Use of a Sterile, Disposable, Radiation-Absorbing Shield Reduces Occupational Exposure to Scatter Radiation During Pectoral Device Implantation

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SIMONS, G.R., ET AL.: Use of a Sterile, Disposable, Radiation-Absorbing Shield Reduces Occupational Exposure to Scatter Radiation During Pectoral Device Implantation. *The aim of this study was to demonstrate the effectiveness of a radiation-absorbing shield in reducing physicians' occupational radiation exposure during pectoral device implantation. A sterile, disposable, lead-free radiation-absorbing surgical drape containing x-ray attenuation material was evaluated. Twenty procedures used the radiation absorbing drape, and 20 were performed without the shielding. Radiation exposure was measured using thermoluminescent dosimetry collar badges. Use of the protective shield was associated with a time adjusted 80% reduction in radiation dose (0.009 mrem/s with shielding vs 0.047 mrem/s without shielding, $P < 0.05$) to the physician performing the procedures. The radiation-absorbing surgical drape did not interfere with technical performance nor add procedural time, and all procedures were successfully completed. This study demonstrates that a sterile, disposable, radiation-absorbing drape provides a convenient means of augmenting conventional radiation shielding. Use of this protective shielding greatly reduces operators' occupational exposure to scatter radiation during pectoral device implantation without compromising sterility or procedural technique. (PACE 2004; 27[Pt. I]:726–729)*

fluoroscopy, x-rays, radiation protection, pacemaker, cardioverter defibrillator

Introduction

There is much concern over the potential adverse side-effects to individuals who are chronically exposed to ionizing radiation. For interventional radiologists and cardiologists who receive excessive exposure to ionizing radiation, there is an increase in adverse effects such as dermatitis, erythema, cataracts, and cancer.[1,2] More recently, there is growing consensus that exposure to even the lowest doses of ionizing radiation may increase overall cancer risk.[3–5] Although the significance of ionizing radiation at the very low doses used in routine noninvasive x-ray imaging continues to be somewhat controversial,[6] the most broadly accepted method for managing human exposure to ionizing radiation is the principle of as low as reasonably achievable (ALARA).[7] There is no established "threshold" below which exposure to ionizing radiation is safe, and individuals consistently exposed to ionizing radiation may be at risk for an increased incidence of cancer.[8]

Prolonged use of ionizing radiation is necessary for many x-ray fluoroscopy procedures, and there is significant concern about the occupational exposure to scatter radiation for the physicians who use it. Among practitioners who implant pectoral pacemakers and cardioverter defibrillators, this issue is particularly problematic due to the mandatory close proximity to the beam source causing more transfer of scatter radiation to the practitioner. Although pulldown shields are sometimes used, many implanting physicians find them to be cumbersome because, in contrast to their use during femoral procedures, they must be placed between the operator's torso and the sites of electrode manipulation.

Use of a sterile, radiation-absorbing drape has been demonstrated to reduce occupational radiation exposure during femoral interventional radiology procedures.[9] It is also known that a significant proportion of scatter radiation exits the patient along the skin surface inferior and lateral to the actual beam path during pectoral device implantation. This study tested the hypothesis that physicians' exposure levels can be reduced while implanting pectoral devices by placement of a radiation-absorbing shield in that region, outside the beam path.

Materials and Methods

A single practitioner (G.R.S.) in one laboratory performed 40 consecutive pectoral device implantations (32 pacemakers, 8 cardioverter defibrillators) using pulsed fluoroscopy (8 frames/s, 25 ms/frame, autoregulated to achieve 2.5 microR/frame) and only anteroposterior (AP) views. The first 20 cases (group A) were performed without

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special shielding. The subsequent 20 cases (group B) were performed using commercially available sterile bismuth-containing shields (RAD-PAD, Worldwide Innovations and Technologies, Overland Park, KS, USA). The rectangular 16.52 × 12 × 3/16 inches shields are supplied with a cut-out biopsy window along their top portion (Fig. 1A). Each shield was modified by folding over a small section to eliminate the window (Fig. 1B), and the resulting rectangle, measuring 13.25 × 12 inches, was placed onto the operative drape, just lateral to the incision, with its long axis pointing away from the patient (Fig. 1C), so that it covered the surfaces inferior and lateral to the beam path (Fig. 2). It was secured to the drape with a preapplied adhesive strip. Care was taken to place the shield outside the fluoroscopic field of view to avoid feedback increases in beam intensity.

