Study on the Intraoperative C-Arm Radiation Exposure in Orthopaedic Surgeries

[1]Dr. Joel Prasad G.L, [2]Dr. K Raghuveer Adiga

[1,2]Father Muller Medical college Hospital, Kankanady, Mangalore, India

Abstract: **To assess the intra-operative screening dose, screening duration, number of improper images taken and the effect of experience of the orthopaedic surgeon and the C-arm technician on the screening dose and duration of the C-arm machine in orthopaedic surgeries.**

Methodology: The study was conducted for a period of 2 calender months (Between September 2015 - November 2015). All the orthopaedic cases satisfying inclusion criteria have been taken into account. The intraoperative Fluroscopy screening dose, screening duration, number of improper images taken for each orthopaedic procedure was tabulated and compared based on the experience of the surgeon and the imaging technician.

Results: The total number of images taken , total exposure time and the total exposure dose for a given surgery was found to be significantly higher when the surgery was carried out by a senior resident (P-Value .002) and when the Fluroscopy machine was operated by a student or an intern (Medical imaging technology) . Open reduction and internal fixation of fractures required less exposure to fluroscopy when compared to closed reduction and fixation. The experience of the surgeon didn't significantly affect the total duration of the surgery.

Conclusion: The experience of the surgeon and the imaging technician significantly affects the intraoperative fluoroscopic radiation exposure. The exposure time and the dosage was far less when the surgery was carried out by an experienced surgeon and when the fluoroscopic unit was handled by an experienced faculty from the medical imaging department.

Keywords: **C-arm operating technician, fluoroscopic unit.**

1. INTRODUCTION

Radiography has significantly improved the physician's capability to diagnose accurately and treat musculoskeletal disease and injury [1]. In orthopaedic surgery, intraoperative fluoroscopy is very much indispensible [2]. However, as the fluoroscopic imaging is commonly used, there is increasing concern with respect to the occupational safety in the operating room (OR) [3, 4]. Frequent use of fluoroscopy exposes the trauma surgeon and the surgical staff to dangerous doses of radiation [1, 4-9].

The health risks associated with radiation exposure is dependent upon the intraoperative exposure time, intra-operative screening dose , cumulative career exposure and the effectiveness of the protective measures that have been utilised [4, 9]. The screening dose and the duration in addition to depending on the procedure, also depends on the experience of the surgeon and the C-arm operating technician.

The surgeon dose can vary 10 to 12-fold depending on the orthopaedic procedure [4, 9, 10]. Unfortunately, most of the surgeons and the surgical staff remain relatively ignorant regarding the specific risks and effects of radiation [1, 2, 9, 11, 12]. This is due to the generally perceived insignificance of exposure in the operation theatre, as compared to the sources of higher radiation dose, like nuclear weaponry or nuclear industrial equipments [14, 15]. It is very much important to understand that even relatively very small amounts of radiation dose can actually result in cumulative tissue damage [1]. Hence it is generally accepted that the exposure should be significantly minimized whenever possible [1, 16, 17]. Surgeons and the surgical staff should work to increase their understanding and knowledge of the exposure risks, and also to improve adherence to the protection procedures. Further, surgical approaches, techniques and technologies which are capable of reducing dependence on repeated or excessive intraoperative fluoroscopy should be utilized if possible.

The international commission for radiological protection recommends –

The total effective dose limit of 20 mSv. Per year, averaged over a period of 5 consecutive calendar years. Effective dose limit in a single year is 50 mSv.

Objectives:

•Assess the intraoperative C-arm screening dose for each orthopaedic surgery.

• Assess the intraoperative C-arm screening duration for each orthopaedic surgery.

•Assess the amount of unwarranted C-arm radiation to which the surgeon is exposed as a result of improper images taken.

Improper images (images requiring repositioning / realignment of the machine thereby an additional exposure is required to get the desired image)

✓ Images of the field other then the desired field taken due to wrong positioning of the C-arm machine.

✓ Images taken in an oblique view (Other than true AP or Lateral)

✓ Blurred images taken due to movement of the machine (an unlocked machine) or movement of the limb while taking the image.

✓ Images taken wherein only a part of the required field is visualized.

•To assess the effect of Experience of the Surgeon on the screening dose and duration

✓ Based on the number of C-arm images asked for.

•To assess the effect of Experience of the C-arm technician on the screening dose and duration.

✓ Based on the number of Improper images taken.

2. MATERIALS AND METHODS

Study type:- An Observational study

Duration:- 2 months

Sample size:-60 (All the surgical cases in the 2 months of study) satisfying inclusion and exclusion criteria given below will be selected by purposive sampling.

METHOD OF COLLECTION OF DATA:

The fluoroscopic device used was a mobile C-arm (Philips BV 25 Gold, Philips Medical Systems, Netherlands) inspected at regular statutory checks. Automatic mode was employed wherein the the C-arm machine sets the screening dose automatically based on the amount of the soft tissue envelope at the surgical site. The machine was controlled by a c-arm technician (trained in imaging technology) who would take an image when asked by the surgeon. A standard fluoroscopy format was employed; shutters and a collimator were not used for any of the procedures. Two standardised set-ups were used for the device : (1) vertical fluoroscopy (Antero-posterior view) wherein the X-ray source is under the patient and the image intensifier above the patient, and (2) Horizontal fluoroscopy (Lateral view) wherein the X-ray source is on one side of the patient and the image intensifier on the other side, placed parallel to the ground. Oblique images were taken when necessary..

