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Patient preferences and acceptable risk for computed tomography in trauma

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ABSTRACT

Background: Rising use of computed tomography (CT) to evaluate patients with trauma has increased both patient costs and risk of cancer from ionizing radiation, without demonstrable improvements in outcome. Patient-centred care mandates disclosure of the potential risks, costs and benefits of diagnostic testing whenever possible.

Objective: We sought to determine (1) patient preferences regarding emergency department (ED) real time discussions of risks and costs of CT during their trauma evaluations; and (2) whether varying levels of odds of detection of life-threatening injury (LTI) were associated with changes in patient preferences for CT.

Methods: Excluding patients already receiving CT and patients with altered mental status, we surveyed adult, English-speaking patients at four Level I verified trauma centres. After informing subjects of cancer risks associated with chest CT, we used hypothetical scenarios with varying LTIs to assess patients' preferences regarding CT.

Results: Of 941 patients enrolled, 50% were male and their mean age was 42 years. Most patients stated they would prefer to discuss CT radiation risks (73.5%, 95% CI [66.1–80.8]) and costs (53.2%, 95% CI [46.1–60.4]) with physicians. As the odds of detecting LTI decreased, preferences for receiving CT decreased accordingly: LTI 25% (desire 91.2%, 95% CI [89.4–93.1]), LTI 10% (desire 79.3%, 95% CI [76.7–81.9]), LTI 5% (desire 69.1%, 95% CI [66.1–72.1]) and LTI <2% (desire 53.8%, 95% CI [50.6–57.0]). If the LTI was <2% and subjects were required to pay \$1000 out-of-pocket, only 34.5% (95% CI 31.4–37.5) would opt for CT.

Conclusion: Most non-critically injured patients prefer to discuss radiation risks and costs of CT prior to receiving imaging. As the odds of detecting LTI decrease, fewer patients prefer to have CT; at an LTI threshold of 2%, approximately half of patients would prefer to forego CT. Adding out-of-pocket costs reduced this proportion to one-third of patients.

Introduction

The use of computed tomography (CT) in United States health care has increased significantly over the past few decades, from approximately 2 million scans performed in 1980 to 85.3 million in 2011 [1–3]. Similarly, emergency department (ED) advanced diagnostic imaging for injury (primarily CT) has increased from 6% of visits in 1998 to 15% in 2007, without corresponding increases in hospital admissions or diagnoses of life-threatening conditions [4]. This increased CT use exposes more patients to potentially harmful ionizing radiation, contributes to ED crowding, and generates annual radiographic charges approaching \$100 billion [5].

Diagnostic medical imaging is a major source of non-natural radiation exposure, accounting for 15–20% of annual doses [6]. In the evaluation of patients with trauma, CT is the largest source of radiation [6]. When compared to plain chest radiographs, for example, CT scans involve as much as 119 times more radiation [1]. This ionizing radiation has been associated with an increased cancer risk in a linear, dose-dependent relationship [6,7]. It is estimated that 1 in 270 women who undergo CT coronary angiography at age 40 will develop cancer as a direct result of the scan, and approximately 29,000 future cancers may be related to the CTs performed in the U.S. during 2007 alone [1,7,8]. Although public awareness of radiation risk is increasing, most patients still remain unaware of radiation exposure risk from CT [2,9].

Respect for patient autonomy mandates providing informed consent for procedures that carry risk whenever possible. Yet, despite emerging knowledge about the potential cancer risks of CT, trauma imaging is typically obtained without informing patients of its risks or discussing their preferences. Patients may prefer to forego CT and accept a chance of missed injury in order to avoid the radiation exposure and costs of CT. Our objectives of this study were to determine (1) patient preferences for the discussion of risks and costs of CT during trauma evaluations in the ED, and (2) whether varying odds of detecting life-threatening injury (LTI) by CT changes these preferences. Knowledge of these patient preferences and risk tolerances may be useful to promote patient autonomy and shared decision making.

Methods

Study design, participants, and setting

We conducted this cross-sectional survey of ED patients who presented to four urban American College of Surgeons verified Level I trauma centres between July 2012 and April 2013. After providing a scripted consent that emphasised voluntary and anonymous participation, we surveyed a convenience sample of patients with the following exclusions: (1) receiving CT scan, (2) altered mental status, (3) intoxication, (4) critical illness, (5) incarceration, (6) psychiatric hold, and (7) inability to understand an English-language survey. We gave subjects the option to read and complete the survey independently or to have the questions read to them by trained research staff. We obtained institutional review board approval at all sites.

