RESEARCH LETTERS

Medical Decision Making Regarding Computed Tomographic Radiation Dose and Associated Risk: The Patient's Perspective

Due to the increasing availability and recent advances in computed tomography (CT) technology, use of CT has increased. In 2007, approximately 68.7 million CT examinations were performed in the United States. In comparison, in 1995 approximately 21 million CT examinations were performed.[1] Many investigators have expressed concern for the rising cumulative doses of ionizing radiation delivered to patients during these examinations[2-8]; however, little is known about patients' feelings concerning CT and the increased radiation exposure. In this study, we sought to evaluate patients' perspectives about the medical decision-making process regarding obtaining a CT scan and to assess the degree of patient knowledge concerning radiation dose and risk resulting from CT.

Methods. Prior to this investigation, institutional review board approval was obtained. The study was carried out in compliance with the Health Insurance Portability and Accountability Act. Informed written consent was obtained from each participant. Patients were informed that they would be participating in an evaluation of patient awareness of radiation dosage and risk and would be asked to complete a questionnaire. The questionnaire was given to consecutive adult patients awaiting an outpatient CT examination at our hospital between March 2007 and April 2007. Inclusion criteria included age older than 17 years, literacy and comprehension of the English language, and ability to complete a written questionnaire.

Patients received a questionnaire consisting of 20 questions (eFigure; http://www.archinternmed.com). Demographic information of age, sex, and education was collected. Patients were asked questions about the decision to obtain a CT scan. In particular, patients were asked about their physician's role and whether the patient participated in any discussion concerning the benefits or risks of radiation associated with CT imaging.

The next set of questions pertained to the patients' knowledge concerning radiation dose and risk. Patients were asked whether a CT scan increases the lifetime risk of developing cancer; whether younger patients have a higher risk of developing cancer from radiation associated with a CT scan; whether they knew the approximate radiation dose of a CT scan of the abdomen and pelvis; and whether they knew the approximate increase in lifetime risk of developing cancer from a CT study.

Following the set of questions regarding radiation dose and risk, brief educational text (eFigure) was provided, discussing ionizing radiation and its potential to cause cancer and that CT exposes patients to 2 to 5 times the amount of background radiation or 25 to 100 times the amount of radiation received from a 2-view chest radiograph. An additional set of questions followed regarding a hypothetical imaging test that could detect smaller cancers but would expose the patient to more radiation compared with currently used tests followed.

The data were analyzed using statistical software (SAS, version 8.2; SAS Institute, Cary, North Carolina). Contingency tables were used to evaluate counts and proportions. Associations between responses were analyzed using the Pearson χ^2 test. $P \leq .05$ was considered statistically significant.

Results. During the study period, 768 questionnaires were distributed, and 296 were returned for a response rate of 38%. Of the questionnaires, 37 were answered incompletely; however, all respondents completed at least 15 of the 20 questions.

Respondent Demographics. Of the respondents, 127 (43%) were women and 168 (57%) were men, with a mean age of 56 years (range, 19-91 years). The level of education achieved by the respondents was postgraduate degree (n=74 [25%]), college degree (n=78 [28%]), some college (n=93 [32%]), and high school degree (n=39 [13%]). Ten respondents (3%) never graduated from high school.

Decision Making. Prior to imaging, of 295 respondents (with the denominator indicating the number of responses to the question) 246 (83%) had discussed reasons with their physician for obtaining a CT examination. When this discussion occurred, 242 of 245 respondents (99%) replied that they understood the reasons for having this study. In comparison, when the respondent replied that no discussion had occurred, only 26 of 40 (65%) replied that they understood the reasons for having the CT, while the remaining 14 (35%) either did not understand the reasons or were uncertain about the reasons ($\chi^2=72.17$; $P<.001$).

