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Supplementary Material (online)

Structured reporting of cross-sectional imaging of the heart: Reporting templates for CMR imaging for diagnosis of ischemia and myocardial viability and cardiac CT imaging of coronary heart disease and TAVI planning

Structured reporting in cross-sectional imaging of the heart: Reporting Templates for CMR Imaging for diagnosis of ischemia and myocardial viability and for Cardiac CT Imaging of coronary heart disease and TAVI planning

COMMENTS ON THE REPORTING TEMPLATES

Structured Reporting – Overview

Currently, the majority of radiological reports have been in the form of non-standardized free text. However, the use of structured reporting templates is becoming increasingly important for report generation and communication as well as targeted archive retrieval [1–3]. Content structuring, standardized text modules, and categorized diagnoses with uniformly applied nomenclature increase the efficiency of report generation and enable consistent quality in terms of completeness, clarity, and focus on clinical relevance [4, 5]. This also facilitates cooperation between different institutions, as a clearly defined structure and nomenclature avoids misunderstanding. Already 15 years ago, the RSNA's "Radlex Initiative" laid a foundation regarding the standardization of terms and the use of uniform language in radiological reports. In 2008, the RSNA established a basis for the use of structured reporting templates with the Radiology Reporting Initiative [6]. The RSNA and ESR findings templates are thematically available at no cost on the open platform www.radreport.org in HTML 5/IHE MRRT format [7].

Structured reporting of cardiovascular cross-sectional imaging

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The Society of Cardiovascular Magnetic Resonance (SCMR) published basic recommendations on reporting structure and content for cardiovascular MR imaging as early as 2009 [8]. The CAD-RADS 2.0 (Coronary Artery Disease - Reporting and Data System) system, a consensus recommendation of the Society of Cardiovascular Computed Tomography (SCCT), the American College of Radiology (ACR), and the North American Society for Cardiovascular Imaging (NASCI) with the approval of the American College of Cardiology (ACC), is already an effective, standardized method of CT coronary angiography reporting [9]. Recommendations on the content of cardiac CT reporting were last published by the SCCT in 2014 [10]. With regard to CT for TAVI planning (pre-TAVI CT – transcatheter aortic valve implantation) two new consensus documents were published in 2019: one by the Society of Cardiovascular Computed Tomography (SCCT) and one by the European Society of Cardiovascular Radiology (ESCR) [11, 12]. Further recommendations on TAVI planning were published in the 2017 American College of Cardiology (ACC) guidelines [13]. The number of templates provided on the "www.radreport. org" platform (currently just over 400) is still being developed in with respect to both content and subject matter and is largely only available in English. The board of the DRG's Cardiovascular Diagnostics working group has therefore defined the creation of structured findings as a central project [14]. Technical support for this project is provided by the Information Technology working group of the DRG. The developed templates will be converted to HTML 5/IHE-MRRT-compliant format and made freely available on the DRG homepage at "www.befundung.drg.de". In 2018, members of the Board of Directors and representatives of the working group for Cardiovascular Diagnostics of the DRG agreed on and approved a total of 11 structured reporting templates for various examination protocols and pathologies in the field of cardiac MRI and CT diagnostics at consensus meetings at the University Hospital of Cologne. In total, templates were developed for the following clinical pathologies and examinations: Myocarditis, dilated cardiomyopathy, hypertrophic (obstructive) cardiomyopathy, arrhythmogenic right ventricular cardiomyopathy (ARVC), siderosis, ischemia and vitality diagnostics, tetralogy of Fallot, aortic isthmus stenosis, coronary CT and CT for TAVI planning.

Reporting templates for cardiac MRI for ischemia and vital signs diagnostics.

Structuring and general finding contents

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The cardiac MRI reporting templates presented in this publication are a continuation of those already published in 2020 for cardiomyopathies including secondary forms of myocardial dysfunction due to cardiac siderosis and myocarditis [15].
As already published, clinical information on the patient, the justifying indication and issue derived from this, as well as the date and time of the examination should always precede the findings [8]. Each of the reporting templates is divided into the sections Technique, Baseline Patient Profile, the relevant report sections Morphology, Functional Analysis, Tissue Characterization and extracardiac findings as well as Summary Assessment. In addition to the field strength and the listing of the acquired sequences in the corresponding orientations, the technique section should also include the evaluation software used, in the case of functional evaluation the source of the standard values used as a basis, in the case of perfusion examinations the amount and type of stressor used and the amount and type of contrast medium used. The latter should also be indicated for the study of late myocardial contrast uptake (LGE).

The reporting templates always distinguish between a “general” part and a “specific” part. The contents of the templates were based on the recommendations of the SCMR [16], current clinical practice, the present state of scientific knowledge [17] as well as internationally published diagnostic standards. The terminology reflects that used by RadLex in its current German-language version (www.radlex.org).

Specific Report Contents

Perfusion Imaging

The 2019 update of the European guideline on chronic coronary syndrome (CCS) calls for a reconsideration of the diagnosis and treatment of patients with angina pectoris and suspected CHD [18]. The European Society of Cardiology (ESC) and the European Atherosclerosis Society (EAS) now recommend primary noninvasive imaging in patients with low intermediate probability of CCS [19]. These include CT coronary angiography, stress echocardiography, myocardial scintigraphy (SPECT), and positron emission tomography (PET), as well as cardiac magnetic resonance imaging (CMR) under stress. Functional imaging such as CMR is preferred in patients with a slightly higher likelihood of CCS when revascularization is likely or CHD has been previously diagnosed.

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The proposed template includes the left ventricular function parameters with the reference values for women/men < 35 years and > 35 years, respectively, according to [20, 21] and the reference values for children 0–18 years, girls/boys according to [22].

In addition to functional parameters, appropriate regional and/or global wall motion abnormalities (hyperkinesia, hypokinesia, akinesia, dyskinesia) should be documented in the findings. Further attention should be paid to intra- and interventricular dyssynchrony [23]. CMR may facilitate the selection of patients with dyssynchrony who will benefit from cardiac resynchronization.

Consideration of left and right atrial size is currently gaining importance in studies [24]. Clinically, the area-length method is mostly used, but it is based on a geometric assumption and has lower reproducibility than determination of volume. In recent years, semiautomated feature tracking has gained prominence but is not yet used as a clinical standard [23].

Perfusion defects are detectable at the earliest when the contrast bolus floods into the left ventricular myocardium, persist during the peak of myocardial contrast uptake over 3–4 RR intervals, and must extend more than two pixels [16]. In addition to stress perfusion, resting perfusion can also be performed as a supplement. This can be helpful to detect perfusion abnormalities already existing at rest and to better discriminate possible artifacts.

The most common and relevant artifact in cardiac MR perfusion imaging is the “dark rim” or “dark band” artifact, as it can be misinterpreted as a hypoperfused area [25]. This artifact is caused by the high contrast agent concentration in the blood pool during first pass. The most common location is septal and subendocardial at the border between the contrasted cavum and myocardium. It occurs predominantly in the phase-encoding direction and is found increasingly at higher field strengths. It can be minimized by using higher spatial resolution and reducing acquisition time.

When using adenosine as a stress medication, attention should be paid to the “splenic switch-off” phenomenon, which is specific for this purpose. Here, the signal from the spleen on the three slices of myocardial perfusion studies is significantly lower than the signal from the myocardium. If the signal is visually comparable to that of the myocardium, insufficient dosage of the stress drug must be assumed, which can lead to false negative results of the stress perfusion test. This phenomenon does not occur when using the stress medication regadenoson [26].

Purely visual analysis may be difficult in balanced 3-vessel CHD as well as circular microvascular dysfunction (such as in diabetes or systemic hypertension) and may lead to misinterpretation. Automated inline perfusion maps implemented in recent years allow determination of myocardial blood flow (MBF) in ml/g/min) on-the-fly. This method is not yet a standard, but initial studies show high diagnostic accuracy [27, 28]. Mapping may help to corroborate the visual result or identify balanced ischemia, if applicable. However, clinical studies with higher patient numbers and comparison with nuclear medicine procedures are still pending.

Patients with chronic coronary syndrome (CCS) are at high risk for a cardiac event if at least two of 16 segments have a perfusion abnormality on stress testing [18]. Scar tissue does not necessarily lead to a perfusion abnormality. This is especially true when resting perfusion is performed after stress perfusion. Therefore, reliable detection of scar tissue should be performed with LGE imaging. If a perfusion abnormality extends beyond the LGE area, this must be explicitly mentioned in the report, indicating the affected segments.

Vitality Imaging

Vitality imaging with late gadolinium enhancement is the current reference standard. Here, MRI has high sensitivity with limited specificity with respect to predicting recovery from myocardial dysfunction. In the early phase after STEMI, according to current recommendations, cardiac MRI can be performed, if necessary, for risk stratification with the issue of infarct extent, microvascular obstruction, and “myocardial salvage” after reperfusion therapy [29].

