Radiation exposure to the spinal surgeon and OT personnel during fluoroscopic assisted surgery

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Journal of Spinal Surgery

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In this issue:

- Cervical disc arthroplasty
- Radiation exposure during MISS
- Spinal arachnoid webs in adults
- Lateral mass fusion (CD-ROM enclosed)
A word from the editor-in-chief

Minimally Invasive Spinal Surgery is very much in vogue. It is most comfortable for the patient but to target the object precisely it requires repetitive use of C-arm intensifier. Obviously, the frequency of exposure to radiation increase. Take the example of placement of Interspinous distraction device. At least ten times the C-arm is to be used. The risk of radiation exposure to the surgeon and staff could be higher. We have analysed the risks of radiation in operation theatre during spinal procedures and has made some recommendations for its efficacious use. In view of changing patterns in this branch of surgery the safety precautions for radiation needs to be reviewed.

Solitary plasmacytoma is of frequent occurrence in the spine. Its total excision followed by chemo and radiotherapy make the surgeon feels the disease is eradicated. Unfortunately haematological markers give a different picture. In this issue, in-depth information is provided on the outlook for plasmacytomatas in the words of haematological onco physician. It will help the surgeons to give a more realistic picture to the patient and the relatives.

Technology is advancing. New generation implants come into the market everyday. It was felt necessary to review cervical arthroplasty, so that surgeons using newer implants are well informed about the technique.

Advance in technology also compels the surgeons’ to invent newer surgical procedures. Not all are useful and some even are looking for indications for its application.

But, it is satisfying to note that spinal surgery is getting well established in India.

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Radiation exposure to the spinal surgeon and OT personnel during fluoroscopic assisted surgery

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Abstract

Introduction: The ongoing trend towards minimal invasive surgical procedures in spinal surgery has sparked an increasing interest and need for surgical navigation, which in most of the cases is performed by intraoperative fluoroscopy.

Risks: With the increasing number of spinal procedures and increasing number of exposures in a given procedure with intraoperative imaging, the question of the radiation exposure to the OT personnel has become an issue for debate.

Recommendations of International Commission: Based on the recommendations of the International Commission on Radiological Protection, the dose limit for occupational exposure must below 20mSv per year, which is safe or 100mSv in 5 years and not more than 30mSv in any one given year to prevent radiation induced carcinogenesis.

Steps to reduce exposure to radiation: Radiation reducing techniques, shielding devices such as whole-body apron, lead-collar, and goggles and personal dosimeter lead to a significant decrease of mortality and morbidity of radiation sensitive tissues such as thyroid gland and eye lens.

Conclusion: Modern minimally invasive spinal surgery requires repeated use of C-arm fluoroscopy to target the lesion. The issue of radiation protection needs to be reviewed.

Key Words
- Spine
- Intraoperative fluoroscopy
- Radiation risk

Introduction

Fluoroscopy produces visualization in real-time for diagnostic purposes as well as therapeutic procedure. Currently, it is used intra-operatively for many spinal surgery procedures such as percutaneous insertion of multiple pedicle screws, percutaneous insertion of interspinous distraction devices and vertebral augmentations. There are many advantages associated with intraoperative fluoroscopic visualization, but on other hand the use of visualization approach has the potential to expose the operating room personnel and the patient to radiation, predisposing them to the development of radiation-induced complications. However, with good understanding of the physics of X-rays, adoption of proper C-arm imaging technique, and adherence to proper safety regulations, it may be possible to decrease the amount of radiation dose to OT personnel as well as the patient. The purpose of this article is to present the potential complications of intraoperative radiation, to discuss the safety limits that have been established to protect the patient and the OT personnel during the procedure and to discuss various techniques that have been accepted to minimize radiation exposure during fluoroscopically assisted procedures and reduce the risks to the patient and surgeon and to provide an overview of personal dosimeter.

Risk from radiation exposure

We live in an environment where the radiation is always present. The radiation which is part of nature is called background radiation. It is a combination of cosmic rays, radiation within our body, in food we eat, water we drink, house we live in, building material etc. On an average we
are exposed to 1–3 mSv/year, but in areas of high background radiation like in the vicinity of radiation activity institutions, we can be exposed to 3–13 mSv/year.3

### Radiation hazards

Radiation can cause many complications such as cancer, death, skin burn, cataract, infertility and genetic effects. When cells are exposed to radiation, some cell will die and others will live with damage and eventually will be dead. Radiation can induce cancer in long term although it takes several decades for cancer to appear. The cells that are susceptible to radiation is rapidly dividing cell.3 Ionizing radiation can cause biological effects which divided into stochastic effect and deterministic effect. Carcinogenesis is caused by stochastic effects. Stochastic effect is not related to the radiation’s dose, there is no cut-off value and damage is cumulative with multiple exposures to radiation. The late effects of this are thyroid cancer or leukemia. Radiation’s deterministic effect is different. Deterministic (somatic) effect is directly related to the dose of radiation. Early deterministic effects include radiation sickness, which occurs after exposure to a large amount of radiation (500–1000 mSv). Late deterministic effects include leukemia, thyroid cancer or radiation cataracts. The good news about somatic effects is that once you get below a certain threshold there is no increased risk of exposure to radiation.3,4

