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ORIGINAL ARTICLE

The Use of Radiation Attenuating Gloves Reduces Exposure to Scatter Radiation but not Direct Radiation

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Abstract

Objectives/Background: Diagnostic and interventional procedures are commonly performed under fluoroscopic guidance. The use of radiation attenuating gloves to reduce direct and scatter radiation to the hands of clinicians has been controversial. The purpose of this study was to determine whether the use of radiation attenuating gloves reduce direct and/or scatter radiation dose to the hands of the operator.

Materials and Methods: We estimated the radiation dose to the hands by using chicken drumsticks to simulate a human hand, and a torso phantom with chicken drumsticks on top of the torso phantom to simulate the source of scatter radiation. Standard aluminum oxide Luxel+ ring badges manufactured by Landauer (Glenwood, IL, US) were placed over the drumsticks (hand) to measure the radiation received by each hand. The detector inside the ring badges is made out of aluminum oxide and can measure doses ranging from 1 mrem to 1000 mrem. On two of the hands, 0.008” thick bismuth oxide lined radiation attenuating gloves from F&L. Medical Products, LLC (Vandergrift, PA, US) (gloves) were placed over the hands, and on two hands, no radiation attenuating gloves were used (non-gloved).

A pair of gloved and non-gloved hands were placed over the chicken-torso phantom (in radiation field) in the mid abdomen area, and the other pair of hands were placed at the groin (in scatter radiation). The radiation field was collimated to include the mid abdomen and hands in radiation field, and exclude the groin, the pelvis, and the scatter radiation hands. The radiation was turned on and off intermittently over 6 hours, at 80 kVp to simulate typical monthly radiation exposure a clinician receives. Radiation exposure readings were obtained in the standard fashion by Landaur.

We evaluated four groups: Group 1: Gloved hand in beam field; Group 2: Non-gloved hand in beam field; Group 3: Gloved hand inscatter radiation; and Group 4: Non-gloved hand in scatter radiation. The radiation was turned on and off intermittently over 6 hours to simulate typical monthly radiation exposure a physician receives.

Results: Total radiation dose for the ring badges were: Group 1: 5914 mrem; Group 2: 5626 mrem ; Group 3: 25 mrem; Group 4: 66 mrem.

Conclusion: The use of radiation attenuating gloves outside of the radiation field reduced the scatter radiation by approximately 62%; however when used in the radiation field, the actual radiation dose to the physician's hand appeared to increase slightly (5%).

Keywords

Radiation attenuating gloves, Scatter radiation, Hand, Interventional procedures

Introduction

Fluoroscopy-guided procedures are widely used in radiology as well as other specialties. While radiation attenuating thyroid shields and aprons are always utilized during procedures, the use of gloves remains controversial. As the hands are in or near the radiation field, the hands are at risk for both stochastic and deterministic radiation damage.

The As Low as Reasonably Achievable (ALARA) principle dose limit recommended by the International Commission on Radiological Protection (ICRP) to the

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hand is 500 mSv/year [1]. Controlling for time, Scheuler, et al. reports that monthly radiation exposure to the hand for providers ranges from 26.7 mrem to 53.3 mrem [2].

The purpose of this study was to determine whether the use of lead-free gloves reduced radiation dose to the hand, both from direct radiation in the field and from scattered radiation.

Methods

In this study, we evaluated four experimental groups to determine levels of radiation exposed to phantoms when in and near an x-ray beam. We estimated the radiation dose to the hands by using chicken drumsticks to simulate a human hand, and a torso phantom with chicken drumsticks on top of the torso phantom to simulate a source of scatter radiation. Standard aluminum oxide Luxel+ ring badges were placed over the drumsticks (hand) to measure the radiation received by each hand. The detector inside the ring badges is made out of aluminum oxide and can measure doses ranging from 1 mrem to 1000 mrem.

On two of the hands, 0.008" thick bismuth oxide lined radiation attenuating gloves (gloves) were placed over the hands, and on two hands, no radiation attenuating gloves were used (non-gloved).

