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RESEARCH ARTICLE

A Study to determine the average Number of X-Rays taken during an Orthopaedic surgery and approximate amount of radiation exposure.

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Abstract

A prospective study was done in a series of 08 different common Orthopaedic surgical procedures at Princess Esra Hospital, Hyderabad, the number of X-Rays taken were calculated which were different for different procedures, amount of radiation exposure differed depending on the duration and surgeons experience were calculated using C-Arm.

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Introduction:-

Radiation exposure for patients, physicians, and staff has become an issue of concern in present day orthopaedics. For physicians and surgeons, the largest radiation exposures involve fluoroscopy use with either fixed or mobile units. For patients, fluoroscopy (C-arm), computed tomography (CT), and nuclear medicine studies constitute the vast majority of exposures. The use of each of these modalities has grown dramatically with changes in the practice of medicine. C-arm use in orthopaedic surgery is increasing rapidly as surgery transitions to minimal-access surgery. With less direct visualization, surgery is being conducted with fluoroscopic guidance. Orthopaedic surgeons are exposed to ionizing radiation during intra-operative fluoroscopy in procedures such as Humerus, Femur and Tibia Nailing, Spine fixation/Laminectomy, Radius and Ulna fractures and number of procedures requiring X-ray examination and at our institution one surgeon performs approximately 50- 60 such operations per year and have a higher radiation exposure per year. During fluoroscopy, the surgeon is exposed to either primary or scatter radiation due to the necessary proximity to the fluoroscope. The assistant surgeon, nurses, and anaesthetists are better protected against radiation from the fluoroscope because they can distance themselves from the fluoroscope when it radiates, thus the exposure is reduced to nearly immeasurable values[1]. However, it must be remembered that the shielding is only relative and most shields do not filter out the entire X-ray beam [2]. During fluoroscopy, the distance to the radiation source (the patient in the case of scattered radiation) determines the amount of radiation exposure according to the inverse square law, which states that the exposure decreases proportionately to the square of the distance between the source and the object of concern. Giachino and Cheng [3] first commented on this principle in a cadaveric hip-pinning study in which a 750-fold reduction in radiation was noted when the measuring equipment was moved 18 in (45.7 cm) from the fluoroscope. Several subsequent authors have documented similar findings2-5. Increasing the distance from the source in order to decrease radiation exposure is a beneficial guideline for operative personnel; however, the dilemma for surgeons is that close proximity to the beam is routinely required for such procedures as maintenance of a difficult reduction or freehand placement of interlocking screws. In

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addition, other dose-reduction techniques based on geometric considerations, such as positioning the patient adjacent to the image intensifier, may be limited by the practical demands of the procedure. With the introduction of smaller c-arm devices, fluoroscopic imaging is now routinely used for fracture treatment in the emergency room and for outpatient orthopaedic procedures because of the portability, convenience, and ease of use of the equipment [4]. Ionizing radiation which specifically refers to radiation waves carrying enough energy to remove electrons from atoms or molecules, thereby generating excessive free radicals capable of inducing cellular damage [5]. This damage increases with the energy of the radiation wave and with higher frequency of exposure, limiting the potential for cell recovery [5]. However, ionizing radiation remains harmful even at relatively low levels [6]. Morphological and functional damage has been observed in some cells dosed with as little as 0.001 rad [6]. Cellular damage from ionizing radiation has been reported for the skin, eyes, gonads, and blood, with the most important long-term concern being cytogenetic and chromosomal damage resulting in increased risk of carcinogenesis [7, 8, 9].

Aim:-

To calculate the average number of x-rays taken during an orthopaedic surgery and to determine the approximate radiation exposure during the procedure.

Objective:-

The objective of this study was to directly measure the Average Number of X-Rays taken during an orthopaedic surgery using c-arm and to measure the approximate radiation exposure which depends upon the type of procedure and surgeon's experience.

Materials and Methods:-

A prospective study was done in a series of 08 different orthopaedic surgical procedures at Princess Esra Hospital, Hyderabad, the number of X-Ray shots taken were calculated along with time taken for x-rays assuming each shot to take one second, which were different for different procedures. Amount of radiation exposure which differed depending on the duration and surgeon's experience were calculated using C-Arm.

The numbers of X-rays taken by C-arm for different surgeries at PEH in 2yrs involving 262 patients were studied:

| | Type of procedure | Number of Procedures |
|---|-----------------------------------|----------------------|
| 1 | Supracondylar Humerus fractures. | 18 |
| 2 | TENS for Radius and Ulna. | 20 |
| 3 | IL Nail Humerus cases. | 10 |
| 4 | Proximal Humerus cases. | 16 |
| 5 | Distal Radius cases. | 38 |
| 6 | Spine fixation/Laminectomy cases. | 32 |
| 7 | Hip(IT fracture) cases. | 68 |
| 8 | IL Nail femur. | 60 |

Calculations:

1 rad = 1 rem

100 rems = 1 sievert (Sv) = 1000 millisieverts (mSv)

Taking regular C-Arm exposure (rad): 4.0 rad/min [10]

: 4.0 rad/60 sec

: 0.066 rad/ sec.

