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Computed Tomography / Tomodensitométrie

# Perception of Radiation Exposure and Risk Among Patients, Medical Students, and Referring Physicians at a Tertiary Care Community Hospital

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## Abstract

**Background:** It is important for physicians to be aware of the radiation doses as well as the risks associated with diagnostic imaging procedures that they are ordering.

**Methods:** A survey was administered to patients, medical students, and referring physicians from a number of specialties to determine background knowledge regarding radiation exposure and risk associated with commonly ordered medical imaging tests.

**Results:** A total of 127 patients, 32 referring physicians, and 30 medical students completed the survey. The majority of patients (92%) were not informed of the radiation risks associated with tests that they were scheduled to receive and had false perceptions about the use of radiation and its associated risks. Physicians and medical students had misconceptions about the use of ionizing radiation in a number of radiologic examinations; for example, 25% and 43% of physicians and medical students, respectively, were unaware that interventional procedures used ionizing radiation, and 28% of physicians were unaware that mammography used ionizing radiation. Computed tomographies and barium studies were thought to be associated with the least ionizing radiation among physicians.

**Conclusion:** There is a need for educating the public, medical students, and referring physicians about radiation exposure and associated risk so that (1) patients receiving multiple medical imaging tests are aware of the radiation that they are receiving and (2) physicians and future physicians will make informed decisions when ordering such tests to limit the amount of radiation that patients receive and to promote informed consent among patients.

## Résumé

**Contexte :** Il est important pour les médecins d'être au courant des doses d'irradiation ainsi que leurs risques associés dues aux procédures d'imagerie diagnostiques qu'ils prescrivent.

**Méthodes :** Une enquête a été réalisée auprès de patients, d'étudiants en médecine et de médecins traitants œuvrant dans divers domaines de spécialité afin de mesurer leur connaissance générale de l'irradiation et des risques associés à certains examens d'imagerie médicale courants.

**Résultats :** Au total, 127 patients, 32 médecins traitants et 30 étudiants en médecine ont participé à l'enquête. La plupart des patients (92 %) n'avaient pas été avisés des risques dus aux rayonnements auxquels ils étaient exposés dans le cadre de leurs examens et avaient des idées fausses à l'égard du rayonnement et des risques associés à la radioexposition. Pour leur part, les médecins et les étudiants en médecine comprenaient mal l'usage du rayonnement ionisant dans le cadre de certains examens radiologiques. Par exemple, 25 % des médecins et 43 % des étudiants en médecine ignoraient que les procédures interventionnelles utilisaient un rayonnement ionisant, et 28 % des médecins ne savaient pas qu'il en était de même pour la mammographie. Toujours selon les médecins répondants, les examens de tomodensitométrie et les études barytées étaient associés à un plus faible rayonnement ionisant.

**Conclusion :** Il convient de sensibiliser la population, les étudiants en médecine et les médecins au sujet de la radioexposition et des risques qui lui sont associés, de manière à ce que 1) les patients devant subir plusieurs examens d'imagerie médicale connaissent les doses de

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rayonnements auxquels ils s'exposent et que 2) les médecins et futurs médecins prennent des décisions éclairées quant aux examens qu'ils prescrivent afin de limiter l'irradiation et de promouvoir le consentement éclairé des patients.

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**Keywords:** Radiation; Computed tomography; Fluoroscopy; Cancer; Risk; Survey

Concern over radiation exposure and radiation-induced ionization has increased tremendously in the past decade. Rising concern may be a result of the availability of more information regarding radiation physics and better estimates of the cumulative effects of radiation as well as the increasing use of computed tomography (CT) in medical practice [1–3]. The 2 main categories for grouping radiation-induced hazardous effects are deterministic and stochastic effects. Deterministic effects are rare in medical imaging and are seen at extremely high doses. Damage to tissues occurs at a particular threshold that varies from person to person, but, above this threshold, direct cellular damage is certain and dose dependent. Stochastic effects (primarily malignancy) are probabilistic, with the probability of occurrence increasing in a dose-dependent fashion, with no known lower “safe” threshold [4]. Risk assessment models based on epidemiologic data show that the cumulative effects of radiation achieved with multiple diagnostic imaging tests can lead to the development of cancer in patients [4,5]. See Table 1 for the average effective dose for several commonly ordered diagnostic imaging tests.