A pair of gloved and non-gloved hands were placed over the chicken-torso phantom (in radiation field) in the mid abdomen area, and the other pair of hands were placed at the groin (in scatter radiation). The radiation field was collimated to include the mid abdomen and hands in radiation field, and exclude the groin, the pelvis, and the scatter radiation hands. The radiation was turned on and off intermittently over 6 hours, at 80 kVp to simulate typical monthly radiation exposure a clinician receives. Radiation exposure readings were obtained in the standard fashion by Landaur.

Thus, we evaluated four groups: Group 1: gloved hand in beam field; Group 2: non-gloved hand in beam field; Group 3: gloved hand in scatter radiation; and Group 4: non-gloved hand in scatter radiation.

Results

The radiation dose in group 1 was 5914 mrem, 5626 mrem in group 2, 25 mrem in group 3, and 66 mrem in group 4.

The results indicate that when directly in the beam field, the use of attenuating gloves did not help reduce radiation exposure. However, when adjacent to the beam field, the use of gloves substantially helped in reducing exposure to scatter radiation (Table 1).

Discussion

Certain radiation protective equipment is universal in rate of use. While lead aprons and thyroid shields are required protective equipment, the use of radiation attenuating gloves is optional. However, there has been concern that use of gloves may increase, rather than decrease radiation exposure to the hands of the clinician. A report by Lynskey, et al. reported that interventionalists regarded lead aprons and thyroid shields as "essential safety," but considered radiation attenuating gloves optional or not helpful [3]. However, Kamusella, et al. and King, et al. both reported that the use of attenuating gloves containing bismuth significantly reduced radiation dose to the interventionalist when exposed to scatter radiation [4,5].

Miller, et al. and members of The Cardiovascular and Interventional Radiological Society of Europe recommend against using lead gloves and suggest avoiding the x-ray beam for protection. However, they support using lead gloves while outside, but near the radiation beam [6]. Kim, et al. agrees with this notion as they concluded that a 20 cm longer distance from the edge of the radiation table can be more effective than the use of radiation attenuating gloves. However, the synergistic effect of being further away from the table and using radiation attenuating gloves had the greatest effect [7]. Wagner, et al. reports that when in the beam's field, glove use can be contraindicated as the presence of forward and backward scatter x-rays can increase radiation exposure [8].

The International Atomic Energy Agency (IAEA) recommends against using lead gloves when directly in the path of the x-ray beam. This is because the automatic exposure control (AEC) system will adjust the kilo voltage in order to maintain a diagnostic image. With lead gloves in the way, the radiation will be absorbed by the gloves instead of the image receptor. The AEC system will then continue to increase radiation until it reaches the pre-set radiation level set by the operator [9]. The IAEA also mentions that when wearing lead gloves in the beam field, interventionalists may feel that the glove will provide adequate protection and extended time in the beam field would cause trivial harm. However, the IAEA remarks that leaded gloves can reduce radiation exposure to the hands by up to 30% as long as the hands are kept out of the direct path of the beam [10].

Since most clinicians keep their hands away from direct radiation, our study recommends the use of attenuating gloves acts as an important piece of safety equipment when exposed to scatter radiation. We also exposed the phantom to 6 hours of direct and scatter

Table 1: Radiation exposure in each group.

Exposure type	Group	Dose (mrem)
Shallow dose equivalent	1	5914
Shallow dose equivalent	2	5626
Shallow dose equivalent	3	25
Shallow dose equivalent	4	66

radiation, despite most clinicians not exposing their hands to direct radiation during procedures. Our study was also unique in that we examined the use of lead-free gloves, despite most research on this topic being geared towards leaded gloves.

Conclusion

Our study examined the use of newer protective gloves that provide radiation safety with non-leaded material. While much of the research regarding radiation protection is geared towards leaded equipment (aprons, gloves, thyroid shields), equipment that is coated with attenuating properties such as bismuth or antimony can provide enhanced protection without sacrificing dexterity to the clinician. The bismuth-containing gloves used in our study substantially reduced exposure to scatter radiation while providing no benefit when in the beam's field. Therefore, we recommend clinicians try to keep their hands away from the direct beam at all times, while wearing protective gloves when outside the beam's field.

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There are no conflicts of interest to report relevant to this study.

Author's Contribution

All authors contributed equally to the production of this manuscript.

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