Regional myocardial edema can be detected using T2-weighted sequences. Higher accuracy can be achieved using T2 mapping (T2-prepared SSFP sequence). Overall, the increase in T2 signal in edema is small (15–20ms), which implies proper acquisition and good image quality. Both procedures are used to detect area-at-risk and possible concomitant myocardial hemorrhage [23]. Early gadolinium enhancement (EGE) is another way to differentiate edematous myocardium. It is acquired approximately 0–2 minutes after contrast injection with the same sequence as late gadolinium

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enhancement (LGE). LGE alone cannot distinguish acute (necrosis) and chronic infarction (scar). In the case of LGE, the localization with indication of the segment as well as the distribution pattern must be documented in the findings. Five categories of ischemic-related LGE are visually distinguished: no enhancement, 1–25%, 26–50%, 51–75%, and 76–100% transmural enhancement. Our template provides a simplified distinction between < 50% and > 50% transmurality. The importance of specifying the extent of LGE is based on studies showing that the success rate of revascularization therapy correlates with the extent of LGE [30]. Furthermore, the high value of LGE imaging in the preparation of CRT implantation regarding clinical outcome was demonstrated [31]. In addition to indication of transmurality, the infarct size in terms of the number of affected AHA segments should also be documented in the findings. Infarcts with > 6 segments of LGE evidence are designated as large. If necessary, the involvement of the right ventricle and the papillary muscles should also be listed in the report. The latter can lead to mitral valve insufficiency. These patients have a significantly higher mortality and MACE rate [23].

Microvascular obstruction refers to an avital region in the center of the infarct that has such capillary damage that no contrast agent can reach it 1 to 2 minutes after contrast administration. The phenomenon is observed in infarcts of large and transmural extent within the first 7–10 days, and the functional impairment in this area is permanent and thus associated with a worse prognosis [32].

Acute infarcts may have hypointense zones in the area-at-risk in the T2-weighted spin echo sequences, often corresponding to intramyocardial hemorrhage. Because these are sometimes difficult to differentiate from a microvascular obstructive zone, more specific T2*-weighted GRE sequences or native T1 mapping have also been proposed for detection [23].

In the authors' point of view, T1 and T2 relaxation times of the myocardium as well as the derived ECV (extracellular volume) in the findings determined from mapping techniques are currently only optional. Essential here is the use of reference values from one's own representative control cohort for the respective locally-used scanner and sequence type [33].

Reporting Template for CT Coronary Angiography

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The content of the presented reporting template is based on the recommendations of the SCCT [10], the ACR [9, 34, 35], the North American Society for Cardiovascular Imaging (NASCI) [9, 35], the German Society of Radiology (DRG), and the German Society of Cardiology (DGK) [36], the current state of science [9, 37–43], and the clinical recommendations of the European Society of Cardiology and the American Heart Association (AHA) [35, 44, 45, 46].

The reporting template includes native CT scan for determination of calcium load (calcium scoring) and CT coronary angiography (CCTA). The terminology reflects that used by RadLex in its current German-language version (www.radlex.org).

The report template is divided into the sections Technique, Baseline Patient Profile, Image Quality, Calcium Scoring, Coronary Artery Findings, Extracoronary Cardiovascular Findings, Other Findings, and Assessment, which we explain below.

The Technique section should record the amount, injection rate, and type of contrast agent used, as well as any necessary premedication (ß-blocker and nitro spray). In addition to the dose-length product (if not already integrated in the dose report), the acquisition technique can be documented in the report, e.g., retrospectively ECG-synchronized, prospectively ECG-triggered using sequential CTA "step and shoot" technique), or, in the case of dual-source devices, using high-pitch technique [37, 38]. In addition, the type and extent of ECG-gated tube current adaptation can be documented in the findings, e.g., ECG-gated tube current modulation ("pulsing") for retrospective techniques and the acquisition window of the ECG cycle ("padding") for prospective scans. Reconstruction techniques/post-processing follow, e.g. MPR (Multiplanar Reformations), CPR (Curved Planar Reconstructions), VRT (Volume Rendering Technique). Baseline Patient Profile (including presence of a pacemaker/ICD, heart rate (beats/min), or arrhythmia) can be added if not already documented in the Radiology Information System (RIS). Limitation of image quality should be documented (limitation: yes/no) and the causative artifacts mentioned, e.g., non-compliance with breath-hold command, arrhythmia and/or tachycardia, reduced contrast of coronary vessels [10].

Native CT is often performed prior to CCTA to determine the calcium load (calcium scoring). The SCCT (Society of Cardiovascular Computed Tomography) recommends reporting the total Agatston score (for all coronary vessels combined) for calcium load determination. The total Agatston score is determined automatically or semiautomatically by assigning all calcium foci in the coronary vessels detected by the

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computer (by definition above 130 HU and ≥ 1 mm²) to the respective vascular territory by the assessing physician [39]. In addition, a classification of the Agatston score against the age- and sex-specific normal population is recommended (see Assessment section), which is often directly output by the evaluation software (Figure 1) [40, 41, 42].

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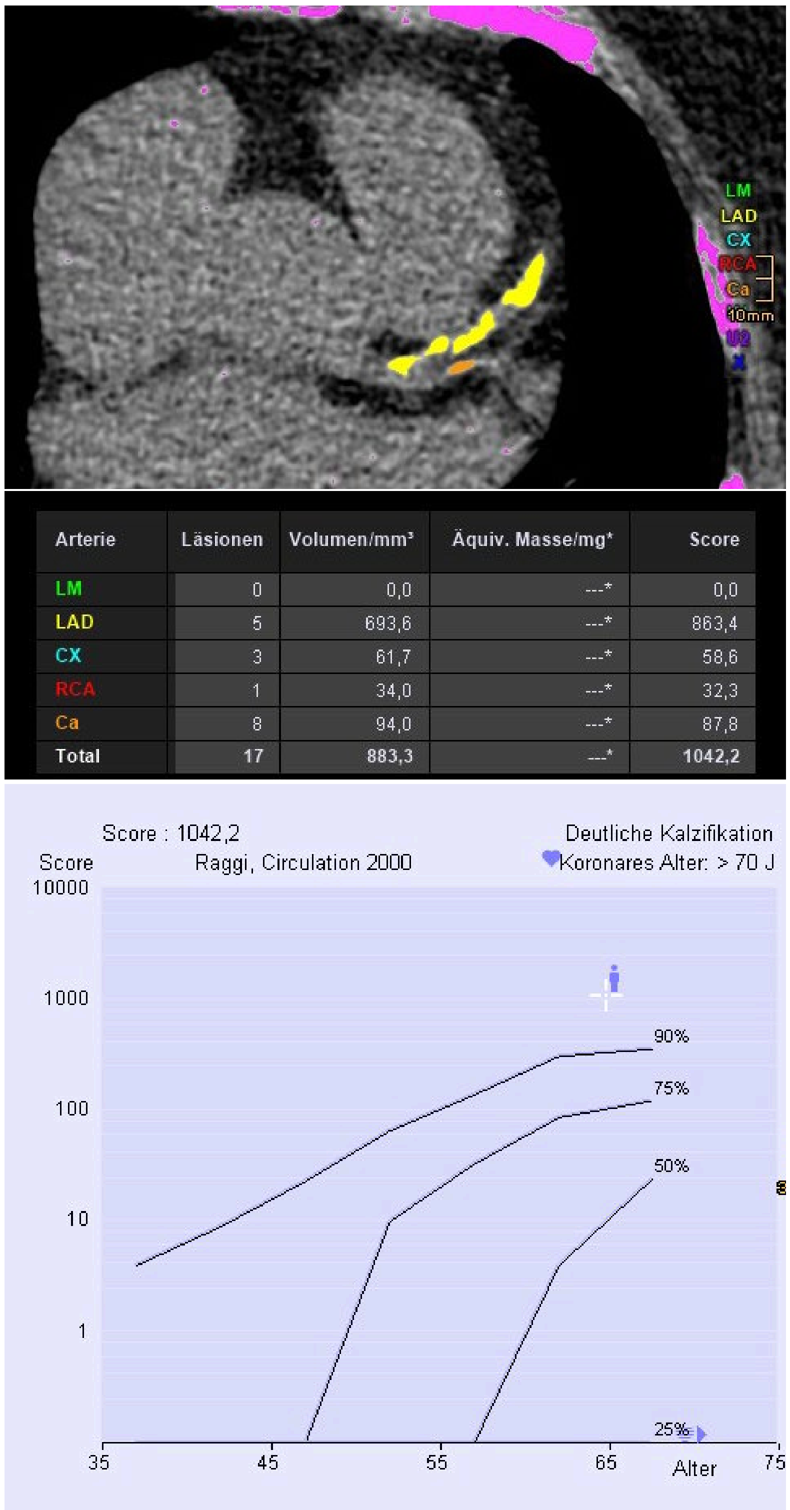

Arterie	Läsionen	Volumen/mm³	Äquiv. Masse/mg*	Score
LM	0	0,0	---*	0,0
LAD	5	693,6	---*	863,4
CX	3	61,7	---*	58,6
RCA	1	34,0	---*	32,3
Ca	8	94,0	---*	87,8
Total	17	883,3	---*	1042,2

Figure 1
ECG-triggered native cardiac scan to determine calcium score in a 64-year-old female patient. The calcifications of the RIVA (=LAD) are marked here in yellow. The total calculated Agatston score is 1042. This is well above the 90th percentile compared to the age- and sex-matched normal population.