Pacemaker and defibrillator implantations were performed via cephalic or subclavian access using standard operative techniques. Radiation exposure was measured using thermoluminescent dosimetry collar badges, which were worn only for these procedures and were stored with control badges when not in use.

Results

All 40 cases were performed successfully without procedural complications. The control badges had no detectable exposure. Fluoroscopy times and badge counts are shown in Table I. The mean fluoroscopy time was 64.4 seconds for group A and 78.3 seconds for group B. The increased group B fluoroscopy time, which was statistically insignificant, resulted from case complexity and was unrelated to the protective radiation shield device. Despite a slightly higher total fluoroscopy time in the group B cases, shield use was associated with a 77% reduction (60–14 mrem) in total radiation dose. In addition, there was an 80% time adjusted reduction in radiation exposure during protective shield use from 0.047 to 0.009 mrem/s. Both of these reductions showed statistical significance ($P < 0.05$).

Discussion

Radiation protection for medical personnel is the standard of care for procedures involving ionizing radiation, and this topic has been extensively investigated.[9–21] Although there has been a decrease in the occupational radiation dose for most medical workers, the areas of cardiovascular and interventional radiology appear to be exceptions.[1,9] This study tested the hypothesis that physicians' radiation exposure due to scatter radiation could be reduced through the use of a radiation-absorbing protective barrier during pectoral device implantation. By covering the surfaces that are the main source of scatter, this shield provided a significant reduction in practitioner exposure.

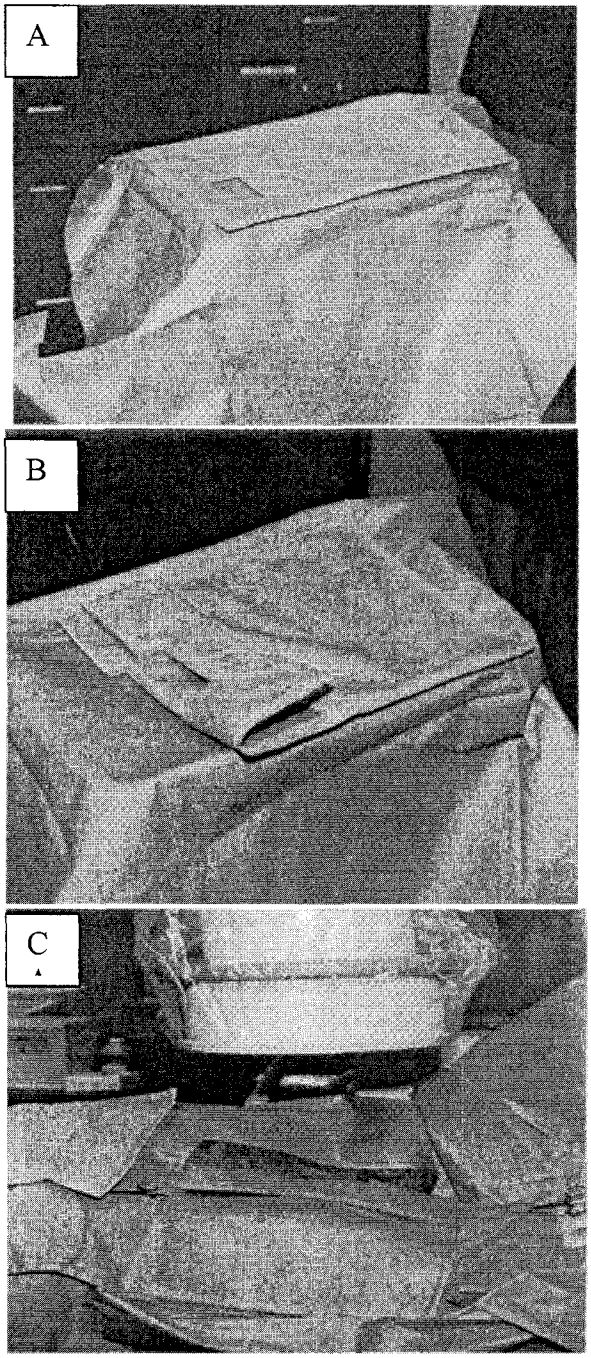

Figure 1. *Preparation of shield and placement in operative field. (A) The shield is provided as a rectangular drape with a biopsy window. (B) The window is removed by folding over its top part. (C) The shield is then placed lateral to the operative field, out of the primary beam path.*

