

Review Article

Strategy to reduce radiation exposure in postoperative spinal computed tomography scans

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ABSTRACT

Background: When diagnosing and treating spinal disorders, spine surgeons commonly utilize computed tomography (CT) scans preoperatively, intraoperatively, and postoperatively.

Methods: This article reviews the literature regarding the potentially harmful effects of X-rays, specifically from CT scans.

Results: The risk for damaging DNA and developing cancer increases with increasing scan length (e.g., increasing amount of radiation received).

Conclusion: When assessing postoperative status, CT scans should be directed only through the area of specific interest to limit the total dose of radiation received by the patient.

Keywords: Cancer, Computed tomography, Computed tomography scans, Radiation, Spinal surgery, Spine

INTRODUCTION

Due to its utility in medicine, the incidence of computed tomography (CT) examinations has exponentially increased in the past few decades. There were an estimated 80 million scans performed in 2019, 5–9 million of which were performed in pediatric patients; this constitutes an annual growth rate of about 10%.^[14] Its popularity is attributed to its ease of use (short duration/large bore size) and relative comfort for both technicians (e.g., positioning/running patients) and for patients. Compared to alternative imaging techniques, CT scans also show a greater level of bone detail.^[2,3] For spinal surgery, CT scans help in preoperative diagnostic/screening, are useful intraoperatively to confirm the placement of instrumentation, and postoperatively to document the adequacy of instrumented arthrodesis. Here, we evaluated whether radiation doses could be limited by performing postoperative CT scans only “through the area of specific (e.g., surgical) interest.”

REVIEW

Mechanism of action

Multiple studies have explored the effect of ionizing X-rays from CT scans.^[18] Although there is continued debate as to whether the low-dose ionizing radiation from CT imaging leads to cancer,

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there is little doubt that it can have mutagenic effects.^[16] Further, the impact of radiation on genetic aberrations is a linear, dose-dependent response (e.g., intermediate CT doses on scans).^[17] Ionizing radiation promotes tumorigenesis through the creation of reactive oxidative species (ROS), which induces radiation-induced double-stranded DNA breaks (DSBs).^[6,20] Although DNA repair pathways are known to have high fidelity, the extent of DNA damage caused by radiation can lead to improper repair of DSBs which increases genomic instability and induces cancer.^[1] Other complicating factors exist when assessing the risk posed by low-dose ionizing radiation including age, environmental factors, and genetic predisposition.^[17] Individuals with certain conditions such as familial retinoblastoma, tuberous sclerosis, neurofibromatosis I, or Li-Fraumeni syndrome are more susceptible to cancer on exposure to radiation.^[9]

VALUES OF EFFECTIVE RADIATION DOSE FROM SINGLE SPIRAL SPINAL CT

The effective radiation dose resulting from a single spinal CT scan ranges from 1.5 mSv to 10 mSv.^[11] For reference, 1 Sv is defined as the amount of radiation that increases the risk of cancer by 5.5%.^[19] In addition, the amount of radiation the average American receives from all sources annually excluding medical procedures amounts to 3.2 mSv; a single CT scan can double or even triple this amount.^[19]

CT SCANS TAKEN WITH MINIMALLY INVASIVE SPINAL SURGERY

The risks associated with radiation are cumulative.^[17] Protocols for complex/minimally invasive spinal surgery utilizing CT-based navigation systems recommend a minimum of two postoperative CT scans within 6 months after spinal surgery.^[4,13] Therefore, a patient undergoing complex/minimally invasive spinal surgery will increase their risk for cancer by 0.03–0.2% (e.g., a conservative estimate), assuming that four CT scans are taken including those taken preoperatively, intraoperatively, and postoperatively.

LIFETIME RISK OF CANCER WITH CT STUDIES

Assuming the lifetime risk of developing cancer in America is 20%, the risk from CT scans seems relatively benign.^[10] Further, most agree that the benefits of CT scans far outweigh their risks.^[5] Nevertheless, given their prevalence, measures should be taken to reduce preventable harm.

APPLICATION OF SELECTIVE CT SCANS TO REDUCE EXPOSURE

The Yale School of Medicine identified multiple factors that directly impact patient exposure including detector

configuration, tube current, reconstruction algorithm, patient positioning, and scan range.^[15] In a 2007 study examining the effectiveness of a full chest CT pulmonary angiogram versus a limited range CT angiogram, there was 48% reduction in effective radiation with limited loss of diagnostic utility in the limited range versus full chest CT angiograms.^[12] This is consistent with the theoretical evaluation that the measure of the genetic impact and cancer risk posed by radiation is directly proportional to scan length.^[7,8]

Here, we propose applying a “limited field exposure” focusing on the area of surgery in postoperative spinal CT scans. Standard protocols for postoperative CT scans image the entire section of the spine (i.e., cervical, thoracic, lumbar, or sacral spine) for which the procedure was performed. However, the region of interest with respect to postoperative evaluations is usually limited to the specific vertebrae impacted by surgery. For two-level lumbar spinal surgery, the CT scan should be limited to the two lumbar vertebrae alone; by not including L1-S1, this would reduce the total radiation exposure by 66%. As the cervical spine contains a greater number of spinal levels, radiation reduction here could theoretically be as high as 75%.

CONCLUSION

To reduce the risks associated with excess radiation exposure, we should adopt a postoperative CT protocol focusing only on the operated spinal levels.

Declaration of patient consent

Patient’s consent not required as there are no patients in this study.

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Conflicts of interest

There are no conflicts of interest.

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