Reducing Dose in Cardiac Fluoroscopy Procedures:

A comparative analysis of dose data for LV lead placement cases using optimized dose protocols

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Background

Concern is growing about medical radiation exposure. Over the past two decades, total lifetime radiation exposure for people in the United States has doubled. Radiation from medical procedures accounts for much of the increase. Interventional cardiology (IC) and electrophysiology (EP) procedures, while accounting for 12 percent of all X-ray exams, are responsible for up to 48 percent of the total medical radiation exposure.\(^1\)

In addition to the well-known risks to patients, clinicians who perform fluoroscopy procedures face potential risks, as well. Exposure to radiation doses of less than 1 Sv were associated with increased incidence of nervous system tumors and the death rate from brain cancer in interventional radiologists was observed to be three times that for other medical specialists who do not use radiation.\(^2\) Additionally, this same study observed that the cancer risk was greater on the side of the head nearest the fluoroscopy.\(^2\) In a recent study, Roguin collected 36 cases of brain cancer in experienced interventionalists (12–32 years; mean 23 years), and identified the location (left or right side) in 30 of them. Of these, 26 of 30 (86%) were observed to be on the left side of the brain.\(^3\)

The concern over medical radiation exposure is reflected in recent regulatory initiatives by the U.S. Food and Drug Administration and The Joint Commission, and by legislative actions taken by states including California and Texas. In addition, hospitals typically have policies dealing with radiation dose, employ radiation safety officers, and organize quality committees that focus on radiation usage.

In exploring methods to optimize dose in cardiac fluoroscopy procedures, physicians at Scripps Memorial focused on left ventricular (LV) lead placements. These procedures helped revolutionize treatment of heart failure just since the turn of the 21st century. LV lead placements are more technically challenging than standard lead placements, requiring a venogram along with specialized placement tools and technical expertise. As such, the procedures last longer and require more fluoroscopy, and thus create greater potential radiation exposure to patients and clinicians. Furthermore, being localized in the heart, the procedures pose specific dose-related issues, notably skin exposure on the back. Techniques for optimizing dose in LV lead placements can be applied to reduce dose in other cardiac fluoroscopy studies.

Methods

The Scripps CRT Radiation Reduction Study proceeded in two parts:

- A retrospective study of radiation exposure in IC and EP cases, followed by clinician education.
- A prospective study of optimized radiation dosage in LV lead placements for cardiac resynchronization therapy (CRT) compared to retrospective controls.

Reviewing past cases

The study first compiled and analyzed data on radiation usage by each of the hospital’s cardiologists in both IC and EP procedures and compared each physician’s performance to the mean. Of particular concern were cases involving fluoroscopy times longer than 40 minutes. For 2013, the analysis found 56 such cases in IC (2.1 percent of the total) and 39 (2.8 percent) in EP.

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\(^3\)Roguin A. SOLACI 2014
IC and EP cases with greater than 40 minutes of fluoroscopy time were also tabulated by physician. The variation was substantial: The percentage of fluoroscopy use over 40 minutes among physicians ranged from zero to 18 percent.

The data was used to educate cardiologists about their specific radiation use and to apply peer pressure on outliers to improve. All received education about radiation reduction techniques using a 10-point scheme described below. A separate series of classroom instruction sessions were conducted for physicians and staff. Posters listing radiation reduction measures were placed in the lab as reminders.

**Measuring and optimizing**

The second step of the study began by retrospectively analyzing a single clinician’s previous six months of CRT procedures (20 cases) performed on a GE Innova* 2100 interventional X-ray system. The procedures were analyzed for dosage, duration of fluoroscopy, and other factors, including patient gender, weight, height, and body surface area. This created a baseline for comparison.

Then, using a 10-point program for radiation reduction developed with assistance of experts with GE Healthcare, the same operator performed eight additional procedures, eliminating the complication of variation among physicians. The radiation reduction protocol included:

- Increasing the source-to-object distance (SOD) from the X-ray tube
- Reducing the source-to-image distance (SID) by keeping the C-arm detector close to patient
- Collimating the field of view (FOV) by coning down without fluoroscopy and not magnifying
- Customizing the protocol for the lab’s daily setting
- Using automatic dose setting and automatic exposure
- Using a low detail setting
- Using the lowest acceptable frame rate (7.5 fps except when using .014 wire)
- Minimizing the duration of X-ray
- Using non-fluoroscopy EP imaging tools such as IVUS, CartoUnivu, 3D mapping, and robotic catheter positioning
- Avoiding cine angiography and instead using stored fluoroscopy

The LV lead insertion techniques did not change – only the protocols and procedures affecting radiation dosage.