So 0.066rads of exposure was observed per shot of X-ray taken, based on which approximate calculation of radiation exposure was calculated.

Example: If it took maximum of 12 X-ray shots for distal Radial fracture fixation with k-wires, it implies an exposure of 12 x 0.066 i.e., 0.792 rads.

Radiation exposure estimates for common radiographs [10]:

| S.No | Radiographic Procedure | Exposure (rad) |
|------|--|--------------------|
| 1 | Chest Radiograph | 0.025 rad |
| 2 | Dental Radiograph | 0.45 rad |
| 3 | Hip Radiograph | 0.5-0.6 rad |
| 4 | Mammogram | 0.51 rad |
| 5 | Computerized Tomography, Hip | 1.0 rad |
| 6 | <i>Pelvic Fluoroscopy, regular C-arm</i> | <i>4.0 rad/min</i> |
| 7 | Fluoroscopy, mini C-arm | 0.12-0.4 rad/min |

Results:-

| | PROCEDURE | MINIMUM No.of X-Rays(Radiation) | MAXIMUM No.of X-Rays(Radiation) | AVERAGE No.of X-Rays(Radiation) per Surgery |
|----|-------------------------------------|---------------------------------|---------------------------------|---|
| 1. | 18 Supracondylar fracture Humerus | 05(0.33rad) | 15(1.00rad) | 09(0.60rad) |
| 2. | 20 TENS for Radius and Ulna | 06(0.40rad) | 16(1.06rad) | 10(0.66rad) |
| 3. | 10 IL Nail Humerus cases | 10(0.66rad) | 20(1.33rad) | 16(1.06rad) |
| 4. | 16 Proximal Humerus cases | 10(0.66rad) | 22(1.46rad) | 15(1.00rad) |
| 5. | 38 Distal Radius cases | 06(0.40rad) | 12(0.80rad) | 08(0.53rad) |
| 6. | 32 Spine fixation/Laminectomy cases | 12(0.80rad) | 25(1.66rad) | 18(1.20rad) |
| 7. | 68 hip(IT fracture) cases | 15(1.00rad) | 30(2.00rad) | 25(1.66rad) |
| 8. | 60 IL Nail femur | 12(0.80rad) | 24(1.6rad) | 20(1.33rad) |

Based on the above results:

There was an increased exposure to radiation when:

- C-arm was operated by an less experienced Operation Theater technician.
- Not properly planned surgery.
- Operated by a less experienced surgeon.
- Patient was not properly positioned.

There was a decreased exposure to radiation when:

- C-arm operated by an experienced C-arm technician.
- Well planned surgery.
- Operated by an experienced surgeon.
- Proper patient positioning.

Discussion:-

Our aim was to measure the approximate exposure to the orthopaedic surgeon during intraoperative fluoroscopy in various surgical procedures and however, no study to date has documented the Average Number of X-Rays taken during an orthopaedic surgery with the use of a c-arm device. These above few important reasons were found by us to increase or decrease the exposure to radiation. Orthopaedic surgeons are increasingly using fluoroscopy to perform complex procedures and are necessarily exposing themselves to more radiation than previously. Modern orthopaedic practice involves increased exposure of the surgeon to ionizing radiation and there is uncertainty in predicting the effects of low-dose radiation; hence, it is wise to act on the basis that there is no safe dose of radiation. Many now believe that a threshold does not exist. What seems clear is that the greater the exposure to radiation the more likelihood there is of incurring serious side effects such as cancer [11,12,13], cataracts[14] and birth defects[11, 12, 15]. There are radiation dose limits for staff recommended by the International Commission on Radiological Protection (ICRP) that most countries tend to adopt. Currently the level is 2rad/year (actually 10 rad in 5 years - not to exceed 5 rad in any one year). Most orthopaedic surgeons using radiation protection devices and tools will have a radiation dose below typically 0.2 rad/year [16].

Conclusion:-

This study was mainly done to calculate the approximate radiation exposure of an orthopaedic surgeon while performing common surgical procedures. However, no study to date has documented the Average Number of X-Rays taken during an Orthopaedic surgery with the use of a c-arm device and concluded that:

- Precautions should be taken to reduce exposure as much as possible.
- Potential decreases in radiation exposure can be accomplished by:
 1. Decreased exposure time.
 2. Increased distance.
 3. Increased shielding with gown.
 4. Thyroid gland cover.
 5. Gloves and glasses.
 6. Beam collimation.
 7. Using the low-dose option available on some c-arm units.
 8. Inverting the c-arm.
 9. And surgeon control of the c-arm.
- Lastly the use of radiation measuring devices should be made mandatory by each and every orthopaedic surgeon as they too are equally exposed as any other Radiologist, which usually is neglected in many parts of the world.

Conflicts of Interest: None.

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