### Radiation risks from fluoroscopic assisted surgery

The International Commission on Radiation Protection (ICRP) has set up several recommendations for radiation safety since 1931 and the evolution of this recommendation has changed the maximum permissible dose to become lower. There are several recommendations such as ICRP 60 (1990) and ICRP 103 (2007) which explain the maximum levels of exposure that are permitted. ICRP 60 recommendation (Table 1) should be taken into consideration when planning for a radiation-related work process including fluoroscopic surgery.6,7

*With further provision that dose in any single year > 30 mSv (AERB) and = 50 mSv (ICRP)*

M.P.D. = Maximum Permissible Dose; 1931 = 500 mSv, 1947 = 150 mSv, 1977 = 50 mSv & 1990 = 20 mSv

AERB = Atomic Energy Regulatory Board

In spinal surgery, the part of the body that is most exposed the surgeon’s hands. Surgeons often use their hands to hold instruments to insert the implants and checking its position. The second part of the body is eyes. Eyes are the most sensitive area of the body to radiation, the maximum permissible annual dose to eyes is 150 mSv. Although they are more distant from the radiation source, the dose of radiation received by eyes is the limiting factor determining the amount of radiation a surgeon can be exposed to during a period of time. This somatic effect causes radiation cataracts. The third is the thyroid with 85% of papillary carcinomas being radiation induced; the maximum permissible annual dose to the thyroid is 300 mSv.3,4

### Radiation safety in fluoroscopic assisted surgery

The main source of radiation for the team and surgeon during fluoroscopy is scattered radiation from the X-ray tube which emits photons. Some are absorbed by the patient and some are scattered around which are received by the surgeons. Small fraction of the X-rays passing through the patient reach the image intensifier.1,9

The principle of radiation protection is ALARA (As Low As Reasonably Achievable). During intraoperative fluoroscopy, the surgeon must apply it and control the factors that may minimize exposure to patient and medical staff.1,2,5,6,12

These factors are:

1. The OT personnel should stand away from the X-ray tube as is possible. The National Council on Radiation Protection and Measurements (NCRP) recommends that the staff members who are not working in the operative procedure should stand at least 6 feet away from the X-ray tube.

2. Maximize the distance between the tube and the patient. To reduce scattered radiation the patient must be placed as close to the image intensifier and as far away from the X-ray tube as possible. The further away the X-ray tube from the patient, the lower the dose of scattered radiation the surgeon can get.

<table>
<thead>
<tr>
<th>Effective dose over 5 years</th>
<th>Number</th>
</tr>
</thead>
<tbody>
<tr>
<td>20 mSv/year averaged*</td>
<td>1 mSv in a year</td>
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<table>
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<tr>
<th>Annual equivalent dose to</th>
</tr>
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<tbody>
<tr>
<td>• Lens of eye</td>
</tr>
<tr>
<td>• Skin</td>
</tr>
<tr>
<td>• Hands &amp; Feet</td>
</tr>
</tbody>
</table>

Table 1. ICRP 60 (1990)
3. Positioning the X-ray tube below the operating table (Figure 1A&B) reduces high dose rates to the thyroid and lens. The best configuration during surgery is with the intensifier up and the X-ray tube below the operation table minimizes the amount of back-scattered radiation. This will reduce the radiation dose to the team.

4. In lateral position, the surgeon should stand on the side of image intensifier. By this single action the amount of radiation exposure received can be reduced to one tenth.

5. Do not use too much magnification. By doing so, the scattered radiation is increased.

6. Minimize the time of exposure.

7. Use the appropriate dose rate for the visualization. Low contrast images may be appropriate visualized at high dose rates. In contrary, high contrast images may be appropriately visualized at low dose rates.

8. It is necessary to collimate the beam for reducing the area of the X-ray beam at patient’s entrance plane. Besides the dose, the radiation volume also influences the risk of ionizing radiation.

9. Obese patient increases skin dose and scattered radiation

10. It is mandatory to use protective devices such as leaded aprons, gloves, thyroid protectors and goggles. Protective devices must always be properly used (Figure 2). When the beam is on; the other Operating Room’s (OR’s) staff must stand behind the lead shielding.

11. For radiation protection measurement, all the operating room staff must wear personal dosimeter appropriately at meaningful locations at the body (Figure 3 A & B) (i.e. behind protective equipment, at trunk). Usually this personal dosimeter is evaluated monthly (film badge) or every three months.

![Figure 1 A&B](image1)

Ideal X-ray tube position during fluoroscopic surgery

![Figure 2](image2)

Radiation protection devices (with modification)

![Figure 3 A&B](image3)

Wearing film badge appropriately

### Discussion

There are many advantages associated with intraoperative fluoroscopic visualization in real-time, but on other hand that the use of visualization approach has the potential to expose the operating room personnel and the patient to radiation, predisposing them to the development of radiation-induced complications. Radiation can cause many complications such as cancer, death, skin burn, cataract, infertility and genetic effects. The principle of radiation safety is ALARA (As Low As Reasonably Achievable), the surgeon must apply it and know how to...
control the radiation exposure, wear the radiation protection devices and personal dosimeter.

## Conclusion

In minimally invasive spinal surgery era the radiation risk is increased. The protective system needs to be reviewed.

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