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The CCTA findings begin with the anatomy (outflow and course of the coronary vessels). Any form of malignant coronary anomaly – e.g., interarterial course between aortic root and RVOT – as well as relevant benign normal variants should be designated. This is followed by the supply type: in the right-supply type, which is the most common, both the ramus interventricularis posterior and the ramus posterolateralis (then dexter) arise from the right coronary artery. In the left-supply type, both vessels mentioned are branches of the ramus circumflexus (RCX, left circumflex artery: LCX) of the left coronary artery (Figure 2). If the left ventricular inferior heart wall is supplied equally by RCA and LCX, there is an indifference type (co-dominance of LCA and RCA) [43].

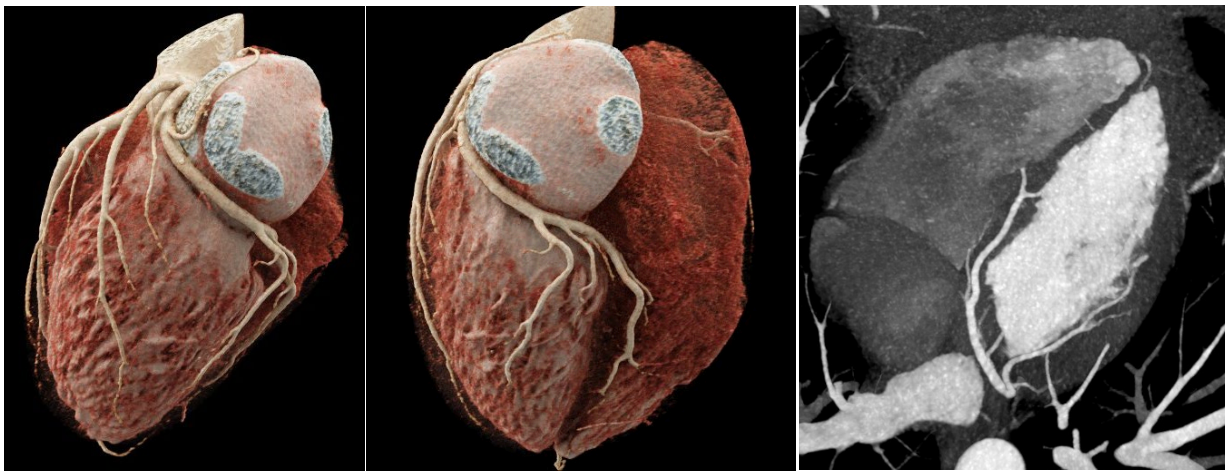

Figure 2
Typical left-sided type with a powerful LCx from which the ramus interventricularis posterior (RIVP) and ramus posterolateralis (PL) arise. In contrast, narrow RCA.

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Coronary plaques are systematically diagnosed along the supply area of the 4 main trunk vessels: RCA (right coronary artery), LCA (left coronary artery = left main trunk), RIVA (ramus interventricularis anterior), LCX (left circumflex artery) and any existing ramus intermedius.

To classify the degree of stenosis, we recommend the SCCT Grading Scale for Stenosis Severity, which is based on the narrowing of the luminal diameter: none/minimal (1–24%), slight (25–49%), moderate (50–69%) , high grade (70%–99%), vessel occluded (Figure 3).

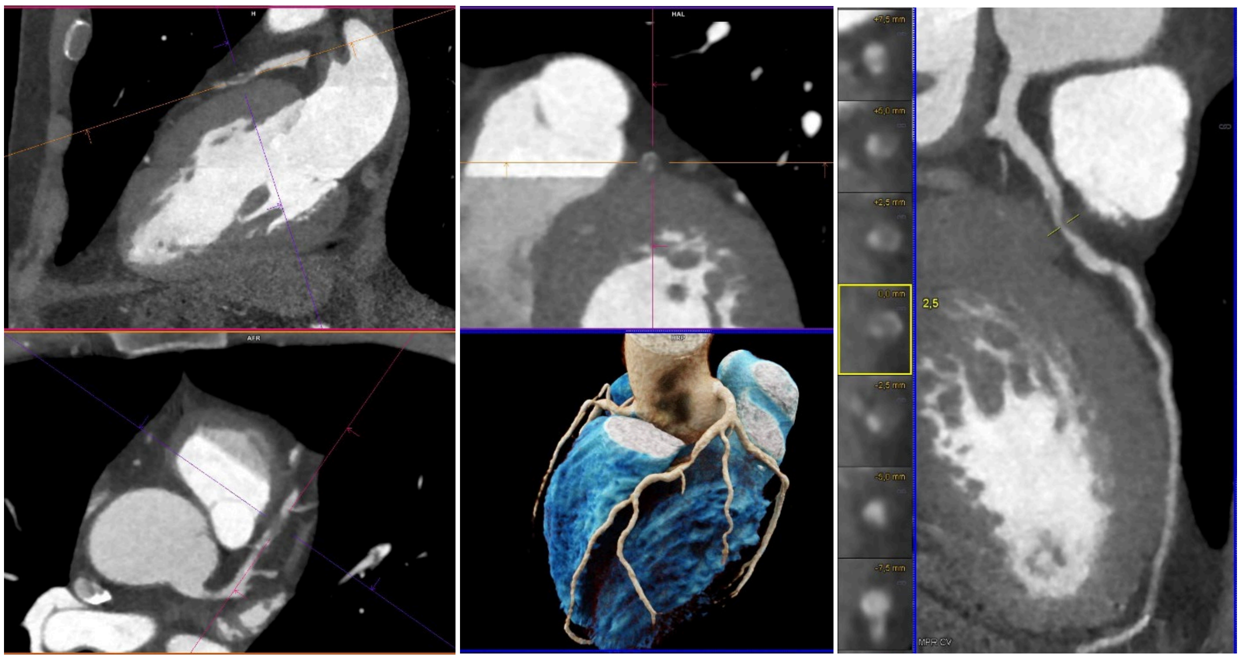

Figure 3
High-grade stenosis (> 70%) of the middle RIVA (segment 7) with mixed plaque. This can already be clearly identified as such visually without measurement and is highly likely to be relevant. The patient underwent cardiac catheterization the same day, which confirmed the hemodynamic relevance of the stenosis (FFR < 0.6). A stent was successfully inserted.

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The maximum degree of stenosis of all coronary vessels, localization of at least intermediate-grade stenoses in the left main trunk, and the number of high-grade stenoses are the key findings that determine the classification in the CAD-RADS 2.0 criteria (Coronary Artery Disease - Reporting and Data System) and thus guide the necessary follow-up examinations (e.g., functional imaging or cardiac catheterization). For the relevant stenoses it is useful to indicate the plaque composition as calcified, non-calcified or mixed. The presence of a stent and its patency – if evaluable – should also be documented. Supplementary information, which can be included in comments, is the length of the stenosis, the coronary segment (e.g., according to the 15-segment model of the AHA [44]), possibly other stenoses of lesser degree, and CT morphological vulnerability criteria of a coronary plaque (low-density plaque (< 30HU), positive remodeling, spotty calcification, and "napkin ring" sign) [9]. In the case of bypass, the type and anatomical location should be described. The next section lists abnormalities in extracoronary cardiovascular anatomic structures such as cardiac veins and sinus coronarius, atria, ventricles, heart valves, pulmonary arteries (PA), aorta, pulmonary veins, and pericardium. "Other Abnormalities" include extracardiac findings, e.g., in the mediastinum, lungs, pleura and chest wall.

The assessment should include the most important information, which is whether CAD exists, what the maximum degree of stenosis is throughout the coronary vasculature, and where it is located. Consequently, the corresponding CAD-RADS category can be documented in the findings [9]. In case of a potentially hemodynamically relevant stenosis (at least moderate, > 50%), the corresponding vessel and, if applicable, the coronary segment should be mentioned [44]. The second important point is the total Agatston score for all coronary vessels and the classification against age- and sex-specific percentiles as risk markers [10].

