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Integrating Cardiac CT and Nuclear Imaging: Protocols for PET-CT

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CT study can be performed first but the protocol can also start with PET perfusion studies depending on patient population but also logistic reasons. One could also consider performing only one study first and then continuing with other only based on the results of the first study. In the protocols where the need of perfusion study is individually decided upon the findings in CT angiography, the protocol naturally starts with CT. This procedure is powerful since it utilises the high negative predictive value of CT and only that fraction of the patients that had suspicious findings in CT will continue with PET perfusion imaging. Depending on the selected patient population this fraction is about 25-50% and, thus, on the average one PET perfusion session is needed for each three patients.

The patient preparation for hybrid study is mostly the same than for the individual scans. It is important that the patients heart rate is controlled for CT and that caffeine containing drinks are avoided during the preceding 12 hours.

The positioning of the patient to the scanner bed is critical to prevent any motion artefacts. It is strongly recommended that hands are supported upright and not within the field of view. The calcium score study can be performed first followed by CT angiography study. The detailed protocol of CT angiography depends on the system used. Thereafter low-dose CT for attenuation correction of PET is performed if needed (in some systems calcium score study can be used for this). The PET tracer injection (1100-2200 MBq of Rb-82, 340-740 MBq of N-13-ammonia, or 700-1500 MBq of O-15-water) is given and resting PET perfusion study performed. The scan protocol depends on the tracer used. With Rb-82 the static scan is started 90-120 s after injection and lasts for 5 min. With N-13-ammonia and O-15-water the dynamic scan started immediately after tracer injection and lasts for 20 or 5 minutes, respectively. Dynamic scan is required for quantitative perfusion measurement. After decay of tracer, the stress study is followed using pharmacologic stressors such as adenosine, dipyridamole or dobutamine. The tracer injection and PET scan are repeated during peak stress. With Rb-82 and O-15-water studies (half-lives 76 s and 112 s) the stress study can be performed practically without delay after the rest study. With N-13-ammonia stress testing is delayed for about 30 min to allow tracer decay.

It is critical to perform quality control of the CT attenuation maps and PET emission images to identify and correct for misalignment. If method to correct patient motion between stress and rest studies is not available, second low-dose CT scan for attenuation correction is needed. If the PET system is capable to list mode acquisition, the data can be collected as ECG gated mode that allows the simultaneous assessment of regional and global left ventricular wall motion from the same scan data. This is particularly practical in Rb-82 studies.

The total time required for whole study session depends on the tracer used. With O-15-water and Rb-82 the whole session can be finished in 30 minutes and with N-13-ammonia in 80 minutes.

For viability testing it is important that patients have fasted minimum of 10 hours (usually overnight). There are 3 options for patient preparation. These alternatives are oral glucose loading, insulin clamping and nicotinic acid derivatives. Especially in diabetic patients monitoring of plasma glucose is necessary to ensure good image quality. After FDG injection (200-350 MBq) imaging is started 45–60 min post injection and image duration is 10–30 min (depending on count rate and dose). Currently, gated acquisition is preferred.

The analysis of CT angiography includes the standard processes and techniques such as visual assessment of original transaxial slices, multiplanar reconstructions and utilisation of quantitative tools available. The analysis of PET studies follows also the standard procedures that have been explained in detail

in guidelines. However, to utilise the true power of hybrid imaging, analysis system that is able to handle fused images and data should be also used. By this way the individual coronary anatomy can be visualised together with functional information enabling accurate association between coronary anatomy and e.g. perfusion. The most advanced analysis includes also visualisation of PET perfusion in diagnostic quality multiplanar reconstructions of CT. If quantitative measurement of flow has been performed, the absolute stress flow values should be also included in the analysis.

References

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