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Please note: The authors have reported that they have no relationships relevant to the contents of this paper to disclose.

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RESEARCH CORRESPONDENCE

# Effect of Modern Dose-Reduction Technology on the Exposure of Interventional Cardiologists to Radiation in the Catheterization Laboratory

Interventional cardiologists are exposed to deterministic and stochastic effects of ionizing radiation, as evidenced by their increased risk of developing cataracts and left-sided brain tumors, respectively (1–3). The ClarityIQ dose-reduction system (Philips Healthcare, Amsterdam, the Netherlands) uses advanced real-time image noise reduction algorithms combined with an optimized acquisition chain (as real-time pixel shift and motion compensation algorithms reducing artifacts, image blur in fast moving areas of anatomy, and virtual collimation) that enable dose reduction while providing adequate image quality. This technology has been shown to reduce the dose of radiation received by the patient during invasive cardiology procedures (4). However, the impact of the ClarityIQ system on the exposure of operators to ionizing radiation in invasive cardiology catheterization laboratories (cathlabs) has never been quantified. In this context, we aimed to estimate the percent reduction in the radiation dose received by the operator that could be achieved using ClarityIQ dose-reduction technology in cathlabs. The population for analysis included all invasive coronary procedures performed in our center from March 2017 to June 2017. Four experienced interventional cardiologists are permanent practitioners at our institution, working in 2 cathlabs. Cathlab A is equipped with the Allura Xper FD10 system (Philips Healthcare), in service since January 2011; Cathlab B is equipped with the Allura Xper FD10 Clarity system (Philips Healthcare) inaugurated in March 2015. Both cathlabs are equipped with flat detectors with the same technical characteristics (frame rate of 7.5 fps for coronary angiography and 15 fps for ventricular angiography; 20 cm size of field; 1,024 × 1,024 matrix). The equipment undergoes half-yearly control by the manufacturer, and annual external quality control. The delivered dose and the quality of the image are checked. Tubes are replaced if their performance is <90% of the standard.

**TABLE 1 Comparison of Invasive Cardiology Procedures Between Cathlab A (No Dose-Reduction Technology) and Cathlab B (Equipped With ClarityIQ Dose-Reduction Technology)**

| | Cathlab A (n = 358) | Cathlab B (n = 219) | p Value |
|---|---|---|---|
| Male | 249 (70) | 152 (70) | 0.9 |
| Age, yrs | 65.5 ± 13.0 | 67.8 ± 12.1 | 0.04 |
| Body mass index, kg/m$^2$ | 27.8 ± 4.7 | 27.3 ± 5.4 | 0.2 |
| Approach | | | 0.5 |
| Radial | 309 (86) | 190 (87) | |
| Femoral | 49 (14) | 29 (13) | |
| Procedure with angioplasty of at least 1 lesion | 174 (49) | 89 (41) | 0.1 |
| Total x-ray time, min | 8.2 ± 6.7 | 7.9 ± 6.3 | 0.5 |
| Operator radiation dose, μSv | 7.0 ± 15.8 | 2.0 ± 3.2 | <0.0001 |
| Total air kerma, mGy | 379 ± 302 | 251 ± 202 | <0.0001 |
| Total dose area product, cGy.cm$^2$ | 3,034 ± 2,480 | 1,451 ± 1,058 | <0.0001 |

Values are n (%) or mean ± SD.
Cathlabs = catheterization laboratories.

The primary endpoint was operator radiation exposure, as assessed by a personal electronic dosimeter (APVL, Tours, France) with a silicon diode (μSv) located on the operator's left arm. Radiation doses were recorded at the end of each procedure. This measurement corresponds to the dose received at 10 mm under the site of the dosimeter (HP10), and represents the probability of stochastic health effects from radiation. Multivariate analysis was performed using generalized linear regression including all variables related to the primary endpoint with a p value <0.20 by univariate analysis. The multivariate model was adjusted for the operator. Analyses were performed using SAS version 9.4 (SAS Institute Inc., Cary, North Carolina). During the study period, there were a total of 577 invasive

coronary procedures performed by a single operator in our institution and were included in this analysis. Patient and procedure characteristics included in the analysis are shown in Table 1. The dose of radiation received by the operator in Cathlab B was on average 71% lower than that received in Cathlab A. By univariate analysis, the operator radiation dose was significantly associated with the arterial approach used ($p = 0.008$), the performance of angioplasty on at least 1 coronary lesion ($p < 0.0001$), and total x-ray time ($p < 0.0001$), but was not associated with body mass index ($p = 0.14$). By multivariate analysis adjusted for the operator, the cathlab where the procedure took place was independently associated with the operator's radiation dose ($p < 0.0001$), as was the use of the radial approach ($p = 0.0003$). Conversely, angioplasty of at least 1 lesion ($p = 0.20$) and body mass index ($p = 0.20$) were not found to be related to operator radiation exposure. Our study of unselected patients undergoing invasive coronary procedures demonstrates that operator radiation exposure is significantly reduced in cathlabs equipped with the ClarityIQ technology. In view of the deterministic and stochastic risks to which operators are exposed during invasive procedures, these findings should prompt catheterization laboratories to modernize their equipment.

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RESEARCH CORRESPONDENCE

# A Pilot Study for Left Atrial Appendage Occlusion Guided by 3-Dimensional Rotational Angiography Alone

Percutaneous exclusion of the left atrial appendage (LAA) by LAA occlusion is a nonpharmacological alternative for stroke prevention in patients at risk for thrombus formation (1). The procedure is mainly facilitated by 2-dimensional transesophageal echocardiography (TEE) in combination with fluoroscopy, which remains the imaging modality of choice today (2,3). Alternatively, 3-dimensional rotational angiography (3DRA) allows 3-dimensional reconstruction of the LAA volume with high accuracy in real time (4,5). As a pilot study, we prospectively evaluated the use and safety of 3DRA in providing adequate guidance as an alternative to TEE during LAA occlusion, with the operator blinded to TEE.

We designed a workflow where the entire procedure was performed using 3DRA and fluoroscopy alone, with TEE as a safety back-up. LAA thrombus was excluded by the TEE operator at the beginning of the procedure, while keeping the implanting operator blinded. At 4 pre-specified break points (transseptal puncture, size selection, deployment, release) the TEE operator was instructed to unblind the operator if and only if an immediate safety risk for the patient was perceived. A total of 20 procedures were performed in a pilot setting. Out of these, 1 was aborted because of access problems in extreme obesity. In all remaining cases device sizing, deployment, stability, and leak assessment were performed using fluoroscopy and 3DRA alone. In 1 patient, the LAA ostium proved to be too large to be occluded with even the largest size device. This was identified without TEE unblinding, and device release was never attempted.

Retrospective analysis of TEE and 3DRA datasets showed a mean maximum LAA ostial diameter of $21 \pm 3$ mm with TEE versus $24.3 \pm 3.5$ mm with 3DRA ($p < 0.05$; $R^2 = 0.64$). In all cases the largest diameter in any particular patient was observed in the 3DRA dataset (systemic bias, TEE underestimating diameter by 3.45 mm compared with 3DRA).

The device was successfully deployed in 19 of 19 attempts, and successfully released in 18 of 19 deployments. As mentioned, in 1 patient device release was never attempted because of complete lack of device compression (and thus device stability) in a