An additional free text space is given to cover possible findings or special cases not covered by the proposed structured categories (e.g., transplanted heart, tumor findings). If a coronary anomaly exists, it should be included in the evaluation and assessed for potential malignancy.

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Reporting Template for CT TAVI Planning

The content of the reporting template is based on the current consensus recommendations of the SCCT [11] and the ESCR of 2019 [12] as well as the consensus document of the ACC for TAVI of 2017 [13]. The terminology reflects that used by RadLex in its current German-language version (www.radlex.org). The report template includes the sections Technique, Baseline Patient Profile, Image Quality, Aortic Root with measurement of the annulus, Arterial Access Routes, Other Findings, and Assessment, which we discuss below.

The Technique section should record the amount, injection rate, and type of contrast agent used. Beta-blockers and nitrospray are usually contraindicated in severe aortic valve stenosis [11].

As with CCTA, acquisition technique plays an important role. The core of the study is ECG-synchronized CT angiography to obtain an artifact-free anatomic view of the aortic root (ideally in systole), followed by CTA, usually non-ECG-synchronized, of the remaining aorta and iliofemoral access routes [11, 12]. Any ECG-gated tube current modulation (pulsing) used in CT angiography of the aortic root should be mentioned in this context, because subsequent reconstructions of the aortic root at time points outside the pulsing window (e.g., diastolic) will show increased image noise. In some hospitals, an additional ECG-synchronized native scan of the aortic valve is performed beforehand. This is usually performed with the same technical parameters as the coronary vessel calcium scoring scan to allow subsequent quantification of aortic valve calcium by Agatston score [12]. The native scan can be used for planning/demarcation of the examination section of the aortic root on the one hand and for determining the calcium load of the aortic valve on the other hand, which correlates well with the degree of aortic valve stenosis [11]. The calcium load can be quantified visually (no / low / pronounced) or by Agatston score (Figure 4).

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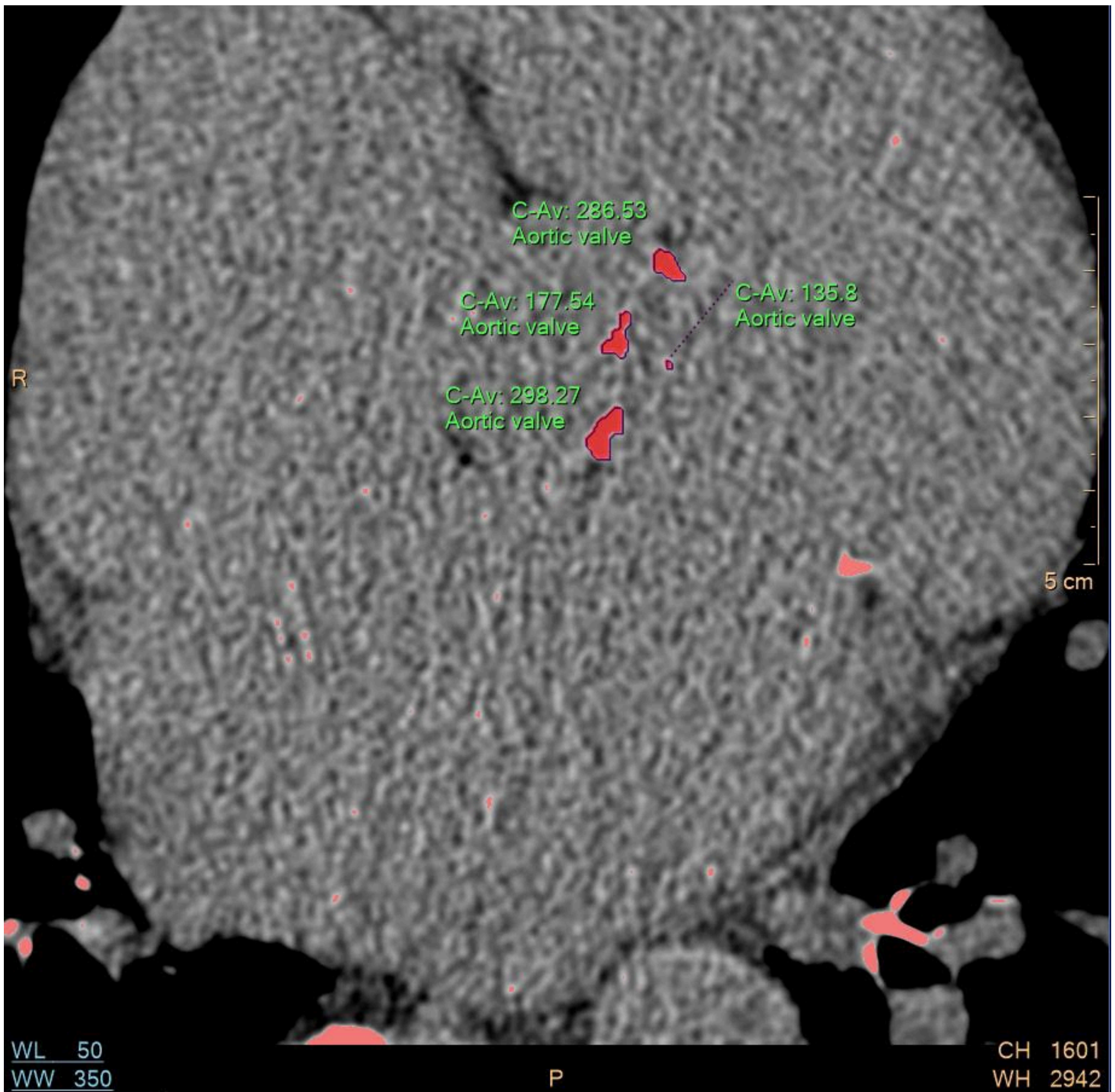

	Scoring Results : Agatston Score Protocol
	Aortic valve
Score	2135.02
#ROI's	274
AreaSq (sq.mm.)	3401.15
Volume (cu.mm.)	1700.57

Figure 4:
ECG-synchronized native scan of the aortic valve using low-dose CT technique in an 82-year-old male patient with higher-grade ACS and high-grade mitral and tricuspid regurgitation to elicit calcium load before TAVI.

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The acquisition technique is followed by post-processing. The ECG-synchronized CTA dataset of the aortic root is usually reconstructed as an axial thin-slice (< 1 mm slice thickness) multiphase sequence, often called “cine” or “functional 4D CT”. The multiphase sequence can be performed in a reconstruction interval of 10% steps (relative approach) or in 50 ms steps (absolute approach), which is advantageous in arrhythmia [11]. Non-ECG synchronized CTA of the aorta and iliofemoral access pathways is usually reconstructed axially thin (< 1.5 mm) in the large field of view (FOV) [11, 12]. The data sets can optionally be reconstructed additionally as MPR (Multiplanar Reformations), CPR (Curved Planar Reconstructions) or VRT (Volume Rendering Technique).

Limitation of image quality should be documented (limitation: yes/no) and the causative artifacts mentioned.. The most important quality criterion is the artifact-free contour of the aortic annulus [11, 12, 13].

The first central section of the findings is the measurement of the aortic root. According to most manufacturer's instructions, the annulus should be measured during the phase of the ECG cycle when it is greatest. This is usually the case in maximal systole (exception e.g. HOCM) [11, 12]. The annulus is defined as the intraluminal contour within the LVOT, which lies in a virtual plane through which pass all 3 farthest basal attachment points of the 3 sac valves (basal hinge points, see Figure 5) [11].

