### What is the future of Cardiac CT?

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**Kurzfassung:** Three aspects on the future of cardiac CT will be presented. 

1. **New technology**
   - The latest developments of CT Myocardial Perfusion Imaging, Transluminal Attenuation Gradient (TAG) and Corrected Coronary Opacification (CCO), fractional flow reserve (FFR) computed from CTA, extrapolation from atherosclerotic plaque characteristics, and three-dimensional printing will be briefly summarized. 

2. **More clinical trials**
   - More recruiting trials, i.e., CONSERVE (NCT01810198), DECIDE-Gold (NCT02178904), CREDENCE (NCT02173275), ISCHEMIA (NCT01471522), will be stressed in this section, rather than the published PROMISE, SCOT-Heart, Platform trials.  

3. **Homogeneous quality**
   - Advance CT technology is one future direction of cardiac CT, and the homogeneous quality in the real world is the other direction. In this part, gaps between guidelines and clinical reality, the importance of standardized training, and the duty of SCCT and radiological societies will be followed with interest. Drawing from all the three parts above, cooperation can be a key point of my talk. In the future time, closer cooperation among radiologists, cardiologists and engineers, among investigators from different countries, among hospitals, industry, and government must be strengthened.

**Lernziele:** 1. Cardiac CT technology keeps developing. 
2. More exciting clinical trial results will be announced in the next few years.
Kurzfassung: Recent developments in CT technology allow myocardial perfusion CT imaging during pharmacologic stress. In previous studies that have reported the feasibility and additional diagnostic values of myocardial perfusion CT imaging, various scan techniques, imaging protocols, and stress agents have been used. This means that the protocol of CT perfusion has not been optimized yet. This lecture provides an overview of various scan techniques, imaging protocols and clinical implications of myocardial CT perfusion.

Various scan techniques
Myocardial CT perfusion imaging can be divided into static and dynamic imaging. The acquisition of static CT perfusion imaging is the same as routine coronary CT angiography. A single data of the myocardium is acquired during first-pass contrast enhancement. All CT scan techniques such as helical, sequential, and high-pitch helical can be applied to static CT perfusion imaging. One drawback of static imaging is that the peak attenuation may be missed because only one sample of data is acquired. Another is that myocardial ischemia may not be detected in cases of balanced ischemia due to limitation of absolute quantification.

In addition to conventional scan modes, static CT perfusion imaging can also be performed by using dual-energy mode. The principle of dual-energy scan modes is vendor specific. First, Dual-source CT (DSCT) scanner with two tubes that operate at two different voltage settings allows simultaneous acquisition of two different data sets at low (100kV) and high (140kV) tube voltages. The second method is the rapid switching of a single x-ray tube between 80 kV and 140 kV in a single gantry rotation. The third method involves sandwich detector technology. The two detectors are superimposed and are composed of different materials. The last method involves a single x-ray source. The tube voltage level is altered between consecutive gantry rotations.

In dynamic CT perfusion imaging, multiple series of myocardial attenuation were acquired during 30-40 seconds after contrast injection. Stationary or shuttle mode can be applied to repeated scanning. A big advantage of dynamic imaging is that the myocardial blood flow and myocardial blood volume can be quantified. A major drawback of dynamic CT perfusion techniques is the higher radiation dose required compared with static CT perfusion.

CT imaging protocol
Myocardial CT perfusion protocol should be comprised of rest and stress image acquisition. The stress phase is used for evaluation of myocardial perfusion on hyperemic state. The rest phase is used for evaluation of both myocardial perfusion at rest and coronary artery stenosis. The optimal evaluation of myocardial perfusion defect is when stress imaging is performed before rest imaging. This is because myocardial contamination by contrast enhancement from rest imaging can be avoided. In addition, pharmacologic-induced stress can be performed without being interfered by premedications used for the rest imaging such as b-blockers and nitrates. On the other hand, rest coronary CT angiography can be performed before stress acquisition. In this protocol, patients without coronary artery disease on coronary CT angiography will not require subsequent stress testing. The major disadvantage of this approach is that stress imaging suffers from myocardial contamination by previous contrast injection from rest imaging. An interval of 10-20 minutes should be given between the two CT acquisitions to resolve the effects of stress agent or to avoid myocardial contamination by previous contrast injection.

Clinical implications
Previous studies have reported the additional values of CT perfusion compared with CCTA alone for coronary stenosis with heavy calcifications, motion artifacts, and poor enhancement. The feasibility of CT perfusion was also reported in patients with coronary stents. In case of dynamic CT perfusion technique, the quantification of myocardial blood flow can help to find balanced ischemia in patients with 3-vessel disease. A few MR perfusion studies have demonstrated imaging findings of coronary artery bypass graft. CT perfusion may also be applied to those patients. However, additional radiation dose of CT perfusion is a major drawback which hinders its wide use for clinical purposes. During the last decade, scan techniques and post-processing softwares have been developed to reduce the radiation dose and various artifacts, but the effort must go on. In the future, studies on large population group should be conducted to establish a guideline regarding clinical indications of CT perfusion.
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