Imaging of coronary atherosclerosis and vulnerable plaque

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CHAPTER 10

Reduction of Radiation Dose using 80 kV Tube Voltage: a Feasible Strategy?

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Computed tomography (CT) coronary angiography has become a highly accurate noninvasive approach for delineation of the presence and severity of coronary atherosclerosis.[1-9] Cardiac CT is optimally suited for the evaluation of patients with a low or intermediate risk of coronary disease, allowing the non-invasive rule-out of coronary disease at relatively low cost and risk.[10-18] However, the appropriate radiation dose remains an important issue in cardiac CT. On one hand, a too low radiation dose may result in a high level of image noise and therefore in non-diagnostic images. On the other hand, using higher radiation exposure levels may put patients at unnecessary risk of radiation damage.[19-26] Effective strategies to reduce radiation dose, such as prospective gating, heart rate control, ECG-correlated modulation of the tube current, and tube voltage below 100 kV, are becoming more and more applied in the clinical situation.[27-31]

Recently, Buechel et al.[32] evaluated a large group of 612 patients referred for CT coronary angiography by 64-slice computed tomography. Intravenous metoprolol (2 to 30 mg) was administered if necessary to achieve a target heart rate below 65 beats/min. Using prospective ECG-triggering a mean effective radiation dose of 1.8 ± 0.6 mSv was obtained with a diagnostic image quality in 96.2% of segments. The authors concluded that low-dose CT coronary angiography by prospective ECG-triggering is feasible in the vast majority of an every-day population, whereby a heart rate below 62 beats/min favors diagnostic image quality. Blankstein et al.[33] investigated the effective radiation dose and image quality of 100 kV versus 120 kV tube voltage among patients referred for cardiac dual source CT imaging in 294 consecutive patients. They convincingly demonstrated that use of low kV resulted in a substantial reduction of radiation dose without compromising image quality. The effective radiation dose for the 100 kV and 120 kV scans was 8.5 and 15.4 mSv, respectively. In the recently published PROTECTION II trial, Hausleiter et al.[34] studied 400 non-obese patients undergoing CT angiography with either 100 kV or 120 kV CT coronary angiography. The study specifically examined the impact of a reduction in tube voltage to 100 kV using 64-slice CT angiography systems from three different manufacturers. It was demonstrated that a further 31% reduction in radiation exposure could be obtained with 100 kV tube voltage settings while image quality was preserved. Zhang et al.[35] prospectively evaluated image quality parameters, contrast volume and radiation dose at the 100 kV tube voltage setting during CT coronary angiography using a 320-row computed tomography scanner. The effective radiation dose was 2.12 ± 0.19 mSv for 100 kV, being a reduction of 54% compared to 4.61 ± 0.82 mSv for 120 kV. Diagnostic image quality was achieved in 98.2% of coronary segments with 100 kV and 98.6% of coronary segments with 120 kV. Therefore, the 100 kV setting allowed significant reductions in contrast material volume and effective radiation dose while maintaining adequate diagnostic image quality.

In the International Journal of Cardiovascular Imaging, Wang et al.[36] investigated the feasibility of a body mass index-adapted low-dose 80 kV scan protocol using prospectively ECG-triggered high-pitch spiral coronary CT angiography in 106 patients referred for coronary CT angiography to rule out coronary artery disease. The image quality and dose performance were compared with 100 kV and 120 kV tube settings. The authors demonstrated that an adequate diagnostic image quality was obtained in more than 98% of coronary segments using the 80, 100, and 120 kV tube voltage settings ($p = 0.482$). Image noise was significantly higher with 80 kV compared to 100 kV and 120 kV tube voltage settings. The effective dose using 80 kV (0.36 ± 0.03 mSv) was significantly lower than that using 100 kV (0.86 ± 0.08 mSv), or the 120 kV tube voltage setting (1.77 ± 0.18 mSv). Use of a tube voltage of 80 kV for patients with a body mass index ≤ 22.5 kg/m^2 resulted in a further dose reduction of 58% and 80% compared with 100 kV and 120 kV protocols, while maintaining diagnostic image quality. Particularly in patients with slim body shape, a further reduction of tube voltage to 80 kV may be advisable. The authors concluded that 80 kV high-pitch spiral coronary CT angiography is feasible for patients with body mass index ≤ 22.5 kg/m^2. The authors also suggested that the amount of contrast material could be decreased, reducing contrast media-associated nephropathy and avoiding the obscuration of calcification caused by excessively high Hounsfield value. To further reduce the high image noise, they introduced iterative reconstruction in clinical routine practice. Consequently, the authors propose a combination of a low kV scan protocol, reduced contrast material injection protocol, and iterative reconstruction for an acceptable low radiation dose together with preserved image quality.

The above-mentioned findings by Wang et al.[36] have been underscored by Abada et al.[37], who used a 64-slice CT 80 kV tube voltage setting in 11 patients with body weight < 60 kg. The authors reported a dose reduction by up to 88% without a negative influence on image quality. Achenbach et al.[38] reported a case of 74-year-old patient with 63 kg body weight using 80 kV tube voltage and showed adequate diagnostic image quality and a dose reduction of 80% compared with a standard 120 kV tube voltage setting. In summary, the study by Wang et al.[36] validly demonstrates that further reduction in tube current may be feasible for reducing radiation exposure in patients undergoing CT coronary angiography.

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