Of the 295 respondents, the final decision to have CT imaging was made by the physician in 138 (47%), by both the patient and physician in 129 (44%), and by the patient in 28 (9%). With regard to patient involvement in the decision to obtain a CT scan, 266 of the 295 respondents (90%) believed that their degree of involvement was satisfactory. When a discussion occurred regarding the reasons for obtaining a CT, patients were more likely to have participated in the final decision (145 of 246 [59%]). In comparison, if patients were unsure or did not recall such a discussion regarding the reasoning for obtaining a CT, the majority of respondents (37 of 48 [77%]) be-

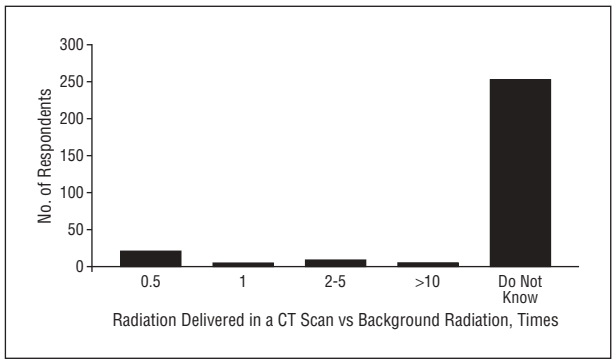

Figure 1. The distribution of 292 responses to the question "How much more radiation is delivered in an average computed tomography (CT) examination of the abdomen and pelvis compared with 1 year of background radiation received from living in this area?" The responses to the multiple choice question are shown on the x-axis. In our area, a CT scan would provide 2 to 5 times the annual background radiation.[9]

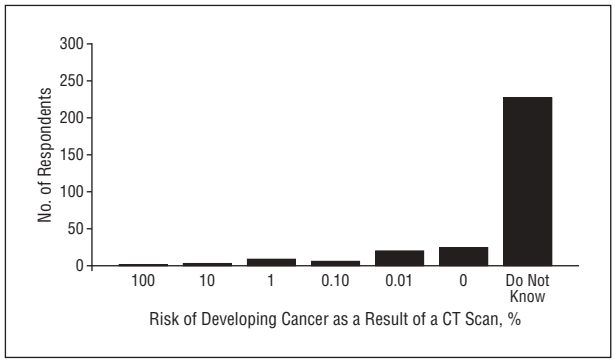

Figure 2. The distribution of 291 responses to the question "As a result of a computed tomographic (CT) scan of the abdomen and pelvis, by how much, if at all, is the lifetime risk of developing cancer like stomach, colon, liver, or lung cancer increased?" The responses to the multiple choice question are shown on the x-axis. The actual increase is estimated to be 0.10%.[9]

lieved that the final decision was made by their physician (χ^2=21.20; $P<.001$). In addition, only 10 of 246 respondents (4%) who had such a discussion wanted more involvement, whereas 17 of the 48 patients (35%) who did not recall the discussion wanted more involvement in the final decision to have a CT (χ^2=43.23; $P<.001$).

In regards to learning about CT, among 296 respondents the resources used most frequently included the following: referring physicians (n=140 [47%]), informational material provided by health care authorities (n=53 [18%]), the Internet (n=50 [17%]), the media (newspapers, magazines, or television) (n=36 [12%]), and friends and family (n=35 [12%]). Seventy four of the respondents (25%) had no prior information regarding CT imaging.

Radiation Awareness. The percentage of respondents who believed that each of the following tests involves exposure to ionizing radiation was as follows: chest radiography, 92%; CT, 85%; mammography, 55%; magnetic resonance imaging, 38%; and ultrasonography, 13%. In a multiple-choice question, the majority of respondents did not know the amount of radiation delivered in a CT examination compared with background radiation exposure and only 3% selected the correct relative dose (**Figure 1**). Similarly, in a multiple-choice question regarding the additional lifetime risk of developing a malignant neoplasm as a result of CT imaging, 2% selected the correct increase in risk (**Figure 2**). When asked whether the risk of developing a malignant neoplasm from the radiation exposure from a CT scan was greater for younger patients compared with older patients, only 9% thought the risk was greater. Similarly, only 6% believed that a CT scan increases an individual's lifetime risk of developing cancer.

Follow-up Questions. The majority (243 of 278 [87%]) of the patients were interested in learning about a new hypothetical "enhanced" CT examination. However, the majority (170 of 243 [70%]) of the interested respondents wanted their physician's input prior to undergoing the scan. Of 278 respondents, when asked about screening CT scans, 116 (42%) were willing to undergo this test when told that the benefit of detecting an abnormality was greater than a real but small risk of causing cancer, 89 (32%) wanted their physician to make the decision, 50 (18%) were unsure, and 23 (8%) were not interested.