![Figure 1](image1.png)  
**Figure 1** – Image using settings in place before implementation of dose reduction strategies – 15fps, normal detail

![Figure 2](image2.png)  
**Figure 2** – Image using settings after implementation of dose reduction strategies – 7.5fps, low detail

**Results**

A comparison of dose data from the CRT procedures showed that the dose-reduction protocol in the prospective studies limited the average radiation dose to the patients to 8 percent of the mean recorded in the retrospective data – or a dosage reduction of 92 percent for this facility and clinician as compared to their previous practice. The accompanying tables contain the detailed data.

**Table 1. Patient characteristics**

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<th>Post</th>
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<td></td>
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<td>Sex (%M)</td>
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<td>60</td>
<td>NS</td>
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<tr>
<td>Height</td>
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<td>1.76</td>
<td>NS</td>
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<td>Weight</td>
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<tr>
<td>BSA</td>
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<td>NS</td>
</tr>
<tr>
<td>EPT (Equivalent Patient Thickness)</td>
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<td>22</td>
<td>NS</td>
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**Table 2. Procedure parameters**

<table>
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<th></th>
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<td>SID (cm) Source-Image</td>
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<td>Table Vert (cm)</td>
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<td>FL time (sec)</td>
<td>436 (7.26 min)</td>
<td>169 (2.82 min)</td>
<td>p&lt;.05</td>
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<tr>
<td>Dose (mGy)</td>
<td>538</td>
<td>42</td>
<td>p&lt;.05</td>
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</table>
Based on the results, the dose reduction protocol has been implemented for all IC and EP procedures at all five Scripps Health hospitals.

Conclusions
The Scripps CRT Radiation Reduction Study confirms that the implementation of a radiation reduction program is feasible. The study observed a 92 percent reduction in average radiation dose as compared to previous practices for a sample patient population that did not present any statistically significant differences. This result was observed in equivalent procedures completed by the same implanter after enactment of a radiation reduction program. Although specific quantitative results will vary from facility to facility, patient to patient and clinician to clinician, it is possible to conclude that the application of this or a similar radiation reduction approach to other physicians and other EP and IC procedures is warranted and is applicable to hospitals worldwide.

Other observations:

- Because there is potential risk associated with all doses of radiation, it is incumbent upon all clinicians to strive for minimization of radiation dosage at all times. (ALARA)
- A challenging aspect of optimizing radiation dose is fostering the necessary changes in clinician and staff behavior.
- A successful radiation reduction program requires full participation among physicians, lab staff (radiology technologists and others) and the fluoroscopy technology vendor.

About the author
Steven L. Higgins, M.D., FHR, is chairman of the Department of Cardiology and Director of Cardiac Electrophysiology at Scripps Memorial Hospital, La Jolla, Calif. Dr. Higgins has been a practicing cardiac electrophysiologist for nearly 30 years. He and a staff of 12 electrophysiologists perform more than 1,500 EP procedures per year.

Dr. Higgins is a paid consultant for GE Healthcare and was compensated for preparing this study.

About the facility
Established in 1924 by Ellen Browning Scripps, Scripps Memorial Hospital La Jolla has been among Southern California’s premier medical centers for more than 80 years. Its wide range of clinical, surgical and specialty services include full-spectrum cardiac care. U.S. News & World Report ranked Scripps Hospitals and Clinics as the 20th best in the U.S. for heart and heart surgery. A $500 million state-of-the-art heart hospital, the Scripps Prebys Cardiovascular Institute, will open on the Scripps Memorial campus in early 2015. Scripps Memorial La Jolla is part of Scripps Health, a private, nonprofit health system in San Diego that includes four hospitals on five campuses, dozens of outpatient clinics, thousands of affiliated physicians, home health, and hospice care.
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