Computed Tomography Scans in Patients With Young Adult Hip Pain Carry a Lifetime Risk of Malignancy

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Purpose: To calculate the lifetime risk of malignancy in young adult patients with hip pain using 5 different imaging and radiation dose protocols with or without pre- and postoperative computed tomography (CT). **Methods:** Radiographic and CT patient radiation doses were retrospectively reviewed. Imaging protocols for hip pain composed of radiographs with or without pre- and postoperative CT scans were modeled and radiation doses were estimated using the PCXMC computer code. Based on these radiation doses, lifetime attributable risks of cancer and mortality for a 10- through 60-year-old male and female were calculated as published by the committee on the Biological Effects of Ionizing Radiation (BEIR) in the BEIR VII report. Relative risks and number needed to harm (NNH) were calculated for each protocol. **Results:** Based on a review of our institutional database, 2 CT scan doses were used for this study: a high 5.06 mSv and a low 2.86 mSv. Effective doses of radiation ranged from 0.59 to 0.66 mSv for radiographs alone to 10.71 to 10.78 mSv for radiographs and CT both pre- and postoperatively at the higher dose. Lifetime attributable risk of cancer for radiographs alone was 0.006% and 0.011% for a 20-year-old male and female, respectively. Lifetime attributable risk of cancer for radiographs along with pre- and postoperative CT scans at higher dose was 0.105% and 0.177% for a 20-year-old male and female, respectively. Radiographs alone lead to an NNH of 16,667 for males and 9,090 for females, whereas the protocol with pre- and postoperative CT scans at the higher dose led to an NNH of 952 for males and 564 for females. The relative risk of this protocol compared to radiographs alone was 17.5 for males and 16.1 for females. **Conclusion:** Protocols with CT scans of the hip/pelvis pose a small lifetime attributable risk (0.034%-0.177% for a 20-year-old) but a large relative risk (5-17 times) of cancer compared with radiographs alone in the imaging evaluation for hip pain that decreases with increasing age. **Clinical Relevance:** This study illustrates the need for clinicians to understand the imaging protocols used at their institution to understand the risks and benefits of using those protocols in their practice.

Evaluation of young patients with hip pain begins with a detailed history, physical examination, diagnostic imaging, and, in some cases, guided injections.[1] Imaging plays a pivotal role in the evaluation of this patient population. Plain radiographs are first obtained to evaluate the acetabular and proximal femoral anatomy.[1,2] Many plain radiographic views have been described in an attempt to fully evaluate the complex 3-dimensional acetabular and femoral osseous morphology including anteroposterior pelvis, false-profile, cross-table hip lateral, frog-leg lateral, and 45° and 90° Dunn lateral among others. Effective dose radiation for lateral hip images ranges from 0.22 to 0.83 mSv, with cross-table radiographs leading to the highest dose of radiation to the patient.[3]

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As our understanding of this complex morphology and its role in hip pain has evolved, so have the 3-dimensional imaging modalities. These advanced imaging techniques are obtained to further assess the bony and soft tissue pathology. Magnetic resonance imaging (MRI) of the hip with or without intra-articular contrast does not use ionizing radiation and is commonly obtained to evaluate the soft tissues about the hip joint, including the status of the acetabular labrum and the articular cartilage of the joint.[1,2] Computed tomography (CT) has evolved as a powerful tool in the evaluation of the osseous anatomy of the pelvis and hip.[4,5] It allows 3-dimensional evaluation of impingement as opposed to 2-dimensional evaluation in certain planes by radiography.[6] Three-dimensional reconstructions are easily obtained from CT and have been developed to help clinicians evaluate bony impingement during hip motion and guide pre- and intraoperative decision making.[4,6,7] Hip and pelvis CT scans have had reported mean effective doses of radiation ranging from 3.1 to 4.9 mSv.[8,9] To put these numbers into context, the effective dose of background radiation that the average person receives is approximately 3 mSv per year.[8] The increased incidence of CT imaging and its associated ionizing radiation dose in diagnostic imaging has led to concerns about the increased risk of radiation-induced tumorigenesis.[10-13]

Data regarding this radiation is of particular importance in this patient population, as hip preservation surgery is most commonly performed in young patients. This is the same population that is at increased risk for radiation-induced cancers. In addition, clinicians rarely understand the patient doses of ionizing radiation from the imaging tests that they order and therefore cannot truly inform patients on the oncogenic risks of medical imaging that uses ionizing radiation.[14,15] Because of these associations, this study was designed to evaluate the risk associated with the estimated dose from ionizing radiation from clinical protocols of radiographic and CT studies on young patients. The purpose of this study was to calculate the lifetime risk of malignancy in young adult patients with hip pain using 5 different imaging and radiation dose protocols with or without pre- and postoperative CT. We hypothesized that the addition of CT scans to imaging protocols would lead to a small attributable risk of cancer but a high relative risk compared with radiographic imaging alone.

Methods

This study was approved by the institutional review board of the University of Utah.

Radiation Dose Units

When comparing radiation effects of one protocol relative to another, it is necessary to account for the absorbed dose to the individual organs. Different techniques will irradiate different organs in differing amounts; thus, it is problematic to compare the radiation effects of one protocol to another without accounting for the dose to each organ and the relative radiosensitivity of each organ. In this study, we use the unit of effective dose to compare the relative radiation effects of one protocol with those of another. The unit of effective dose used here is that defined by the International Commission on Radiation Protection (ICRP 103).[16] Effective dose accounts for the absorbed dose to an organ, the type of radiation that deposits energy in the organ, and the relative radiosensitivity of each organ. Thus, effective dose permits the calculation of radiation detriment from each imaging protocol. This detriment, or risk, can then be compared to the risk associated with other imaging protocols.

Effective dose uses the units of sievert (Sv) or roentgen equivalents man (rem) (1 Sv = 100 rem). It should be noted that Sv and rem are also used in quantifying the radiation terms of dose equivalent, Equivalent Dose (ICRP 103), and Effective Dose Equivalent.[16] Thus, the use of Sv here refers to the radiation term of effective dose. The unit of gray (Gy) is also used throughout this article. The unit of Gy is simply defined as joules per kilogram of material (J/kg). In this article, as is standard convention, both radiation absorbed dose and volume CT dose index ($CTDI_{vol}$) values are quantified using the unit of Gy. The $CTDI_{vol}$ is an index representing the dose from a particular set of CT scan parameters in a polymethyl methacrylate cylindrical phantom; CTDI is not a measure of dose to the patient or a particular organ. Conceptually, for this article, the $CTDI_{vol}$ can be thought of as the amount of radiation that is emitted from the CT scanner in acquiring the imaging test. These units are also defined by the ICRP.[16]

Patient Imaging Techniques

To determine the average effective dose to patients from the different imaging protocols, a retrospective review of our imaging database was performed. Data were obtained from digital imaging and communication in medicine (DICOM) headers from images of patients acquired from January 2015 to September 2016. The image DICOM header contains information about the machine settings at the time of patient exposure. Under appropriate institutional review board oversight, DICOM header information was collected from patient images acquired at our institution over the stated time period. The data from the DICOM headers was acquired using a Python script and the Pydicom tool library.

Patient imaging included in the survey was for those patients undergoing imaging for the hips and pelvis from CT and general digital radiographic (DR) imaging. Specifically, patients receiving CT scans of the hips (single or bilateral) and pelvis were collected; patients