The image intensifier set the potential difference in kilovolts (kV) and the current in milli-amps (mA) automatically. The details of the cases that were performed, image intensifier output were recorded. The operation data collected also included the case type, the screening time (min) and dose output from the image intensifier in milliGrays.square centimetres (mGy.).

-Screening time of the c-arm for each surgery as measured by the C-arm machine,

-Screening dose of the c-arm for each surgery as measured by the C-arm machine.

-Total number of improper images taken requiring repositioning of the C-arm machine as calculated by the assistant surgeon/resident.

-The data collected is tabulated for each surgery and analysed.

SOURCE OF DATA:

a) INCLUSION CRITERA:

All the patients who would undergo

-Elective Orthopaedic surgical intervention requiring C-Arm imaging

-Emergency Orthopaedic surgical intervention requiring C-Arm imaging

b) EXCLUSION CRITERIA:

-Images taken prior to incision

-Images taken following closed reduction

-Images taken to localize the surgical site

3. RESULTS

The frequency of fracture fixation was highest for Tibia (12) followed by hip (10) (Fracture of the neck , Inter-trochanteric and subtrochanteric fractures) during the period of study. The frequency of surgeries carried by Senior residents accounted to 40% , while the surgeries carried out by a professor , associate and assistant professors were 10% , 18.3% and 31.7% respectively. With regards to the C-arm technician , the C-arm machine was operated by students (pursuing undergraduation in medical imaging technology) in 40% of procedures , by interns in 20% and by the faculty in 33.3 % .

The total number of images taken , total exposure time and the total exposure dose for a given surgery was found to be significantly higher when the surgery was carried out by a senior resident (P-Value .002) when compared to those carried out by a professor , assistant professor or associate professor. The exposure time and the exposure dose didn't significantly alter when the surgery was performed by the professor , associate or the assistant professor. The total number of extra images asked for was higher when the C-arm machine was operated by students and interns than when operated by the Imaging faculty. Metatarsal fracture fixation using closed reduction and K-wiring needed more exposure time when compared to rest of the surgeries which were operated with closed reduction and fixation. Open reduction and internal fixation required less exposure to fluroscopy when compared to closed reduction and fixation. The experience of the surgeon didn't significantly affect the total duration of the surgery.

	Frequency	Percent
Tibia	12	20.0
Supracondylar fracture (Femur)	5	8.3
Metacarpal fracture	4	6.7
Metatarsal fracture	3	5.0
Hip fractures	10	16.7
Femur- Shaft fracture	3	5.0
Distal radius fracture	9	15.0
Humerus shaft fracture	3	5.0
Ankle fracture	5	8.3
Other fractures	6	10.0
Total	60	100

No. of cases performed by the Orthopaedic surgeons

Qualification	Frequency	Percent
Professor	6	10.0
Associate Professor	11	18.3
Assistant Professor	19	31.7
Senior resident	24	40
Total	60	100

No. of cases attended by the C-Arm technicians

Qualification	Frequency	Percent
Student	24	40.0
Intern	16	20
Faculty	20	33.3
Total	60	100.0

P value to compare the experience of the doctor

	Kruskall wallis test value	p-value
TOTAL NO. OF IMAGES TAKEN	14.929	.002, HS
NO. OF EXTRA IMAGES TAKEN	13.717	.003
TOTAL EXPOSURE TIME (SEC)	15.084	.002, HS
TOTAL EXPOSURE DOSE (mGy)	9.825	.020
TOTAL DURATION OF SURGERY (MIN)	1.825	.609

P-Value to compare the experience of the C-arm technician

	Kruskall wallis test value	
Total number of images taken	0.405	0.817
Total number of extra images taken	1.662	0.436
Total exposure time	0.280	0.869
Total exposure dose	0.601	0.741
Total duration of surgery	1.412	0.494

4. CONCLUSION

Orthopaedic surgeries involve significant intra-operative c-arm radiation exposure. From the study conducted , we can infer that the experience of the surgeon and the c-arm technician does play an important role in minimising the exposure to radiation. Standard guidelines are required regarding the use of fluoroscopy for each orthopaedic procedure. The presence of an experienced surgeon and the imaging technician during the time of surgery is important as it led to reduced number of images asked for and also reduced number of improper images taken. All the radiation protective measures must be utilized to minimize and to prevent the harmful effect of radiation.

5. LIMITATION OF THE STUY

✓ The amount of radiation a surgeon is likely to get exposed is calculated.

✓ The actual amount of radiation to which a surgeon is getting exposed is not calculated as Dosimeters were not included in the study.

✓ The contribution of the surgeon towards the number of improper images taken (Moving the limb at the time of imaging, holding the limb in an oblique direction , etc) is not accounted .

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