

Radiation Exposure with Use of the Mini-C-Arm for Routine Orthopedic Imaging Procedures

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INTRODUCTION

The use of mobile fluoroscopic devices in orthopedic procedures results in significant concern with regard to the radiation exposure to the surgeons and their support staff. The perceived increased risks are well documented with regard to large c-arm devices. However, no study to date has documented the relative radiation risk associated with the use of a mini c-arm. The current study was designed to determine the amount of radiation received by the surgeon during use of the mini-c-arm in comparison with documented measurements associated with the large c-arm. Radiation exposure to surgical personnel is dependent on relative fluoroscopic beam orientation to the patient, total exposure time, distance from the beam to the surgeon, surgeon positioning within the operative field, and use of protective lead garments and shields. The purpose of this study was to quantify the amount of scattered radiation present during a typical mini c-arm examination and utilize this data to determine the relative risk of radiation exposure to the surgeon with extended use, assess whether or not modifying surgeon positioning is pertinent, and determine if protective shielding should be employed.

METHODS

The OEC MINI 6600 Digital Mobile C-arm combines a small C-arm with enhanced fluoroscopic imaging and is used for imaging extremities at low entrance exposure and scattered radiation levels.

The experimental setup makes use of anthropomorphic phantoms positioned as a patient might be positioned within the C-arm for a typical forearm or ankle exam. The anthropomorphic phantoms incorporated were composed of human bones surrounded by tissue-simulative material. Air kerma measurements were made in the plane parallel to the floor at various radial distances from the phantom. These measurements were representative of the amount of scattered radiation the orthopedic surgeon performing the procedure was exposed to. The fluoroscopic technique factors were set automatically by the automatic brightness control system in the normal fluoroscopy mode of the mini c-arm. The forearm techniques were found to be higher than the ankle exam values due to the fact that the phantom was positioned midway between the x-ray tube and image intensifier, thus resulting in a magnified image. Because of its proximity to the x-ray tube, the radiation incident on the forearm phantom was also significantly higher than on the ankle phantom.

A Radical Industries MDH model 1015C radiation meter (Monrovia, CA) with a 180cc pancake ion chamber was used to measure exposures (in mR). Thirty-second exposure readings were then obtained at distances of 20, 40 and 60 cm from the center of the phantom. Air kerma rates in mGy/min were determined from these exposure measurements, and the average air kerma for a typical exam was estimated using an exam time of 5 minutes. The mini C-arm was equipped with an alarm that alerts the user after 5 minutes of fluoroscopy.

RESULTS

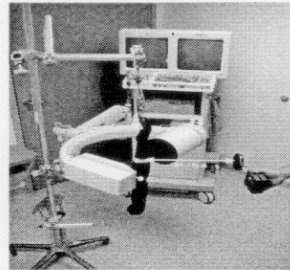


Figure 1: Forearm Examination Setup

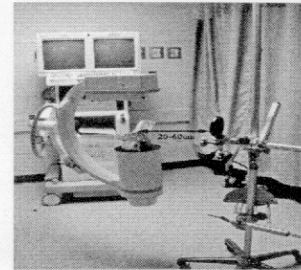


Figure 2: Ankle Examination Setup

NCRP Recommended Annual Dose Limits	Whole Body	Hand/feet	Eye Lens
	50 mSv	500 mSv	150 mSv
Total Number of Cases Allowable Before Limits Hit			
Unshielded Surgeon Positioned 20cm from Mini C-arm (Forearm)	1,250	12,500	3,750
Unshielded Surgeon 40cm from the Mini C-arm (Forearm)	5,000	50,000	15,000
Unshielded Surgeon Positioned 20cm from Large C-arm (200Gy/hr)	50	345	300

Figure 3. Comparison of number of 5-minute fluoro cases required to exceed NCRP occupational radiation exposure limits for mini c-arm and large c-arm

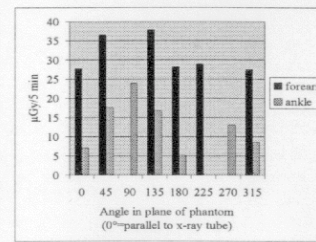


Figure 4. Radiation levels versus position for the mini c-arm

DISCUSSION

When performing fluoroscopy, the distance to the radiation source and the relative spatial orientation of the beam during imaging determine the amount of radiation received.

Based on the results of our current study, the exposure levels from the miniature c-arm are substantially less at much closer distances than previously published reports with the large c-arm. We have seen a greater than 92- 98% reduction in direct exposure rates when compared with the large c-arm unit in similar positions.

With regard to orientation of the miniature c-arm, radiation levels in general were lower when the phantom was closest to the image intensifier with the unit positioned in an inverted manner resulting in exposure rates averaging 58% less for the ankle examination as compared to the forearm exam.

Aside from the aforementioned techniques, the orthopedic surgeon can most readily and effectively limit radiation exposure from the large c-arm by using leaded shielding and reducing total fluoroscopic time. Despite all the measures previously discussed, any surgeon that consistently uses fluoroscopy will remain at an elevated risk of suffering from any of the numerous negative effects caused by radiation throughout their lifetime.

CONCLUSION

On the basis of our current data, it is clear that use of the miniature c-arm is substantially safer than that of the large c-arm and is associated with significantly lower occupational exposures as measurements both within the beam and at various distances from the beam. Given these findings, we feel that some of the indispensable precautions required for use of the large c-arm are not applicable to the miniature fluoroscopic unit. Due to its afforded safety and less cumbersome use, we would strongly advise utilization of the miniature c-arm instead of the large c-arm whenever clinically applicable.