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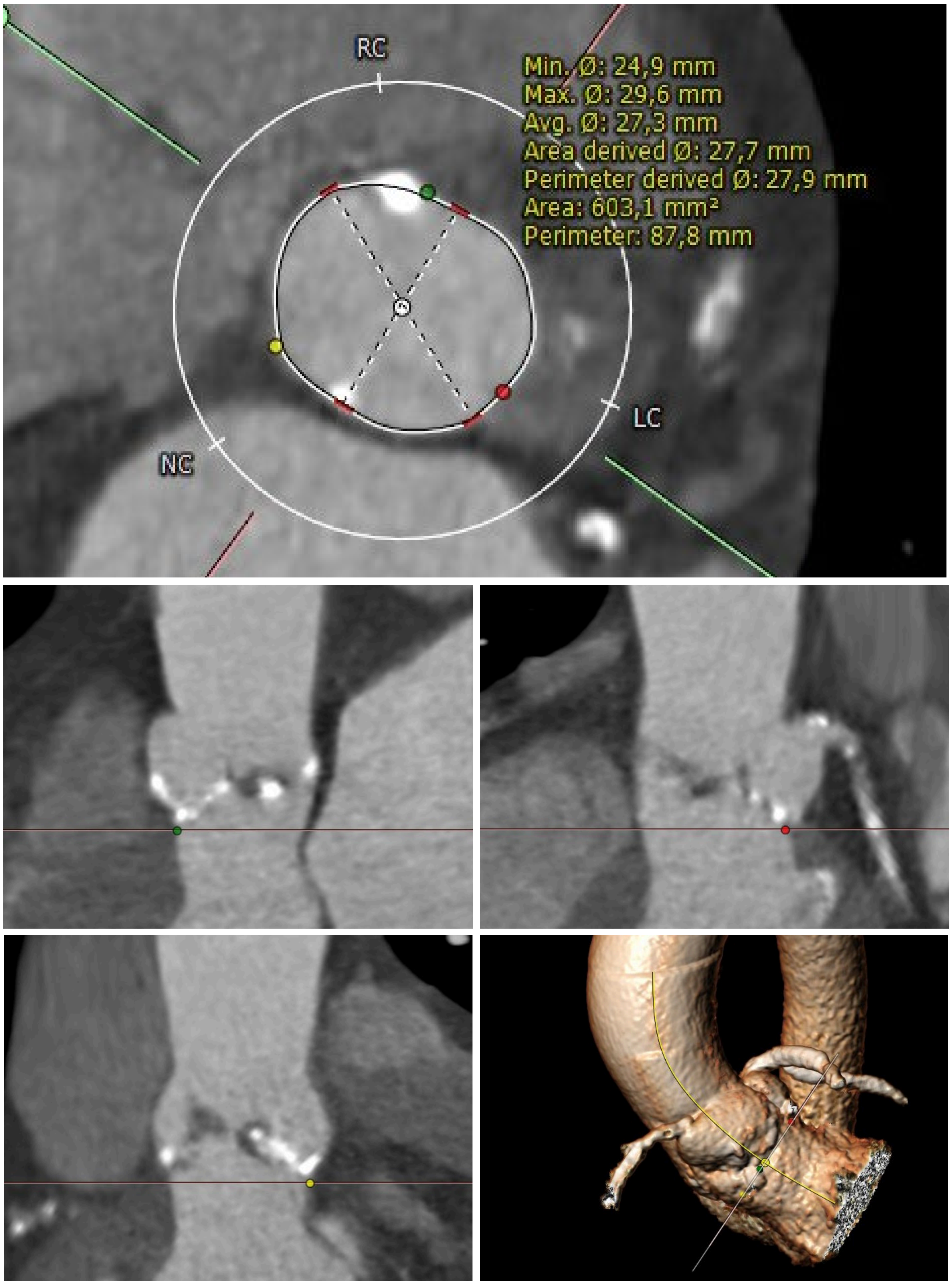

Figure 5
Metrics of the aortic valve annulus formed per by the anchor points of the valve base.

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Here, calcifications of the LVOT are partially counted as part of the lumen. This is done practically by interpolating the annulus circumference in the area of the calcification based on the annulus edges adjacent to the calcification, so that a harmonic circumference is planimetrized (as an example, see Figure 5, first image: right coronary annulus calcification). The planimetric area of the annulus, the perimeter, the effective diameters from these two quantities, and optionally the minimum and maximum diameters of the annulus, which allow a conclusion to be drawn about the eccentricity of the annulus, are measured and documented [11, 12]. This is followed by the diameters of the sinus valsalvae at the level of their maximal extension (always sac to commissure measured parallel to the annulus, all three values or minimal and maximal value, see Figure 6), the minimum and maximum diameters of the sinotubular junction (Figure 7), and the distances of the coronary arteries and sinotubular junction orthograde to the annulus (Figure 8).

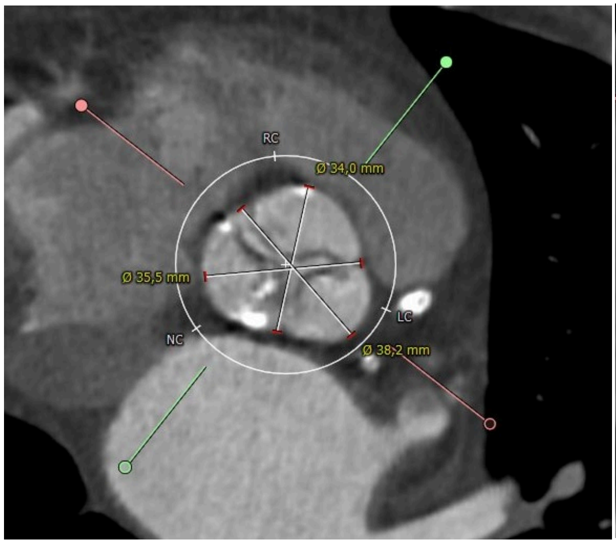

Figure 6
Sinus valsalvae as the maximum width of the aortic root, each from sac to commissure.

Figure 7
Diameter of the sinotubular junction between the aortic root and the ascending aorta

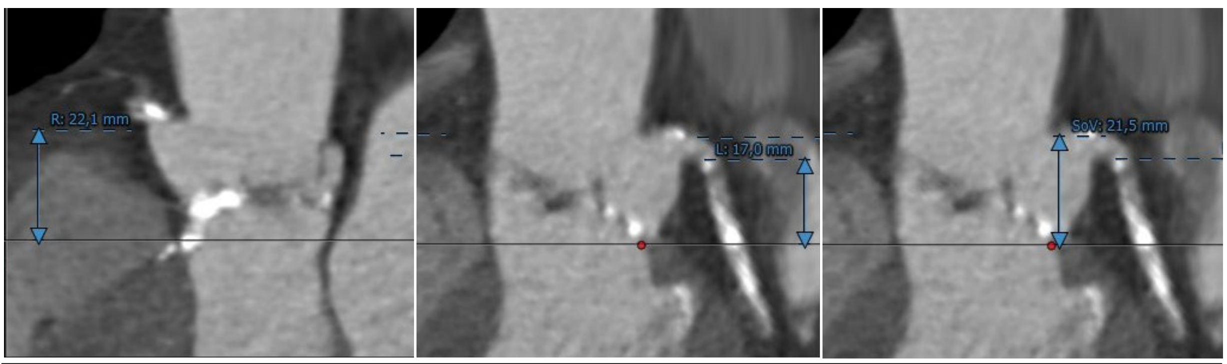

Figure 8
Distance of the right coronary ostium, the left coronary ostium and the sinotubular transition (between the aortic root and the ascending aorta) to the annulus plane.

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Small valsalva sinuses (< 30 mm) associated with a small distance of one of the coronary vessels (< 12 mm) represent a risk factor for coronary artery occlusion [11]. The diameter and height of the sinotubular junction are important to identify anatomical constellations in which the planned TAVI prosthesis could potentially come into contact with the sinotubular junction. Especially when balloon-expandable prostheses are used with low sinus heights, the minimum diameter of the sinotubular junction should be compared with the planned prosthesis diameter in order to anticipate an increased risk of injury to the sinotubular junction with larger prosthesis diameters [11]. Optionally, a favorable C-arm angulation (cranio-caudal and RAO/LAO) can also be set for a coplanar view of the annulus (parallel to the annulus plane) (Figure 9). This is usually directed orthograde in the center of the right coronary sac or the right coronary artery [13].

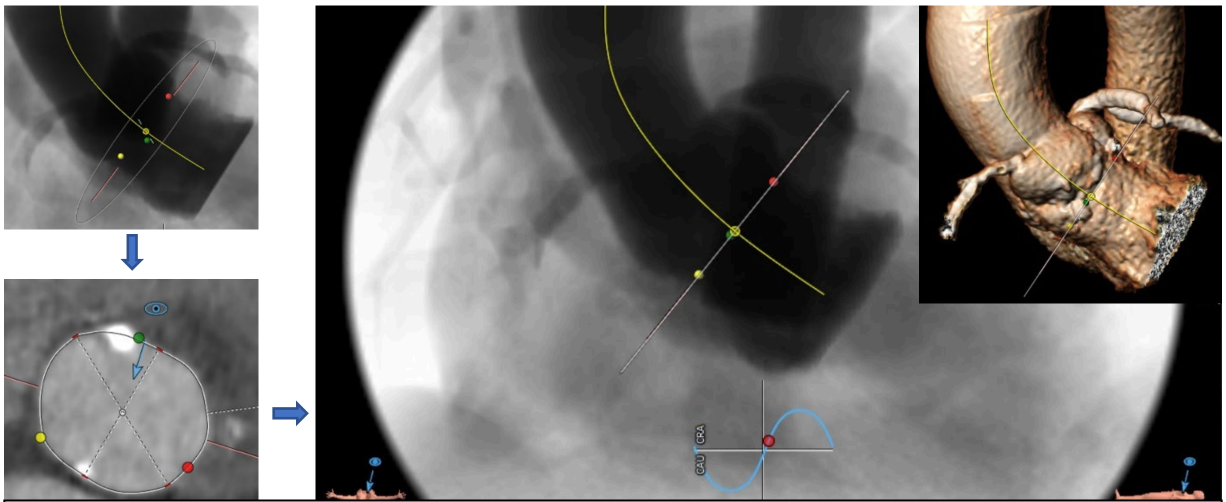

Figure 9
Angulation for a coplanar view of the annulus. The anchor points of the base of the 3 aortic sacs form the annulus plane, which are marked as three dots in red, yellow and green. The fluoroscopic image on the upper left shows a view obliquely onto the annulus plane. Appropriate angulation should be used to achieve a coplanar view of the annulus.
After appropriate angulation, the blue eye marks the view of the center of the right coronal sac coplanar to the annulus plane. The virtual fluoroscopy image on the right simulates the desired coplanar view of the annulus during intervention with LAO 14°/cranial 12° C-arm angulation (bottom left and right of image).

