Fighting with the invisible: radiation exposure in cardiac resynchronization therapy

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Received 21 October 2009; accepted after revision 23 October 2009

This editorial refers to ‘Radiation exposure to patients’ skin during cardiac resynchronization therapy’ by S. Suzuki et al., on page 1683.

Cardiac resynchronization therapy improves quality of life, exercise capacity, and outcome in patients with heart failure of NYHA functional class III and IV, left ventricular (LV) ejection fraction \( \leq 0.35 \), and QRS duration \( \geq 120 \) ms.1,2 The most challenging part during the implantation is the positioning of the LV lead in the coronary sinus (CS), leading to procedure times of \( >4 \) h and total fluoroscopy times (TFTs) of \( >60 \) min in some patients.3 Total fluoroscopy times and the dose–area product may be on average four times higher in cardiac resynchronization therapy (CRT) implantations compared with conventional pacemaker or defibrillator implantations.4

Radiation effects

Radiation carcinogenesis is not dose-dependent: the smallest quantity of ionizing radiation exposure has a finite probability of causing the damage. The estimated risk for fatal cancers is around 280/1 000 000 patients undergoing CRT implantation and 70/1 000 000 patients in the cases of conventional rhythm device implantation in a Greek patient population.4

Other radiation effects are threshold-dependent (a deterministic effect). Fluoroscopic exposure with an absorbed dose of 2 Gy leads to early transient skin erythema and may result in skin necrosis when the adsorbed dose exceeds 12 Gy. Many fluoroscopy equipments have a high-dose rate mode of fluoroscopy, with \( 0.1 \) Gy/min delivered dose. Skin necrosis may be induced at \( <30 \) min of exposure working in this mode. Continuous fluoroscopy doses in the normal dose rate mode are in the range between 20 and 50 mGy/min. Using the pulsed fluoroscopy mode of 7.5 frames/s, radiation exposure can be lowered to approximately one-third to one-fifth of that using the continuous mode.5

Suzuki et al.3 report on radiation exposure to the skin in patients undergoing CRT implantation. Entrance skin doses (ESDs) were measured using radiosensitive indicators (10 x 10) placed on the back of the patient on a special jacket. Adsorbed doses were evaluated and the maximum ESD and TFT were analysed in 16 patients. The average TFT was 56.7 ± 28.0 min, the maximum ESD was 1.0 ± 0.6 Gy. In six patients, the maximal ESD was \( >1 \) Gy, and in one of them with a body mass index (BMI) of 25.7 and a TFT of 98.4 min, the ESD was 2.5 Gy.

Although the number of patients in the study was limited and the variability in procedure and fluoroscopy times (105–270 and 20.8–114.8 min, respectively) was considerable, there was a significant correlation between TFT and the maximum ESD. On the basis of their regression equation, authors state that TFT of 60 min roughly corresponds to the maximum ESD of 1 Gy. Apart from TFT and the technical specifications of the fluoroscopy unit, patient body mass, CS anatomy, and operator skills have a significant effect on the adsorbed dose.

Body mass

Patients with a higher body mass receive a higher ESD during the implantation of a CRT device.3,4 Patients undergoing atrial fibrillation (AF) ablation procedures have a similar or higher radiation exposure as patients receiving CRT implantation. In a study of 85 patients undergoing AF ablation with a median TFT of 83 ± 26 min and procedure times \( \sim4 \) h, the BMI was a more important determinant of the effective dose than TFT. In that study, the dose–area product per hour of fluoroscopy was 58, 109, and 184 Gy cm\(^2\)/h in normal (BMI \( <25 \) ), obese (BMI 25–30), and overweight (BMI \( >30 \) ) patients, respectively.6 The implanting physician should be aware of this important phenomenon during the pre- and intra-operative radiation risk assessments.

Anatomical variation of the coronary sinus

The most challenging part in implanting a CRT device is transvenous implantation of the LV lead. Patients show a high variability...
in the anatomy of the CS system with variable dilation of the right ventricle. Currently, a plethora of implantation tools such as different CS sheaths, inner sheaths, or LV leads guiding wires are available to reach the targeted lead position. Even when the desired position could be reached (in 84–100% in our patients), ∼20% of these positions should be given up because of lead instability, threshold problems, or phrenic nerve stimulation. If the lead could not be implanted in the first targeted side branch, the average TFT was nearly double that of the average TFT in the cases of successful implantation in the first targeted vein.

Operator skills

Patients in the reported study were the first 16 CRT implantation procedures for the operating cardiologist. A marked learning curve effect was observed in the study with 40 and 30 min lower average procedure and fluoroscopy times after the 10th procedure compared with the first 5 procedure. In order to avoid excess patient risk during the learning phase, the ESC guidelines recommend prior experience of at least 200 device implantations or coronary angiographies/interventions or electrophysiological studies before starting training in CRT implantation. After observing several CRT implantations, at least 20 supervised implantations as a primary operator are suggested. As the implantation may be extremely long-lasting, termination of the procedure should be considered after 4 h of unsuccessful attempts or after 60 min of X-ray exposure.

According to analysis in the CARE-HF trial, the experience of the implanting centre was the only predictor of implantation success. Centres implanting <10 CRT devices per year had an implant success rate of 82% compared with more experienced centres with the success rate of >90%. The average TFT was two-fold greater in failed implantations compared with successful implantation in patients with intraventricular conduction disturbances. Implantation of a resynchronization device, however, remains challenging, with long procedural and fluoroscopy times, with risk of radiation injury in difficult cases, especially in obese patients. To minimize radiation exposure and its inherent risks, the knowledge of the most recent implantation guidelines and efforts to keep the fluoroscopy time as low as possible are two major key points.


References