial late iodine enhancement in

computed tomography and comparison with cardiac magnetic resonance. Int J Cardiovasc Imaging 33(10):1609–1618
89. Goitein O, Fink N, Hay I, Di Segni E, Guetta V, Goitein D, Brodov Y, Konen E, Glikson M (2017) Cardiac CT Angiography (CCTA) predicts left atrial appendage occluder device size and procedure outcome. Int J Cardiovasc Imaging 33(5):739–747
90. Collet C, Sotomi Y, Cavalcante R, Asano T, Miyazaki Y, Tenekecioglu E, Kistlaar P, Zeng Y, Suwanasson P, de Winter RJ, Nieman K, Serruys PW, Onuma Y (2017) Accuracy of coronary computed tomography angiography for bioresorbable scaffold luminal investigation: a comparison with optical coherence tomography. Int J Cardiovasc Imaging 33(3):431–439
91. Tu S, Hu F, Cai W, Xiao L, Zhang L, Zheng H, Jiang Q, Chen L (2017) Visualizing polymeric bioresorbable scaffolds with three-dimensional image reconstruction using contrast-enhanced micro-computed tomography. Int J Cardiovasc Imaging 33(5):731–737
92. Cantinotti M, Valverde I, Kutty S (2017) Three-dimensional printed models in congenital heart disease. Int J Cardiovasc Imaging 33(1):137–144. https://doi.org/10.1007/s10554-016-0981-2
93. Hernández-Enríquez M, Brugaletta S, Andreu D, Macià-Muñoz G, Castrejón-Subirá M, Fernández-Suelves S, Hernández-Obiols M, Dantas AP, Freixa X, Martin-Yuste V, Camara O, Sabaté M (2017) Three-dimensional printing of an aortic model for transcatheter aortic valve implantation: possible clinical applications. Int J Cardiovasc Imaging 33(2):283–285
94. Tu S, van de Hoef TP, Kim Y-H, Escaned J, Wijns W (2017) Whence we came, whither we go? Int J Cardiovasc Imaging 33(7):957–959
95. Corcoran D, Hennigan B, Berry C (2017) Fractional flow reserve: a clinical perspective. Int J Cardiovasc Imaging 33(7):961–974
96. Chu M, Dai N, Yang J, Westra J, Tu S (2017) A systematic review of imaging anatomy in predicting functional significance of coronary stenoses determined by fractional fl ow reserve. Int J Cardiovasc Imaging 33(7):975–990
97. Hennigan B, Johnson N, McClure J, Corcoran D, Watkins S, Berry C, Oldroyd KG (2017) Validation of the "smart" minimum FFR Algorithm in an unselected all comer population of patients with intermediate coronary stenoses. Int J Cardiovasc Imaging 33(7):991–997
98. Meimoun P, Clerc J, Ardourel D, Djou U, Martis S, Botoro T, Elmkies F, Zemir H, Luycx-Bore A, Boulanger J (2017) Assessment of left anterior descending artery stenosis of intermediate severity by fractional flow reserve, instantaneous wave-free ratio, and non-invasive coronary flow reserve. J Cardiovasc Imaging 33(7):999–1007
99. Yang DH, Kim Y-H (2017) CT myocardial perfusion imaging: current status and future perspectives. J Cardiovasc Imaging 33(7):1009–1020
100. Driessen RS, Raijmakers PG, Stuijfzand WJ, Knaapen P (2017) Myocardial perfusion imaging with PET. J Cardiovasc Imaging 33(7):1021–1031
101. van de Hoef TP, Echavarría-Pinto M, Escaned J, Piek JJ (2017) Coronary flow capacity: concept, promises, and challenges. J Cardiovasc Imaging 33(7):1033–1039
102. Mejía-Rentería H, van der Hoeven N, van de Hoef TP, Heemelaar J, Ryan N, Lerman A, van Royen N, Escaned J (2017) Targeting the dominant mechanism of coronary microvascular dysfunction with intracoronary physiology tests. J Cardiovasc Imaging 33(7):1041–1059
103. Broyd CJ, Rigo F, Davies J (2017) Non-invasive coronary wave intensity analysis. J Cardiovasc Imaging 33(7):1061–1068
104. Kamphuis VP, Westenberg JJM, van der Palen RLF, Blom NA, de Roos A, van der Geest R, Elbaz MSM, Roest AAW (2017) Unravelling cardiovascular disease using four dimensional fl ow cardiovascular magnetic resonance. J Cardiovasc Imaging 33(7):1069–1081
105. Li S, Chin C, Thondapu V, Poon EKW, Monty JP, Li Y, Ooi ASH, Tu S, Barlis P (2017) Numerical and experimental investigations of the flow–pressure relation in multiple sequential stenoses coronary artery. J Cardiovasc Imaging 33(7):1083–1088
106. Eshtehardi P, Brown AJ, Bhargava A, Costopoulos C, Hung OY, Corban MT, Hosseini H, Gogas BD, Giddens DP, Samady H (2017) High wall shear stress and high-risk plaque: an emerging concept. J Cardiovasc Imaging 33(7):1089–1099
107. Huang D, Muramatsu T, Li Y, Yang W, Nagahara Y, Chu M, Kitslaar P, Sarai M, Ozaki Y, Chatzizisis YS, Yan F, Reiber JHC, Wu R, Pu J, Tu S (2017) Assessment of endothelial shear stress in patients with mild or intermediate coronary stenoses using coronary computed tomography angiography: comparison with invasive coronary angiography. J Cardiovasc Imaging 33(7):1101–1110
108. Wu X, von Birgelen C, Wijns W, Tu S (2017) Superficial wall stress assessed from 4-D analysis of coronary angiography in vivo. J Cardiovasc Imaging 33(7):1111–1112