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In addition to the above measurements, morphologic aspects and calcifications are relevant for TAVI planning. Due to the high prevalence of extensive calcification in this patient population, the coronary vessels cannot be reliably evaluated for stenoses on CT [13]. However, the following parameters should be mentioned briefly: Presence of coronary anomaly (no / yes) and relevant calcifications near the ostium (no / yes) [13]. We also recommend that large calcium spurs be specified in the LVOT. This can be done qualitatively visually: Calcification spur LVOT: no / low / moderate / pronounced below left / right / non-coronary sac (Figure 10).

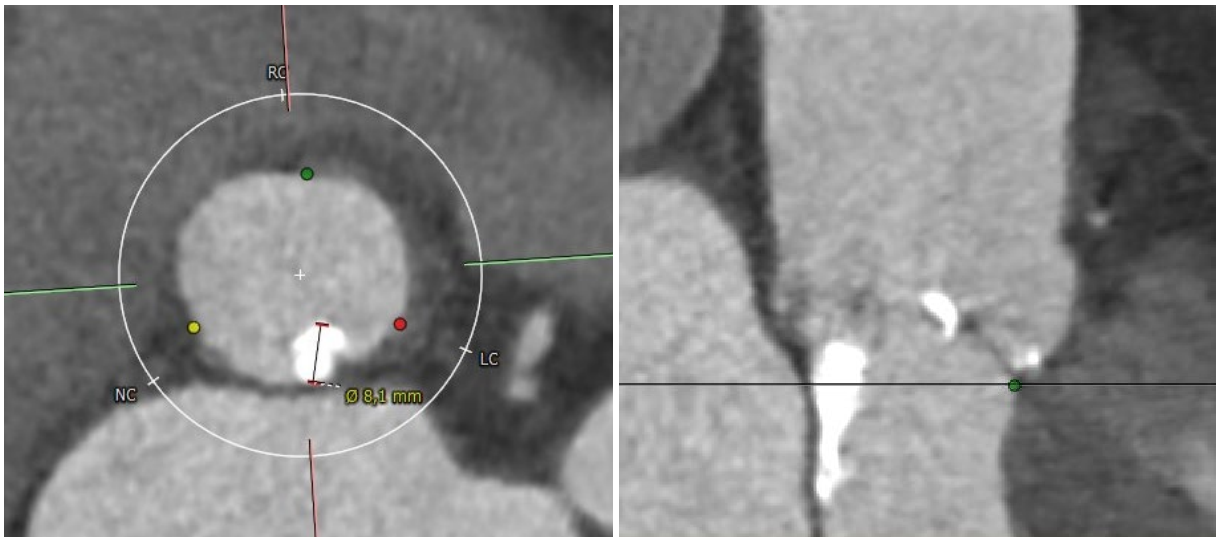

Figure 10
A prominent calcification spur increases the potential risk of annulus injury during intervention. Therefore, self-expandable prostheses rather than balloon-expandable prostheses are used in these cases.

The assessment of severity is based on the length extension caudally into the LVOT, circumference of calcification, and thickness of the calcifying spur/how far it protrudes into the lumen [11]. Pronounced calcification spurs, especially in the landing zone at the annulus and 4–5 mm caudal to the annulus in the LVOT, increase the risk of paravalvular regurgitation and, in balloon-expandable prostheses, the risk of annulus rupture [11]. Thus, they may also lead to the decision to eventually choose a self-expandable prosthesis [13]. A commissural calcification, on the other hand, does not carry the risk of annulus injury to the same extent as in LVOT. In this case, balloon-expandable prostheses are often used to better expand the stenosed valve (Figure 11) [13].

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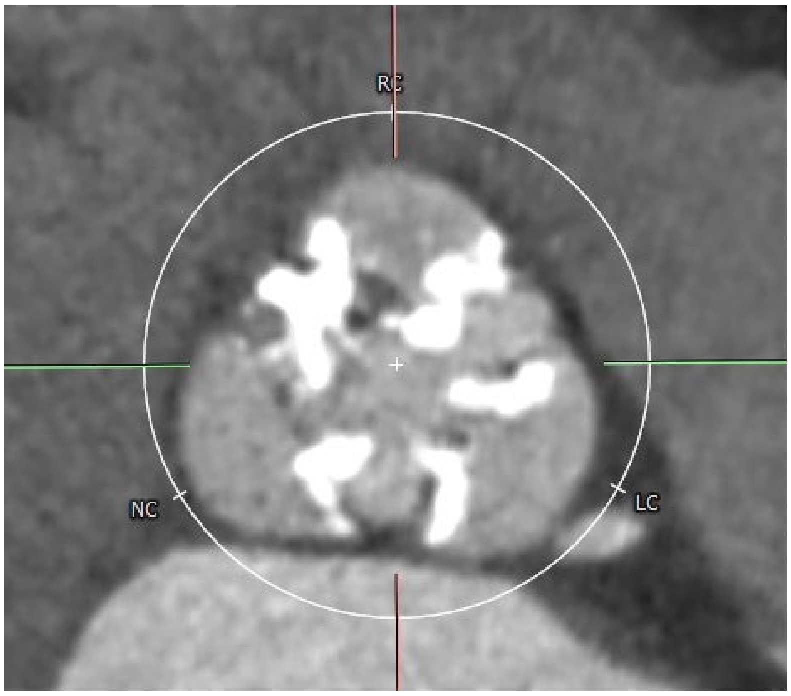

Figure 11
Pronounced valve calculus along the commisures. Functional (acquired) bicuspid valve with partial fusion of the right coronary (RC) and non-coronary (NC) sacs at the commissure. A commissural calcification, on the other hand, does not carry the risk of annulus injury to the same extent as in LVOT (prior example Figure 9).. In the case of pronounced calcifications and adhesions, balloon-expandable prostheses are often used here in order to be able to better expand the stenosed valve.

It is also recommended to indicate the cuspidity of the aortic valve (bicuspid / tricuspid), as this is associated with lower prosthesis success rates, more pacemaker implantations and higher rates of paravalvular regurgitation [11, 12] (see also Figure 11).

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The second central section of the reporting template includes the iliofemoral access routes. The minimum vessel diameters of the A. iliaca communis (AIC), the A. iliaca externa (AIE) and the A. femoralis communis (AFC) should be determined on both the left and right and the smallest of the 3 measured vessel diameters should be noted in the report. If the AFC has a very small diameter (<5.5 mm for most sheaths used today [12]), a high puncture may be performed above the constriction in the AIE. In these cases, the minimum diameter of AIE and AIC must be specified. In addition to the minimal diameter, pronounced calcifications (> 270° vessel circumference) should also be documented in the findings, especially if there is also pronounced kinking. All 3 factors can determine the option of a transfemoral approach (Figure 12) [13]. For the puncture, anterior calcifications of the AFC and a high bifurcation of the AFC should be mentioned.