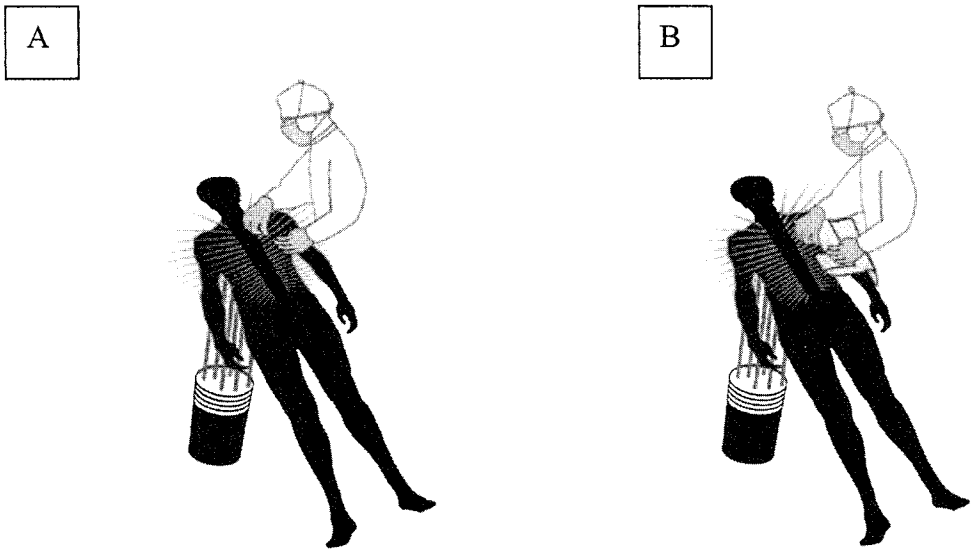

Figure 2. *Scatter radiation during pectoral device implantation with and without shield.*

The recommended exposure limit from the National Council on Radiation Protection is a total of 5 mrem per year. Without a shield, strict adherence to this recommendation would limit a single implanter to approximately 80 procedures per year. Although the effects from exceeding this upper limit may not be immediately apparent, the potential harm over the course of 1 year, career, or lifetime could be very large. With this in mind, the concept of ALARA becomes especially important.[7]

Practitioners who use x-ray fluoroscopy have traditionally modified three variables—time of exposure, distance from the beam source, and shielding—to limit exposure to scatter radiation. In the case of pectoral device implantation, the first variable can be significantly reduced by meticulous procedural technique, and it can be influenced further by the use of pulsed x-ray fluoroscopy.[21] Because implantation of pectoral devices requires close proximity to the patient, the second variable of distance is nonmodifiable and problematic. Thus, optimized practitioner shielding is of great importance during pectoral device implantation. Although lead gowns, thyroid collars, and glasses are used during these procedures, significant scatter radiation still contacts partially shielded and unshielded tissues.

At no point during these procedures did the shields impinge on the x-ray beam path. This is an essential issue, since most x-ray systems would automatically increase beam intensity via automatic brightness control feedback if this were to occur. The authors observed that placement of the shields lateral to the surgical site allowed gravity to keep the shields from slipping medially; thus, this was not a significant problem. Although none of the procedures in this study were biventricular implants, the authors have since routinely used the shields during left ventricular lead placement (unpublished data), and they have noted no beam-path interference despite the requisite angulated views and increased complexity of these cases.

The results of this study demonstrate that a sterile, disposable, radiation-absorbing drape provides a convenient means of augmenting conventional shielding without compromising sterility or procedural technique. Use of this drape greatly reduces occupational exposure to scatter radiation during pectoral device implantation. For high volume operators, large reductions in yearly radiation exposure can be easily achieved.

Table I.

Fluoroscopy Times and Radiation Counts

	Group A (without shields) N = 20	Group B (with shields) N = 20
Fluoroscopy time, seconds*		
Total	1288*	1565*
Mean	64.4*	78.3*
Total radiation dose, mrem	60†	14†
Time-adjusted dose, mrem/s	0.047†	0.009†

*P = NS. †P < 0.05.

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