Survey instrument

After review of the limited prior work in this field, we developed an instrument consisting of yes/no/not sure, multiple choice, and free-text response questions [2,10–15]. A faculty health care literacy expert, who was not otherwise involved in the study, reviewed the preliminary instrument and made recommendations regarding structure and content. We conducted a pilot test of the instrument on five ED patients to assess understanding and test retest consistency.

The first set of questions assessed preferences for being informed about radiation risks and costs of CT. We then provided subjects with the following risk statement: “According to recent estimates, the lifetime risk of developing cancer from the radiation of a chest CT may be as high as 0.26% (1/380) for a 20 year old woman (risks of developing cancer are likely lower for older persons and may be lower depending on the type of CT scanner used)” and gave them a series of hypothetical situations with varying risks of life threatening injury (LTI) detected on CT (range from 25% to <2%). For each scenario, we asked subjects whether they would want their physicians to order a CT. See Appendix A for the full survey instrument.

Data analysis

We managed data using Research Electronic Data Capture (RedCAP), hosted by the University of California, San Francisco [16]. We summarised and reported demographic data in aggregate form and performed statistical tests using STATA version 9.0 (StataCorp, College Station, TX).

Our a priori sample size determination was governed by the width of the confidence intervals around the point estimates for proportions in the yes/no survey questions. Seeking to establish a point estimate of the risk patients are willing to accept with 95% confidence within 4% of this point estimate, our minimum sample size was 666 subjects.

We calculated 95% confidence intervals for each of our point estimates at varying risk of LTI detection and determined whether gender, age >42 years (the median age of our study population), and higher education level (any education beyond a high school degree) were associated with differences in desire to discuss radiation risks and in preferences for CT. We additionally determined whether lower income (less than \$30,000) and lack of insurance were associated with differences in desire for discussions of CT costs and lower preferences for CT with a \$1000 out of pocket cost. We used multiple logistic regression to assess whether any of these subject characteristics were independently associated with CT preference in each of the five hypothetical situations.

Results

Of the 941 subjects enrolled, the mean age was 42 years and 50% were male. See [Table 1](#) for complete subject characteristics. Most subjects stated that they would prefer to discuss trauma CT radiation risks (73.5%, 95% CI [66.1, 80.8]) and costs (53.2%, 95% CI [46.1, 60.4]) with their physicians prior to receiving CT. As the hypothetical odds of LTI decreased, the desire for CT scan decreased accordingly: LTI 25% (desire 91.2%, 95% CI [89.4, 93.1]), LTI 10% (desire 79.3%, 95% CI [76.7, 81.9]), LTI 5% (desire 69.1%, 95% CI [66.1, 72.1]) and LTI 2% (desire 53.8%, 95% CI [50.6, 57.0]). If the LTI was less than 2% and subjects were required to pay \$1000 out of pocket for CT, only 34.5% (95% CI [31.4, 37.5]) would opt for imaging. These data are presented graphically in Figs. 1 and 2.

Table 1
Subject characteristics (n = 941).

Characteristic	n (%)
Gender	
Male	473 (50.3)
Female	467 (49.6)
Transgender	1 (0.1)
Age (yr), mean (SD)	42 (15.5)
Race/ethnicity	
White (non-Hispanic)	393 (41.9)
Black	228 (24.3)
Hispanic	222 (23.6)
Chinese	11 (1.2)
Other Asian	36 (3.8)
Other	51 (5.4)
Education	
No formal education	3 (0.3)
Some elementary/middle school	20 (2.1)
Completed middle school	20 (2.1)
Some high school	105 (11.2)
Completed high school	250 (26.6)
Some college	290 (30.8)
Completed college	170 (18.1)
Some graduate school	23 (2.4)
Completed graduate school	60 (6.4)
Annual income (n = 895)	
<\$10,000	337 (37.7)
\$10,000–\$30,000	265 (29.6)
\$30,001–\$60,000	153 (17.1)
\$60,001–\$100,000	72 (8.0)
>\$100,000	68 (7.6)
Health Insurance (more than 1 response allowed)	
Private insurance	218 (23.2)
Kaiser/other HMO	119 (12.6)
Medicare	112 (11.9)
Medicaid	214 (22.7)
Other city/state-funded	123 (13.1)
No insurance	139 (14.8)
Don't know	51 (5.4)

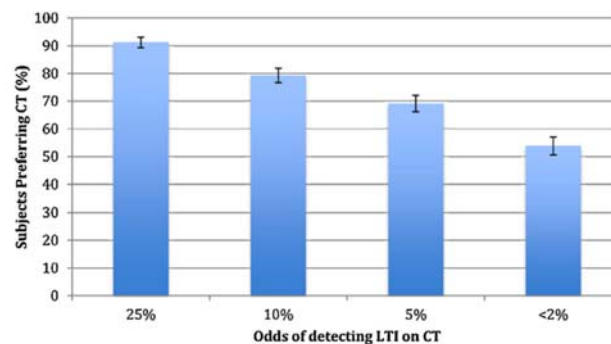


Fig. 1. Subject preference for CT versus odds of detection of LTI.