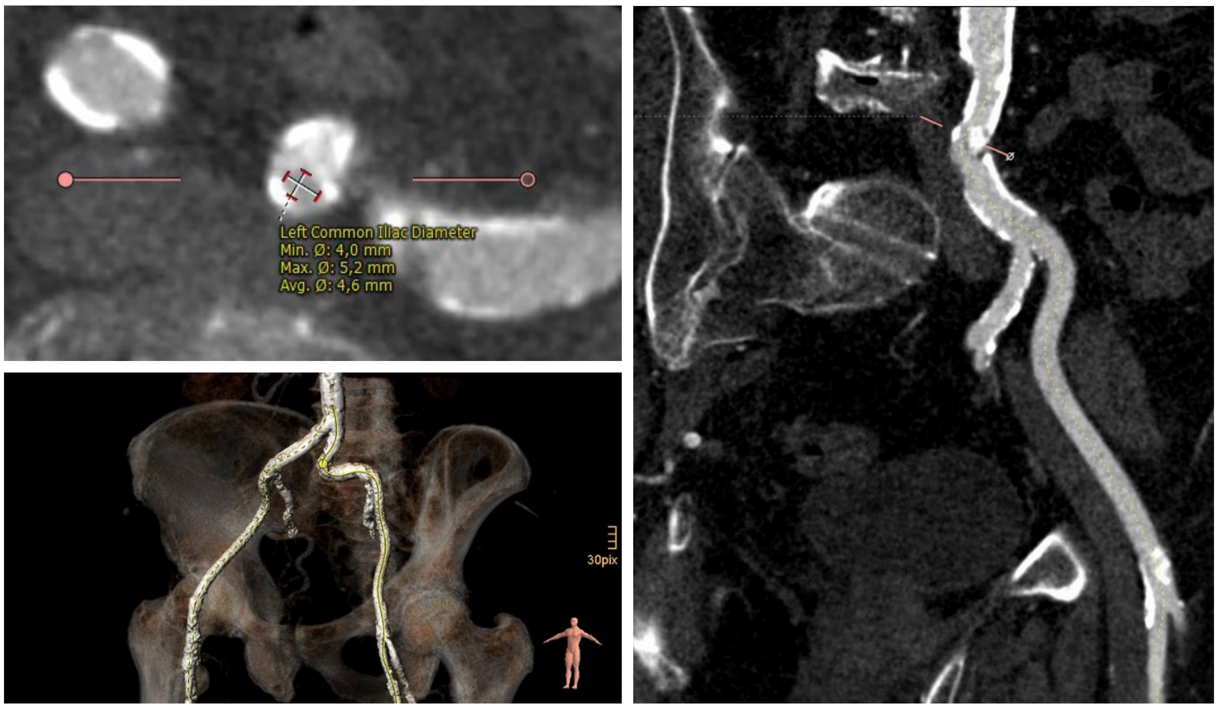

Figure 12
Left-sided iliofemoral access route with relevant constriction iliaca communis up to a minimum of 4 mm vessel diameter with pronounced calcified plaques, which occupy at least 270° of the vessel circumference. Simultaneously pronounced kinking of the A. iliaca communis at this point. Left femoral access would not be recommended here. Measurement of the peripheral arterial vascular axis.

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In the aorta, pronounced plaques protruding into the lumen and wall thrombi should be documented in the findings. In addition, attention should be paid to calcifications of the ascending aorta. Pronounced calcifications of the ascending aorta can significantly complicate surgical valve replacement as an alternative procedure and thus strengthen the indication for TAVI. If a transfemoral approach is not possible, a transapical approach (via the apex of the heart) or an approach via the subclavian artery are possible alternatives [13]. Stenoses or normal variants of the supraaortic vessels as well as intracardiac thrombi or pronounced calcifications at the apex of the heart should therefore also be mentioned. Incidental findings in the thorax and abdomen can be listed under "Other abnormalities".

In the assessment, the measured values of the annulus (effective diameter according to perimeter, area and min./max. diameter) are listed first, or reference is made to the measured values in the report (e.g. "The measured values mentioned in the report result before planned interventional aortic valve replacement"). We also recommend briefly naming anatomical or pathological variants of the aortic root (e.g. "pronounced calcareous spur below the left coronary sac" or "very short distance from the ostium of the LCA to the annulus"). The second point is the access routes. Information can be given about the possibility of an access route on both sides (e.g. "In the case of a transfemoral procedure, access would be possible from both sides" / "Transfemoral access does not appear to be possible using a 14 F sheath.") or the preferred procedure for a specific side can be suggested (e.g. "In the case of a transfemoral procedure, access via the right/left side would be preferable."). Obstructions in the access pathway, such as large plaques or thrombi, should also be mentioned. Other relevant findings, such as malignancies, pulmonary fibrosis, emphysema, or aortic dissection, should also be listed, especially if they significantly limit life expectancy. Extracardiac findings are also crucial when discussing the indication, feasibility, and further procedure in the interdisciplinary TAVI board.

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Summary and Outlook

The interdisciplinary report templates developed in cooperation with clinical colleagues from cardiac surgery, cardiology, pediatric cardiology and radiology are to be understood as a suggestion of the DRG's Cardiovascular Diagnostics working group; there is therefore no claim to binding or general validity. Other jointly developed structured findings templates will be presented in subsequent publications. The reporting templates presented in this publication have been converted to HTML 5/IHE-MRI-compliant format by AGIT and can be downloaded free of charge from the page “www.befundung.drg.de” (corresponding rights of use are described in [47]). Critical feedback is explicitly desired and is welcome via the e-mail address “strukturierte-befundung@drg.de” or via “https://github.com/DRGagit/ak_befundung/”. In addition to feedback, new scientific evidence and updated guidelines are to be included by the working group at regular intervals and incorporated by consensus into the findings templates on the DRG homepage “www.befundung.drg.de”.

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References

[1] Schwartz LH, Panicek DM, Berk AR et al. Improving communication of diagnostic radiology findings through structured reporting. Radiology 2011; 260: 174–181

[2] Bosmans JM, Weyler JJ, De Schepper AM et al.The radiology report as seen by radiologists and referring clinicians: results of the COVER and ROVER surveys. Radiology 2011; 25+9: 184–195

[3] Franconeri A, Fang J, Carney B et al. Structured vs narrative reporting of pelvic MRI for fibroids: clarity and impact on treatment planning. Eur Radiol 2018; 28: 3009–3017

[4] European Society of Radiology (ESR). ESR paper on structured reporting in radiology. Insights Imaging 2018; 9: 1–7

[5] Douglas PS, Hendel RC, Cummings JE et al. ACCF/ACR/AHA/ASE/ASNC/HRS/NASCI/RSNA/SAIP/SCAI/SCCT/SCMR 2008 Health Policy Statement on Structured Reporting in Cardiovascular Imaging. J Am Coll Cardiol 2009; 53: 76–90

[6] Morgan TA, Helibrun ME, Kahn CE. Reporting Initiative of the Radiological Society of North America: Progress and New Directions. Radiology 2014; 273: 642–645

[7] IHE Radiology Technical Committee. IHE Radiology Technical Framework Supplement – Management of Radiology Report Templates (MRRT), Rev. 1.7 – Trial Implementation [Internet]. Verfügbar unter: https://www.ihe.net/uploadedFiles/Documents/Radiology/IHE_RAD_Suppl_MRRT.pdf

[8] Hundley WG, Bluemke DA, Bogaert JG et al. Society for Cardiovascular Magnetic Resonance guidelines for reporting cardiovascular magnetic resonance examinations. J Cardiovasc Magn Reson 2009; 11: 5

[9] Cury RC, Leipsic J, Abbara S, Achenbach S et al. CAD-RADS™ 2.0 - 2022 Coronary Artery Disease - Reporting and Data System.: An expert consensus document of the Society of Cardiovascular Computed Tomography (SCCT), the American College of Cardiology (ACC), the American College of Radiology (ACR)

Zusatzmaterial

and the North America Society of Cardiovascular Imaging (NASCI). J Am Coll Radiol. 2022 Nov; 19(11):1185-1212.

[10] Leipsic, Jonathon; Abbara, Suhny; Achenbach, Stephan; Cury, Ricardo; Earls, James P.; Mancini, Gb John et al. SCCT guidelines for the interpretation and reporting of coronary CT angiography: a report of the Society of Cardiovascular Computed Tomography Guidelines Committee. Journal of Cardiovascular Computed Tomography 2014 Sept., 8 (5): 342–358.

[11] Blanke P, Weir-McCall JR, Achenbach S et al. Computed Tomography Imaging in the Context of Transcatheter Aortic Valve Implantation (TAVI)/Transcatheter Aortic Valve Replacement (TAVR): An Expert Consensus Document of the Society of Cardiovascular Computed Tomography. JACC Cardiovasc Imaging 2019 Jan, 12: 1 – 24.