Demographics and Decision Making. A significant association (χ^2=9.19; P=.01) was found between the respondent's sex and who the respondent thought made the final decision to obtain the CT. The majority (86 of 167 [52%]) of men replied that the decision was made solely by their physician, while 61 (36%) replied that the decision was made together with their physician. Conversely, the majority (68 of 127 [53%]) of the women replied that the decision was made together with their physician, while 51 (40%) replied that the decision was made solely by their physician. No significant relationship was found between education level and the final decision to obtain the imaging study.

The sex and education level of the respondent was not significantly related to patient awareness of increased cancer risk associated with CT or patient interest in the hypothetical CT examination.

Comment. There is a growing trend in medical care toward increased patient participation in medical decision making.[10,11] Degner et al[12] found that 44% of patients with breast cancer wanted to make treatment decisions in collaboration with their physician and 34% wanted to leave the decision to their physician. Similarly, in a study of 79 patients with human immunodeficiency virus/AIDS,[13] 59% of respondents preferred shared medical decision making with their physician and 13% wanted their physician to decide for them.

Our results reflect this trend in medical practice. The majority (83%) of our respondents stated that they had discussed the reasoning for obtaining a CT examination with their physician and the decision to undergo CT imaging was shared by both the physician and patient in 44% or solely by the patient in 9% of instances. Interestingly, the majority (53%) of women stated that they shared the decision with their physician, whereas the majority of men (52%) replied that the decision was made by their physician. This difference has been reported previously by other investigators who found that a more active role in medical decision making was preferred by patients with an increased level of education, younger age, and female sex.[14]

Our study reflects the influential role physicians play in managing patient care. A physician was involved in 91% of the decisions to undergo CT imaging (either with the patient or solely). In fact, a large minority (47%) of patients believed that the decision to undergo CT imaging had been made entirely by their physician. This is not surprising, as it has been shown that patients are often less involved in decision making regarding a diagnostic procedure.[11] However, we found that when a physician discussed with the patient the reasons for obtaining a CT scan, patients felt more involved in the decision-making process and were more satisfied with their involvement. Our study group also indicated that their main source of information regarding CT was their referring physician (47%).

Despite the amount of physician involvement in the decision to obtain a CT scan, our respondents knew little about ionizing radiation. In addition, despite the high level of education achieved by our study group (51% had achieved a college degree or greater), our investigation revealed that patients are not aware of the risks associated with medical imaging, which was demonstrated by the fact that only 6% of respondents knew that the radiation associated with CT increased the lifetime risk of cancer. Our results are similar to those of Lee et al,[15] who found that only 3% of surveyed emergency department patients believed that their lifetime risk was increased as a result of a CT scan. The authors concluded that patients are not given adequate information about the risks of CT. Unfortunately, the referring physicians themselves may be unaware of radiation risks associated with CT imaging. In the study by Lee et al,[15] emergency department physicians and radiologists were surveyed about their awareness level concerning radiation dose. The investigators found that only 47% of radiologists and 9% of emergency department physicians believed that there was increased risk of cancer associated with CT scans.

Medical imaging is the largest source of man-made ionizing radiation exposure to humans, and CT is estimated to contribute more than 70% of that amount.[3,16] According to the Biological Effects of Ionizing Radiation (BEIR) VII Report, the estimates of the number of radiation-induced solid cancers and leukemias are 90 excess cases for male patients and 137 excess cases for female patients per 10 millisieverts (mSv) received by 100 000 persons. According to this data, it would be expected that approximately 1 individual in 1000 will develop cancer from an exposure of 10 mSv. This provides an excess relative risk of approximately 0.2% compared with causes of cancer unrelated to radiation.[9] Brenner and Hall[2] have suggested that approximately 1.5% to 2% of all cancers in the United States may soon be due to radiation exposure from CT examinations.

In conclusion, in the current era of new CT technology development, physicians are ordering increasing numbers of newer and more radiation-intensive CT examinations. According to our study, patients are not receiving adequate information regarding their exposure to ionizing radiation when these examinations are obtained. We have also found that patients rely heavily on their referring clinical physician for this information. Thus, there is an urgent need for physicians to educate themselves and more importantly their patients about ionizing radiation and its associated risks.

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