Studies that investigated the perception of radiation risk are scarce. In 2002, Ludwig and Turner [7] surveyed adult shoppers in malls about their perceptions of radiation risk. Many subjects admitted to not worrying about the risks associated with radiation and had limited knowledge of radiation sources and equivalent risk. Referring physicians were not surveyed. In 2004, Lee et al [8] surveyed patients, emergency department physicians, and radiologists at a tertiary care center about awareness of CT radiation dose and possible associated risks. They reported that 95% of patients who received CTs had not received information regarding risks and benefits. Seventy-eight percent of emergency department physicians declared that they did not explain risks and benefits of the CT to patients [8].

The purpose of the current study was to identify the background knowledge about radiation exposure and risk

among inpatients and outpatients towards radiologic examinations for which they are referred as well as the referring physicians and medical students. The following questions were addressed:

1. Do patients know about radiation exposure and the risk from diagnostic imaging studies for which they are referred?
2. How concerned are patients about the radiation risk?
3. Do referring physicians inform their patients about the radiation risk?
4. Do referring physicians and medical students have misconceptions about radiation exposure and the risk from diagnostic imaging studies?
5. How concerned are physicians and medical students about the radiation risk among patients?

## Materials and Methods

An anonymous, 5-minute cross-sectional survey was administered to patients and physicians in a tertiary care community hospital as well as to referring physicians and medical students from the University of Toronto. Survey respondents performed the survey immediately after the request, ensuring that they could not consult reference books to answer the questions. Both inpatients and outpatients were included in this study.

## Results

### Patient Survey Results

A total of 127 surveys were administered and collected during the study period. Ten patients declined to participate in the study. Ten of the patients (7.8%) were scheduled for magnetic resonance imaging, 20 for mammography (15.7%), 11 for ultrasound (8.7%), 21 for CT (16.5%), 22 for fluoroscopy-guided studies or interventional procedures (17.3%), 20 for upper- and lower-gastrointestinal studies (15.7%), and 23 for radiographs (18.1%).

Among patients referred for radiologic examinations, 42% believed that they would not be exposed to radiation. The patients had an average level of concern of 2.3 on a scale from 1 (not concerned) to 10 (very concerned) about the radiation that they would receive. The average level of concern was greatest for patients receiving gastrointestinal studies (average, 4/10). The lowest level of concern was reported by mammography patients (average, 1.6/10).

Table 1

Average effective dose per diagnostic imaging test<sup>a</sup>

Type of diagnostic imaging study or procedure	Average effective dose, mSv
Interventional fluoroscopy procedure	5–70
CT	2–16
Angiography	5–15
Barium study	5–8
IVP	3
Mammography	0.4
Radiography	0.001–1.5

CT = computed tomography; IVP = intravenous pyelogram.

<sup>a</sup> From Ref. 6.

Ninety-one patients (72%) were unaware of the radiation risk associated with the study that they were about to undergo. For those who were informed of radiation risk, the most common sources of information were the radiologic technologist (42%), nurse (33%), and referring physician (17%). Ninety-two percent of patients did not look up any information on radiation risk before their radiologic study. Reported sources included the Internet (5 patients) and an Ontario Breast Screening Program pamphlet (1 mammography patient). When asked whether the examination would give the patient cancer, 6.6% of patients having diagnostic imaging tests that used ionizing radiation indicated yes.

*Physician Survey Results*

Physicians from a number of different specialties were included in this study. These included 10 family/general practice physicians (32.25%), 5 internal medicine physicians (15.6%), 4 surgeons (12.5%), 3 nephrologists (9.4%), 2 cardiologists (6.25%), 2 pediatricians (6.25%), 1 critical care specialist (3.1%), 1 gastroenterologist (3.1%), 1 neurologist (3.1%), and 1 obstetrician (3.1%).

Twenty-eight percent of physicians were unaware that mammography used ionizing radiation, and 25% were unaware that interventional procedures used ionizing radiation (Table 2). Most of the physicians believed that CT uses the most radiation (62.5%), with angiography being the next most common (18.75%) (Table 3). The majority of physicians correctly indicated that radiographs were associated with the least radiation (59.4%). Approximately 9% and 3% of physicians incorrectly indicated that CT and barium studies, respectively, are associated with the least ionizing radiation (Table 4). The majority of physicians correctly thought that lumbar spine radiographs were associated with the most radiation from a number of representative radiographic studies.

