Determinants of operator radiation exposure during percutaneous coronary procedures

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Background Radiation exposure is an important issue for interventional cardiologists that is often underevaluated. Our aim was to evaluate determinants of operator radiation exposure during percutaneous coronary procedures.

Methods The RADIANT (NCT01974453) is a prospective, single-center observational study involving 4 expert operators and 2 fellows performing percutaneous coronary procedures. The operator radiation dose was evaluated using dedicated electronic dosimeters in 2,028 procedures: 1,897 transradial access (TRA; 1,120 right and 777 left TRA) and 131 transfemoral access (TFA).

Results In the whole population, operator radiation dose at the thorax did not differ between TFA (9 μSv [interquartile range 5-18 μSv]) and TRA (9 μSv [4-21 μSv]), but after propensity score matching analysis, TFA showed lower dose (9 μSv [5-18 μSv]) compared with TRA (17 μSv [9-28 μSv], $P < .001$). In the whole transradial group, left TRA (5 μSv [2-12 μSv]) was associated with significant lower operator dose compared with right TRA (13 μSv [6-26 μSv], $P < .001$).The use of adjunctive protective pelvic drapes was significantly associated with lower radiation doses compared with procedures performed without drapes ($P < .001$). Among the operators, an inverse relation between height and dose was observed. Finally, left projections and the use of angiographic systems not dedicated for coronary and high frame rates were all associated with a significant higher operator radiation exposure.

Conclusions In a high-volume center for transradial procedures, TFA is associated with lower operator radiation dose compared with TRA. The use of adjunctive anti-rx drapes seems a valuable tool to reduce the higher operator radiation exposure associated with TRA. (Am Heart J 2017;187:10-18.)

In the last several years, the advancements in the field of percutaneous coronary procedures have resulted in the treatment of more complex lesions with better results and with a greater degree of patient safety. Despite these step forwards, interventional coronary procedures still require the use of x-rays, which have well-known adverse effects for the patient[1] and for the operator.[2-4] Consequently, interventional cardiologists should apply the "As Low As Reasonably Achievable" principle when performing the procedure to reduce their and patient radiation exposure.

Many factors have been associated with different radiation exposure for the operator and the patient during percutaneous coronary procedures, such as the angulation of the radiation tube,[5] the x-rays pulse rate,[6] the exposed field size,[7] the positioning of image receptor and table,[7] the use of fluoro rather than cine mode acquisition,[8] and the use of adjunctive protective drapes.[9] However, most studies thus far have evaluated these factors independently and there is no single study that evaluated multiple determinants of radiation dose.

Another important determinant of radiation dose in percutaneous coronary procedures might be represented by the vascular access. In many countries, the radial access is generally preferred over the femoral[10] because of lower bleeding and vascular complications risks,[11,12] and better patient comfort.[13] However, a recently published very large meta-analysis showed a small but significant increase in operator and patient radiation exposure for the radial compared with the femoral access.[14] Despite the large number of studies and patients included in this meta-analysis, most data were obtained using an indirect measure of the operator dose expressed in terms of fluoroscopy time or dose area product (DAP) and only in a minority of studies dedicated operator dosimeters were used.

Finally, for the radial approach, there is also a possible effect associated with the use of left or right radial access, although actually the results of the studies are conflicting.[15,16]

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The aim of our prospective study was to evaluate the determinants of operator radiation exposure during percutaneous coronary procedures performed through different vascular accesses in a center with a high volume of transradial procedures.

Methods

Study design and population

The RAdiation Dose In percutANeuos Coronary Procedures Through Transradial Approach (RADIANT) study (NCT01974453) is a single-center prospective, observational study designed to evaluate radiation dose absorbed by operators during percutaneous coronary procedures using different vascular accesses.

All patients who underwent diagnostic or interventional percutaneous coronary procedures older than 18 years were eligible for the study. Only patients with hemodynamic instability were excluded.

