# The Virtue of Anatomical Imaging in Coronary Artery Disease with Coronary CT Angiography and CMR

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Coronary CTA and Cardiovascular MR have been emerging as workhorses in noninvasive imaging in coronary artery disease and both have established their own places, although the modern multi-slice CT system is developing very rapidly into a readily available technique with multiple measurement outcomes. Great advantages of CTA are of course its high spatial resolution, it's very short acquisition times, the ability to assess calcium scoring, and upcoming possibilities for myocardial perfusion, ECV (extra-cellular volume) assessment, RV and LV function, etc. Disadvantages are still the radiation dose, so that multi-frame functional analysis is not the first choice, but the radiation dose is becoming lower and lower. Although calcium scoring has been around for a long time, there is renewed interest as prognostic value, and allows the calculation of the biological age of the vessels including values of blood pressure and cholesterol levels. Plaque burden and even plaque composition can be assessed in a quantitative and reproducible manner using image processing techniques, and have been shown to have prognostic value as well.

Cardiovascular MR has the advantage of evaluating the heart in a highly comprehensive manner. While spatial resolution is reasonable, it is not yet at the level of CTA and limited in depicting coronary arteries in daily practice. However, combining this with good temporal resolution and non-ionizing radiation has made Cardiovascular MR the golden standard modality for evaluating left and right ventricular function. In addition, Cardiovascular MR has great ability to differentiate soft tissues and allows for excellent myocardial classification. Other assessments include, myocardial perfusion and measurement of volumetric blood flow. The most widely used applications for MRI for more than 15 years are LV function and infarct sizing, viability using late gadolinium enhancement (LGE) and measurement of volumetric blood flow through the great vessels including valve insufficiency. Important parameters are ejection fraction, myocardial wall motion and thickening/thinning, myocardial mass including or excluding papillary muscles and trabeculations, and strain, whereby global strain values have shown to have high prognostic value, infarct size, flow volume and regurgitation. 4D Flow is also gaining a lot of interest. New acquisition techniques allow for the real-time assessment of all the data without any triggering, and whereby the patient can continue to breath; particularly of interest for patients with rhythm disturbances. More extensive analyses allow for the assessment of the core of the infarcted region, plus the border zone and of course the degree of transmurality. Myocardial classification has received a lot of interest over the last few years, as new sequences are becoming available. Measurements include native and post T1 mapping and the associated assessment of ECV, T2 and T2* for iron overload in Thalassemia. MR perfusion at rest and stress, including absolute perfusion, is being performed but are still somewhat cumbersome to apply these in daily practice. MR Flow is a highly automated technique for assessment of regurgitation, aortic stenosis, shunt evaluation, etc, and particularly important in pediatric applications. All in all, CVMR has developed into a highly comprehensive technique with a broad range of applications, but whereby scanning time and availability may be an issue in many centers.

# The value of quantitative plaque burden by CTA in clinical research

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Coronary CTA has developed into a technique that can visualize the coronary artery system with relatively high resolution, with acceptable radiation dose with the modern scanners, and with excellent sensitivity and specificity for the recognition of coronary stenoses. However, for clinical research a quantitative and reproducible approach is needed, whereby any user interactions are minimized as much as possible and that also would provide additional information that otherwise would be difficult to obtain.

We have developed a quantitative approach based on automated segmentation of lumen and vessel boundaries, from which volumetric plaque burden as well as plaque composition can be derived. The segmentation technique is based on a 2-step approach. First, initial border detection is performed in 4 longitudinal cuts through a straightened MPR stack of a selected vessel. These create landmarks for the subsequent contour detection step in all of the individual cross sections. The segmentation has been validated against segmented and registered IVUS pullbacks of the same vessel segment, and published in the international literature (1). In addition, H-B Park et al assessed the clinical feasibility of 3D automated plaque quantification and found excellent correlations between IVUS and expert QCT analyses. Even a fully-automated analysis showed comparable performance to non-expert QCT analysis, and required only 1/6 of the time of an expert analysis (2). A derived coronary plaque score has demonstrated in the ROMICAT II trial to predict acute coronary syndromes among patients with acute chest pain (3). Also, Deseive et al demonstrated that plaque volume quantification in coronary CT predicts all-cause death and myocardial infarction in 1577 patients with 5.6 years FU (4). Furthermore, coronary CT angiography has been shown to provide promise as a tool for quantifying total and non-calcified coronary artery plaques, which are associated with LDL cholesterol level, systolic blood pressure and diabetes (5).

References

1. Graaf MA de, Broersen A, Kitslaar PH, Roos CJ, Dijkstra J, Lelieveldt BPF, Jukema JW, Schalij MJ, Delgado V, Bax JJ, Reiber JHC, Scholte AJ Automatic quantification and characterization of coronary atherosclerosis with computed tomography coronary angiography: cross-correlation with intravascular ultrasound virtual histology. Int J Cardiovasc Imaging 2013; 29: 1177-1190
2. Park H-B, Lee BK, Shin S et al. Clinical feasibility of 3D automated coronary atherosclerotic plaque quantification algorithm on coronary computed tomography angiography: comparison with intravascular ultrasound. Eur Radiology 2015; doi: 10.1007/s00330-015-3698-z
3. Ferencik M, Mayrhofer Th, Puchner SB et al. Computed tomography-based high-risk coronary plaque score to predict acute coronary syndrome among patients with acute chest pain – Results from the ROMICAT II trial. J Cardiovasc Comput Tomogr 2015; doi: 10.1016/j.jcct.2015.07.003
4. Deseive S, Straub R, Kupke M, Hadamitzky M, Kitslaar P, Broersen A, Massberg S, Hausleiter J. Semi-automatic plaque volume quantification in coronary CT angiography predicts all-cause death and myocardial infarction in 1577 patients with 5.6 years follow-up.
J Cardiovasc Comp Tomogr 2015; S23
5. Rodriguez K, Kwan AC, Lai S et al. Coronary plaque burden at coronary CT angiography in asymptomatic men and women. Radiology 2015.