Approximately 78% of the physicians correctly thought that CT abdomen-pelvis examinations were associated with the greatest radiation dose in comparison with CT head (15.6%) and CT chest examinations (6.25%). Fifty percent of the physicians indicated that between 0% and 25% of their patients inquired about radiation risk, whereas the remainder of the physicians stated that no patients inquired. On a scale

Table 2  
Percentage of physicians unaware of the ionizing potential of a variety of commonly used diagnostic imaging tests

Type of diagnostic imaging study or procedure	Physicians unaware of associated ionizing potential, %
Mammography	28.1
Interventional fluoroscopy procedure	25
Barium study	15.6
IVP	15.6
CT	9.4
Angiography	9.4
Radiography	9.4

CT = computed tomography; IVP = intravenous pyelogram.

Table 3  
Diagnostic imaging tests that physicians perceived to have the most radiation

Type of diagnostic imaging study or procedure	Physicians indicating test as having the most radiation, %
CT	62.5
Angiogram	18.8
Barium study	12.5
Radiography	6.2
IVP	6.2
Interventional fluoroscopic procedure	6.2
MRI	3.1

CT = computed tomography; IVP = intravenous pyelogram; MRI = magnetic resonance imaging.

from 1 (not concerned) to 10 (very concerned), physicians had an average level of concern of 3.8 for radiation use in their patient population. The most common sources of education on radiation risk for physicians came from their medical training (46.9%), conferences and/or meetings (15.6%), and radiologists (12.5%). The majority of physicians correctly indicated that children are the most susceptible to the carcinogenic effects of radiation (90.6%).

*Medical Student Survey Results*

The majority of the medical students who participated in this study were in their fourth year of study (86.7%). The remainder were in their third (10%) or second (3.3%) year of study. When asked the field of medicine that they intended on practicing, a variety of specialties were stated. The majority of students chose family medicine (26.7%), internal medicine (26.7%), and surgery (20%).

All of the medical students were aware that CT was associated with ionizing radiation. However, approximately 43% were unaware that interventional procedures were associated with ionizing radiation (Table 5). When asked which diagnostic imaging test is associated with the most radiation, 86.7% of the medical students indicated CT. The remainder indicated either interventional procedures (6.7%) or angiography (3.3%). When asked which diagnostic imaging test was associated with the least radiation, the majority of medical students chose radiographs (46.7%) or mammography (43.3%). When asked which radiographic study is associated with the most radiation, the majority of medical students incorrectly chose abdominal (46.7%) and chest radiographs (30%). The majority of medical students

Table 4  
Diagnostic imaging tests that physicians perceived as having the least radiation

Type of diagnostic imaging study or procedure	Physicians indicating test as having the least radiation, %
Barium study	3.1
CT	9.4
Mammography	28.1
Radiography	59.4

CT = computed tomography.

Table 5  
Percentage of medical students unaware of the ionizing potential of a variety of commonly used diagnostic imaging studies

Type of diagnostic imaging study or procedure	Medical students unaware of associated ionizing potential, %
Interventional fluoroscopy procedure	43.3
Mammography	20
IVP	16.7
Angiography	16.7
Barium study	10
Radiography	6.7

IVP = intravenous pyelogram.

chose CT of the abdomen-pelvis as the CT examination associated with the most radiation (73.3%), and 25.7% chose CT of the chest. The majority of medical students (80%) chose children as being the most susceptible to the carcinogenic effects of radiation. The medical students had an average level of concern about the radiation risk in patients of 5.3 of 10. The majority of medical students identified their medical training as being the source of most of their radiation risk education (73.3%).

## Discussion

This study aimed to answer 5 questions.

### 1. Do patients know about radiation exposure and the risk from diagnostic imaging studies for which they are referred?

Overall, the majority of the patients receiving examinations that use ionizing radiation were aware that they would be receiving radiation (58%). However, among patients referred for interventional procedures, the majority of patients (81.8%) were unaware of the associated radiation. These studies are among those that deliver the greatest amounts of radiation, depending on the procedure, and, therefore, are often associated with the greatest risk of cancer [9]. Patients had significant misconceptions about the relative amounts of radiation that they would receive before their examination. Overall, the patients thought that they would receive lower doses of radiation from CTs in comparison with radiographs.