All patients signed an informed consent form to perform the procedure and the Institutional Ethics Committee approved the protocol.

Transradial coronary catheterization

All procedures were performed by 4 expert transradial operators (>250 procedures per year) and 2 fellows. All expert operators (age range 37-45 years) had the same experience in transradial access with a rate of transradial procedures >80% each. The procedures were performed using 4 different angiographic systems: 3 dedicated coronary angiographic systems (IGS 520 [General Electric Healthcare, Buckinghamshire, United Kingdom]; Allura, XPER FD 10 [Philips, Eindhoven, the Netherlands]; Innova 2000 [General Electric Healthcare]) and one combined coronary and neuroradiologic system (Axiom Artis Zee; Siemens, Erlargen, Germany). The systems were set according to the standard of the operators, and the field of view or fluoroscopic and cine-acquisition speed were recorded for each procedure. The diagnostic procedures were generally performed using a standard sequence of 3 projections for the right coronary artery and 5 projection for the left coronary artery. Differently, the percutaneous coronary interventions (PCIs) were performed according to the lesion and to the operator preference.

Vascular access as well as the sheath selection (long vs short, hydrophilic vs non hydrophilic), the catheter curve used, and the use of adjunctive tools (manual thrombus aspiration, intracoronary ultrasound) were at the discretion of the operator involved in the procedure.

In all procedures, standard operator radioprotection was ensured using a lead apron, a thyroid lead collar, lower body x-ray curtain fixed on the angiographic table, an upper mobile leaded glass suspended from the ceiling, and leaded glasses. The use of adjunctive protective drapes to reduce operator radiation exposure was left to the operator's discretion and they were used only in radial procedures.

Radiation measurement

Patient and procedural radiation measures included fluoroscopy time (expressed in seconds) and the DAP (expressed in Gy · cm^2). The DAP is the product of the adsorbed dose to air (air Kerma) and the cross-sectional area of the x-ray field for all segments of an interventional radiology procedure. The DAP generally provides a good estimation of the total radiation energy delivered to a patient during a procedure and is correlated with the long-term risk of cancer. This parameter was measured using specially designed ionization chambers mounted at the collimator system and elaborated by a dedicated software.

Operator radiation exposure was measured using wearable personal electronic dosimeters placed at the left wrist (RADOS-RAD60; LAURUS Systems Inc, Ellicott City, MD) and at the thorax level outside the pocket of the lead apron (PM1610; Polimaster, Vienna, Austria) and expressed in μSv. In January 2014, a third dosimeter (PM1610; Polimaster) was available and was used to record the operator radiation dose at head level (in the middle front). All dosimeters have a Geiger-Mueller detector dedicated for x-ray, with an energy range of detection between 0.001 and 12.0 Sv. The radiation and operator measures were recorded at the beginning and the end of each procedure. For those patients who underwent a PCI after the diagnostic procedure, the measures of fluoroscopy time, DAP, and dose of the wearable dosimeters were reset after the end of the diagnostic procedure and restarted at the beginning of the PCI.

To take into account possible differences in patient radiation dose affecting the operator exposure, the DAP-normalized operator dose was also calculated.

End-point of the study

The primary end-point of the study was the operator radiation dose absorbed at the thorax level. We also prespecified as a secondary end point the radiation dose absorbed by operators at the left wrist and head levels. Finally, we also prespecified an analysis evaluating the radiation dose with the use of adjunctive protective drapes, according to the angiographic system used and according to the angulation of the radiation tube.

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The authors are solely responsible for the design and conduct of this study, all study analyses, the drafting and editing of the manuscript, and its final contents.

Statistical analysis

Continuous variables are reported as mean and SD for variables normally distributed and as median with interquartiles range for those not normally distributed, and were compared using analysis of variance if normally distributed or Kruskal-Wallis and Mann-Whitney *U* test if not.

Categorical variables are indicated as the absolute number and percentage and were compared by Pearson