[12] Francone M, Budde RPJ, Bremerich J et al. CT and MR imaging prior to transcatheter aortic valve implantation: standardisation of scanning protocols, measurements and reporting-a consensus document by the European Society of Cardiovascular Radiology (ESCR). Eur Radiol. 2019 Sep, 1-24

[13] Otto CM, Kumbhani DJ, Alexander KP et al. 2017 ACC Expert Consensus Decision Pathway for Transcatheter Aortic Valve Replacement in the Management of Adults With Aortic Stenosis. Journal of the American College of Cardiology 2017 Mar, 69: 1313 – 1346

[14] Pinto dos Santos D, Hempel JM, Mildenberger P et al. Structured Reporting in Clinical Routine. RöFo – Fortschr Röntgenstr 2019; 191(01): 33-39

[15] Bunck AC, Baeßler B, Ritter C etal. Structured Reporting in Cross-Sectional Imaging of the Heart: Reporting Templates for CMR Imaging of Cardiomyopathies (Myocarditis, Dilated Cardiomyopathy, Hypertrophic Cardiomyopathy, Arrhythmogenic Right Ventricular cardiomyopathy and Siderosis). RöFo – Fortschr Röntgenstr 2020; 192: 27–37

[16] Schulz-Menger J , Bluemke DA , Bremerich J et al. Standardized image interpretation and post-processing in cardiovascular magnetic resonance - 2020 update. Society for Cardiovascular Magnetic Resonance (SCMR): Board of Trustees

Zusatzmaterial

Task Force on Standardized Post-Processing. Journal of Cardiovascular Magnetic Resonance 2020; 22:19

[17] Anderson TJT, Lu N, Brook OR. Disease-Specific Report Templates for Your Practice. J Am Coll Radiol 2017; 14: 1055–1057

[18] Knuuti J, Wijns W, Saraste A et al. 2019 ESC Guidelines for the diagnosis and management of chronic coronary syndromes. The Task Force for the diagnosis and management of chronic coronary syndromes of the European Society of Cardiology (ESC). European Heart Journal 2020; 41: 407-477

[19] Eckert N, Gießelmann K. Chronisches Koronarsyndrom: Zu wenige Ischämietests. Deutsches Ärzteblatt 2019; 116(51–52): A2400-2402

[20] Herzog B, Greenwood J, Plein S. Pocket Guide Cardiac Magnetic Resonance. EACVI 2014

[21] Kawel-Boehm N, Maceira A , Valsangiacomo-Buechel ER et al. Normal values for cardiovascular magnetic resonance in adults and children. Journal of Cardiovascular Magnetic Resonance 2015; 17: 29-62

[22] van der Ven JPG, Sadighy Z, Valsangiacomo-Buechel VE et al. Multicentre reference values for cardiac magnetic resonance imaging derived ventricular size and function for children aged 0–18 years. European Heart Journal - Cardiovascular Imaging 2020; 21(1): 102–113

[23] Lombardi M, Plein S, Petersen S et al. The EACVI Textbook of Cardiovascular Magnetic Resonance. European Society of Cardiology 2018. Oxford University Press, Oxford, Großbritannien. 1. Auflage (3. Oktober 2018)

[24] Ebtia M, Murphy D, Gin K et al. Best method for right atrial volume assessment by two-dimensional echocardiography: validation with magnetic resonance imaging. Echocardiography. 2015; 32: 734–739

[25] Ferreira PF, Gatehouse PD, Mohiaddin RH et al. Cardiovascular magnetic resonance artefacts. J Cardiovasc Magn Reson 2013; 15:41

 © 2022. Thieme. All rights reserved.

Zusatzmaterial

[26] Manisty C, Ripley DP, Herrey AS et al. Splenic switch-off: a tool to assess stress adequacy in adenosine perfusion cardiac MR imaging. Radiology 2015; 276: 732-40

[27] Robinson AA., Salerno M, Kramer CM. Contemporary Issues in Quantitative Myocardial Perfusion CMR Imaging. Curr Cardiovasc Imaging Rep 2019; 12: 9

[28] Knott KD, Camaioni C, Ramasamy A et al. Quantitative Myocardial Perfusion in Coronary Artery Disease: A Perfusion Mapping Study. J Magn Reson Imag 2019; 50: 756–762

[29] Achenbach S, Barkhausen J, Beer M et al. Konsensusempfehlungen der DRG/DGK/DGPK zum Einsatz der Herzbildgebung mit Computertomografie und Magnetresonanztomografie. RöFo – Fortschr Röntgenstr 2012; 184: 345–368

[30] El AH, Adams A, Moons KG et al. Cardiac Magnetic Resonance imaging findings and the risk of cardiovascular events in patients with recent myocardial infarction or suspected or kown coronary artery disease: a systematic review of prognostic studies. J Am Coll Cardiol 2014;63: 1031-1045

[31] Leyva FL, Foley PWXChalil S et al. Cardiac Resynchronization therapy guided by late gadolinium-enhancement cardiovascular magnetic resonance. J Cardiovasc Magn Reson 2011;13(1):29

[32] Hundley WG, Bluemke DA, Finn JP et al. DACCF/ACR/AHA/NASCI/SCMR 2010 Expert Consensus Document on Cardiovascular Magnetic Resonance. A Report of the American College of Cardiology Foundation Task Force on Expert Consensus Documents. JACC 2010; 55(23): 2614–2662

[33] Messroghli DR, Moon JC, Ferreira VM et al. Clinical recommendations for cardiovascular magnetic resonance mapping of T1, T2, T2* and extracellular volume: A consensus statement by the Society for Cardiovascular Magnetic Resonance (SCMR) endorsed by the European Association for Cardiovascular Imaging (EACVI). J Cardiovasc Magn Reson 2017; 19: 75

Zusatzmaterial

[34] ACR Appropriateness Criteria Chronic Chest Pain-Noncardiac Etiology Unlikely-Low to Intermediate Probability of Coronary Arter Shah AB, Kirsch J, Bolen MA et al. ACR Appropriateness Criteria® Chronic Chest Pain-Noncardiac Etiology Unlikely-Low to Intermediate Probability of Coronary Artery Disease. Journal of the American College of Radiology 2018; 15: S283

[35] Taylor AJ, Cerqueira M, Hodgson JM et al. ACCF/SCCT/ACR/AHA/ASE/ASNC/NASCI/SCAI/SCMR 2010 Appropriate Use Criteria for Cardiac Computed Tomography. Journal of the American College of Cardiology 2010; 56: 1864 – 1894

[36] Achenbach S, Barkhausen J, Beer M, et al. Konsensusempfehlungen der DRG / DGK / DGPK zum Einsatz der Herzbildgebung mit Computertomographie und Magnetresonanztomographie. Der Kardiologe 2012 2:105-125

[37] R. Fischbach , S. Miller , M. Beer , J. Lotz , D. Kivelitz. Empfehlungen der Arbeitsgemeinschaft Herzdiagnostik der Deutschen Röntgengesellschaft für den Einsatz der Computertomografie und Magnetresonanztomografie in der Herzdiagnostik. Teil 1 – Computertomografie. Fortschr Röntgenstr 2009; 181(7): 700-706.

[38] Machida H, Tanaka I, Fukui R et al. Current and Novel Imaging Techniques in Coronary CT. RadioGraphics 2015; 35: 991 – 1010

[39] Agatston AS: Quantification of coronary artery calcium using ultrafast computed tomography. J Am Coll Cardiol. 1990; 15: 827e832.

[40] McClelland RL, Chung H, Detrano R et al. Distribution of Coronary Artery Calcium by Race, Gender, and Age. Circulation 2006; 113: 30 – 37.

[41] Raggi P, Callister TQ, Cooil B et al. Identification of patients at increased risk of first unheralded acute myocardial infarction by electron-beam computed tomography. Circulation 2000; 101: 850 – 855

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Zusatzmaterial

[42] Hoff JA, Chomka EV, Krainik AJ et al. Age and gender distributions of coronary artery calcium detected by electron beam tomography in 35,246 adults. Am J Cardiol 2001; 87: 1335 – 1339

[43] O'Brien JP, Srichai MB, Hecht EM et al. Anatomy of the heart at multidetector CT: what the radiologist needs to know. Radiographics 2007; 27: 1569 – 1582

[44] Austen WG, Edwards JE, Frye RL et al. A reporting system on patients evaluated for coronary artery disease. Report of the Ad Hoc Committee for Grading of Coronary Artery Disease, Council on Cardiovascular Surgery, American Heart Association. Circulation 1975; 51: 5 – 40

[45] Knuuti J, Wijns W, Saraste A, et al. ESC Scientific Document Group. 2019 ESC Guidelines for the diagnosis and management of chronic coronary syndromes. Eur Heart J. 2020 Jan 14;41(3):407-477.

[46] Mark DB, Berman DS, Budoff MJ et al. ACCF/ACR/AHA/NASCI/SAIP/SCAI/SCCT 2010 Expert Consensus Document on Coronary Computed Tomographic Angiography. Circulation 2010; 121: 2509 – 2543.

[47] Deutsche Röntgengesellschaft e.V. Nutzungslizenz Befundvorlagen der DRG [Internet]. Verfügbar unter: https://github.com/DRGagit/ak_befundung/blob/master/LICENSE