Limiting radiation exposure in coronary CT angiography: much can be achieved with little extra effort

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Radiation dose is of concern in coronary CT angiography: a very recent international survey of 50 sites which routinely perform coronary CT angiography—the PROTECTION I study—revealed that some centers performed their scans with average effective radiation doses as high as 30 mSv [1]. However, these high doses are only one end of what is really a spectrum—in fact, a quite extreme end of that spectrum. In PROTECTION I, some sites used average dose as low as 5 mSv, and the median effective dose associated with coronary CT angiography in a total of 1,965 patients was 12 mSv.

This needs to be put in perspective in several respects. First of all, other diagnostic measures also expose patients to radiation. A recent Science Advisory of the American Heart Association reported typical effective doses of 7 mSv for an invasive coronary angiogram, 15 mSv for a percutaneous coronary intervention, 9 mSv for a sestamibi 1-day stress/rest myocardial perfusion scan and 41 mSv for a thallium stress/rest myocardial perfusion scan [2]. This in no way means that the radiation exposure of coronary CTA is negligible or irrelevant, but in 2006, it was estimated that cardiac CT accounted for 1.5% of the

collective CT-related radiation dose in the US population while cardiac nuclear medicine studies, of which more than 10 million were performed, accounted for about 20% of the collective CT-related radiation dose.

Second, the effect of a given radiation exposure is extremely difficult to determine and it also varies tremendously, depending on who the exposed patient is. The induced lifetime cancer risk is superbly difficult to quantify. Assumptions are that an effective dose of 10 mSv increases the lifetime risk of fatal cancer by 0.5 per 1,000 individuals—while the background lifetime risk of “naturally occurring” cancer is 212 per 1,000 individuals (for comparison, the lifetime risk of a fatal motor vehicle accident is 12 per 1,000 individuals) [2]. Radiation effects in young patients and women are more severe than in older individuals and in men, so that protection from overly high radiation doses are most important in young individuals. In older patients, using a higher radiation dose for coronary CT angiography may be completely justified if it helps to avoid invasive coronary angiographies with the associated risk of invasive arterial access, such as bleeding. Radiation effects decrease and non radiation-related risks increase in older patients [3, 4] so that the balance may be entirely different than in younger individuals.

All the same, there is absolutely no doubt that radiation exposure carries a risk, as small and difficult to quantify as it may be, and that doses should always be “as low as reasonably achievable”. Tremendous progress has recently been made to provide low-dose

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scan protocols for coronary CT angiography. ECG-controlled tube current modulation has meanwhile become standard. The use of 100 kVp scan protocols (as opposed to the “traditional” 120 kVp) reduces radiation dose by as much as 40% without influencing image quality, at least in individuals with a low body weight [1, 5]. Finally, prospectively triggered data acquisition leads to substantial reduction of radiation dose, with doses reported between 1.2 and 4.3 mSv [6–11].

Along these lines, the article by Gopal and colleagues in this issue of the *International Journal of Cardiovascular Imaging* [12] clearly demonstrates the effects of various measures on radiation exposure: prospective data acquisition and the use of 100 kVp tube voltage resulted in 83 and 42% reductions of dose and the combination of both lowered radiation exposure by as much as 90% when compared to the protocol that has until recently been considered “standard”, retrospectively gated helical acquisition and 120 kVp tube voltage. This is not a prospective or randomized trial—the authors retrospectively analyzed data that were accumulated during clinical use. The specifics of the patients that were study did influence the choice of image acquisition protocol. Therefore, their conclusion that low-dose scan protocols do not affect image quality or the rate of diagnostic segments is based on the *selective* use of low-dose protocols: prospective image acquisition and 100 kVp tube voltage were preferentially used in younger patients, in female individuals, and in those with a lower body weight.

This approach is a wise one. In challenging patients, preserving image quality is important, and it may be necessary to use protocols that are not associated with superbly low dose in individuals with high body weight, when heart rate cannot be sufficiently lowered, or if the disease pattern is complex. Artifacts and sub-optimal image quality usually lead to false-positive findings in coronary CT angiography—false-positive interpretation is much more frequent than false-negative studies [13, 14]. Avoiding the risk of suboptimal image quality and a false-positive CT scan result that leads to additional testing (with associated radiation-related and other hazards) is probably worth an “extra few mSv”, especially in older individuals. However, in patients who are more susceptible to radiation, and, very importantly, in patients where the use of low-dose scan protocols is

likely *not* to negatively affect image quality, every effort should be made to limit exposure. A low radiation dose should not be the primary goal of performing a coronary CT angiography scan. Fully diagnostic image quality is most important. However, we cannot afford to ignore the possibilities that are now in our hands to lower dose, even if it requires a little extra effort.

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