Measuring Radiation Dosages using Standard Fluoroscopy and Mini C-arm at Varying Distances in the Operating Room

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Statement of Purpose

With continual use of fluoroscopy during foot and ankle surgeries, the importance of understanding safe zones and necessary precautions for the team are becoming more applicable. We aim to measure the dose of absorbed radiation (with and without lead) during 1 minute of continuous exposure from both machines at the most common distances in the operating suite. These include the Surgeon (In field), Surgical Technician/Surgical Representative (4 feet) and Anesthesia Team/circulating Registered Nurse (9 feet).

Figure 1. Labeled dosimeters

Figure 2. Set up With Mini C-arm

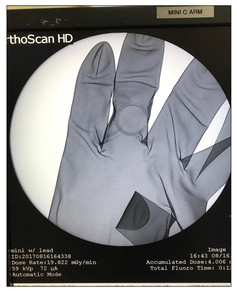


Figure 3. Lead glove with ring dosimeter on C-arm screen

Methodology & Hypothesis

In a customary operating room of 20 ft. X 20 ft., a standard set up including an operating room table, back instrument table and anesthesia machine were positioned in the room with the fluoroscopy machine located at the foot of the bed. A stand and whole body dosimeter were placed 9 feet from the location of the C-arm representing anesthesia and the circulating nurse location. A whole body dosimeter was placed 4 feet and to the left from the C-arm on the back instrument table representing the surgical technician. Finally, a ring dosimeter was placed directly in the field on the x-ray tube representing the surgeon or assistant positioning the foot.

We hypothesized that the standard fluoroscopy machine would emit more radiation than the mini C-arm with and without lead to the staff. We also believed the Surgeon and Scrub Technician (4 feet) would experience the most radiation.

Procedure

After room set up, a mini- C arm was turned on for one minute without interruption at an automatic setting of 51 kVp. The dosimeters were collected and placed in a package outside the operating room. Lead aprons measuring .5mm thickness were then brought in and placed in front of the two whole body dosimeters while the ring dosimeter was placed inside a radiation attenuating surgical glove with a lead equivalency of .05mm. The mini C-arm was then turned on for one minute without interruption at an automatic setting of 59 kVp. The dosimeters were collected and placed in a package outside the operating room. A standard operating room C-arm then replaced the mini and the same process described above was performed with kVp of 51 and 44. All dosimeters were packaged and sent to Mirion Technologies for data analyzation.

Literature Review

The use of intra-operative fluoroscopy in foot and ankle surgery has become a routine process for a surgeon and their staff. Typically a mini C-arm is operated by the surgeon and used for forefoot procedures while a standard C-arm is operated by a Radiologic Technologist and used for hindfoot/rearfoot procedures.

A trend in the increase use of the mini c-arm in extremity surgeries came after comparative studies of a standard fluoroscopy machine and a mini C-arm which showed significant reduction in radiation using the mini [1]. However some studies do show that exposure time was significantly longer with the mini C-arm but had no effect on overall radiation doses [2]. The long term effects of low-dose-radiation are still unknown with most surgical staff concern for infertility or thyroid disease. To help reduce radiation effects, The American College of Radiology provides an occupational ALARA (As Low As Reasonably Achievable) dose of 5 REM or 5000 millirem for whole body including head, trunk, organs and gonads and an occupational safe dose for the skin of an extremity of 50 REM. To reduce radiation doses, one can increase distance from the X-ray tube and/or wear a lead apron during surgical procedures. The general guideline today is 6 feet or 2meter away from the x-ray tube and the recommended thickness of a lead apron is .5mm [3].

Results

A total of twelve badges were used to measure millirems (unit of absorbed radiation dose) in the operating room. Of the twelve badges only four recorded millirems over one during the 1:00 min period of live fluoroscopy. The surgeons hand badges for standard and mini C-arm both with and with out lead were the only badges to register over 1 mrem. All other badges located at four and nine feet ,with and without lead, from the x-ray tube presented with an asterisk indicating that there was less than 1 mrem on the badge at time of analyzation.

The reading from the four badges with over 1 millirem were as follows:
Mini C arm surgeon hand with out lead 474 millirems
Mini C arm surgeon hand with lead 42 millirems
Large C arm surgeons hand with out lead 626 millirems
Large C arm surgeons hand with lead 27 millirems

Conclusions

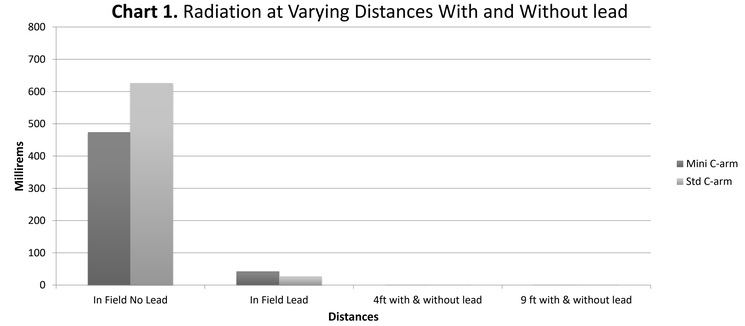
While using live fluoroscopy in foot and ankle cases, our research concluded there is of great benefit for the surgeon to wear .5mm lead apron and radiation attenuating lead gloves due to the significant decrease in radiation exposure from both the mini and standard fluoroscopy machine. For cases requiring 1 minute of exposure time or less (i.e. standard bunionectomys, hammertoe arthroplastys, retrocalcaneal exostectomys) our study showed at the distance of four and nine feet from the x-ray tube, radiation was negligible and therefore the choice of lead could be left to the discretion of the surgical team member.

Discussion

We chose to measure one minute of continuous fluoro due to the median exposure time shown to range from 13 seconds for midfoot arthrodesis to 77 seconds for ankle arthrodesis [3]. Even at this length of exposure, at four and nine feet from the x-ray tube, less than 1 millirem was recorded. However, at our reported dosage of 42 mrem for the mini C-arm with lead, extrapolating the data out for an average of 4 cases/week, 52 weeks/year, resulted in an exposure to the skin of an extremity at 8,736 mrem which is 17% of the allowed occupational dosage. The mini C-arm data without lead resulted in 98,592mrem almost double the allowed occupational dosage.

Our ring dosimeter experienced the most detectable dosage however it was placed directly in the field on both the C-arm tubes which is considered improper technique creating high exposure when compared to the object being placed closer to image intensifier. In a previous study looking at hand surgeon's exposure from the mini c-arm, they concluded the surgeons hands with no lead protection were exposed to an average of 20mrem per case which is equivalent to the exposure a patient receives with a chest x-ray [4]. Our study revealed results using lead protection of 42mrem per 1 minute (average case). The use of radiation attenuation sterile gloves are more commonly used in cardiovascular intervention procedures and spine surgeries however make an excellent option to help protect the busy foot and ankle surgeon. The specialty gloves cost on average forty dollars a pair compared to standard sterile gloves of five dollars a pair, a more affordable option could be the use of sterile standard supplies such as a gauze bandage roll or lap sponge to help position the foot during the case.

Chart 1. Radiation at Varying Distances With and Without lead



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