### 2. Were patients informed of the radiation risk?

The patients indicated that the radiation risk was not explained to them in the majority of cases (91%). This result was similar to that of Lee et al [8] in which 95% of patients who had CT investigations reported not having the benefits and risks explained to them. The majority of patients (77.2%) were unaware that diagnostic imaging tests increase their likelihood of cancer. Goske et al [10] have previously suggested that the use of education tools for patients and informed consent may be a useful aid for relieving patient anxiety and increasing patient's objective knowledge regarding imaging studies.

### 3. How concerned are patients about the radiation risk?

Overall, patients had minimal concern about radiation exposure and risk, with patients having a mammography being the least concerned (level of concern of 1.6/10).

### 4. Do referring physicians and medical students have misconceptions about radiation exposure and the risk from diagnostic imaging studies?

A number of physicians (16.1 %) were unaware that diagnostic imaging tests use ionizing radiation. Although the majority of physicians (91%) correctly identified diagnostic imaging tests that are among those using the most radiation (CT, angiography, and barium studies), there was uncertainty about radiation associated with other interventional procedures (Tables 2 and 3). The majority of physicians agreed that radiographs and mammography were associated with the least ionizing radiation, but some physicians incorrectly believed that CT was associated with the least amount of radiation (9.4%). Misconceptions regarding radiation risk associated with high-dose radiation studies may result in physicians referring their patients for multiple high-dose examinations in a short period of time rather than using lower dose options. In a study conducted by Borgen et al [11], only 58% of physicians were aware of referral guidelines for medical imaging, and approximately 20% of physicians made use of such guidelines.

Some physicians may believe that their patients would refuse pertinent diagnostic imaging tests if they are informed of the associated risks. However, this may not be the case. In a study by Larson et al [12], 100 parents of children receiving nonemergent CT studies were surveyed on their knowledge of the radiation risk before and after receiving educational material on radiation risk. After being informed of the risks associated with radiation exposure, none of the parents refused or requested deferral of the CT. In addition, this study showed an increase in the level of knowledge that parents had of CT radiation dose and risk after the administration of educational material.

Based on the study results, medical students had minimal knowledge of the relative amounts of radiation associated with radiographic studies. However, they had a good sense of the relative amounts of radiation received from various CT examinations and the susceptibility of pediatric populations to radiation. They had received most of their education on radiation exposure and risk from their medical training. In a recent survey of 670 medical students from years 1 through 5 in a 5-year curriculum, students who received diagnostic radiology and radiation protection teaching in their medical curriculum performed better on objective assessments of radiation knowledge [13].

### 5. How concerned are medical students and physicians about the radiation risk among patients?

Physicians had the lowest levels of concern about radiation risk and indicated that fewer than one-fourth of their

patients inquired about radiation risk. Physicians should become familiar with the American College of Radiology Appropriateness Criteria. This is a point system that allows physicians to determine the warranted radiologic procedures for more than 200 medical conditions. For example, a physician may choose to investigate a reproductive age woman or a child with possible abdominal pathology by using ultrasound if they do not meet the criteria for a CT. In addition, physicians should advise their patients to keep copies of imaging examinations on CD-ROM and to keep track of radiologic examinations that they undergo [2].

## Conclusion

This study found that there were significant gaps in knowledge about radiation exposure and risk among patients referred for a variety of diagnostic imaging tests, among patients, medical students, and physicians who commonly refer their patients. Based on these results, patients, medical students, and physicians are in need of more education on radiation exposure and risk. The medical school curriculum is a major source of radiation risk education for medical students and physicians. Therefore, there is a role for incorporating more radiation risk and protection education into the medical curriculum. In addition, there may be a role for educational seminars or meetings on the topic of radiation for all health professionals. Keeping abreast of the issues regarding medical imaging and radiation risk can help physicians appropriately estimate the benefit-to-risk ratio, particularly in younger patients. It is hoped that the information from this study will help provide impetus to better educate referring physicians and medical students so that they may properly inform their patients and use discretion when ordering medical imaging tests. It is also hoped that this study will promote raising awareness of the radiation risk among patients served by the diagnostic imaging

department so that they can be informed and play an active role in making decisions with regard to their care.

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