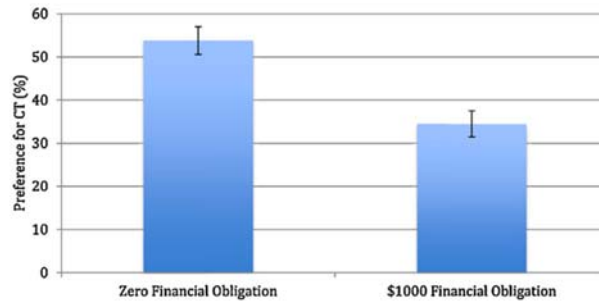


Fig. 2. Preference for CT with <2% detection LTI versus <2% LTI and financial obligation.

Older age was associated with less desire to discuss CT radiation risks [69.8% versus 77.3%: mean difference 8.6% (95% CI 2.9– 14.4%)]. Lower income was associated with less desire to discuss CT costs [44.4% versus 57.3%: mean difference 12.9% (95% CI 6.0– 19.7%)]. Female gender was associated with a lower preference for CT scanning if the LTI was less than 2% and subjects were required to pay \$1000 out of pocket (OR = 0.71, 95% CI [0.54–0.94]). None of the other subject characteristics analysed was associated with a difference in preference for CT in any of the scenarios.

Discussion

Similar to the recent work of Youssef et al., we found that nearly three quarters of non-critically ill patients want to discuss radiation risks before receiving CT (when possible) [17]. Considering that we asked these preference for discussion questions before presenting the statement about radiation risk, patients may already have been aware of some of these radiation concerns. Our study is novel in exploring variable acceptable risk thresholds and the effects of costs on preference for imaging. Just over half our subjects also wanted to discuss the costs of CT. Older age was associated with less desire to discuss radiation risk and lower income was associated with less desire to discuss CT costs.

The concept of acceptable risk or risk tolerance has been previously studied in non-trauma patient populations. In outpatient pediatrics practices, parents of children with fevers of unknown origin were willing to accept a low risk of an adverse outcome in order to avoid the short-term pain of diagnostic testing [10,11]. In the ED, Davis et al. found that patients with chest pain were more likely than their physicians to be willing to accept the small risk of a poor outcome that might result from ED discharge rather than admission [12].

We presented patients with a simple statement regarding CT radiation risk and found that as the hypothetical odds of detecting LTI decreased, patients' desires for CT correspondingly decreased. This finding supports the notion that, even with minimal discussion of radiation risks, patients logically weigh risks and benefits. At higher hypothetical LTI, the long-term risk from radiation is superseded by the more immediate risk of death. Notably, the majority of patients preferred CT scans at all levels of LTI when solely considering radiation risk. However, when a hypothetical out of pocket cost was incorporated into the low risk (LTI <2%) scenario, almost two-thirds of patients preferred not to be scanned.

Costs of CT are likely less of a concern for citizens of other regions of the world that support universal health care with no out of pocket charges. However, our data suggest that the LTI incidence affected subjects' preferences for CT more than (or at least as much) as cost concerns. The drop in preference for CT from a 25% LTI risk to a 2% LTI risk was 37.4% (95%

CI [36.1, 38.8])-significantly greater than the 19.3% (95% CI [19.2, 19.5]) drop in preference for CT that subjects indicated when considering the associated \$1000 out-of-pocket cost.

All current trauma imaging decision instruments designed to decrease unnecessary imaging use (including NEXUS Cervical Spine, NEXUS Chest and the PECARN Head CT rules) have imperfect sensitivity for injury; they carry some risk of missing injury when used to forego imaging [18–20]. Clinicians have differing views on how many and what injuries can acceptably be missed, and some practitioners may therefore be reluctant to rely on these rules [21]. It may be useful to identify acceptable risk thresholds for individual patients in order to support broader implementation of these guidelines. When the risk of finding injury on CT is less than the acceptable risk that patients are willing to assume, clinicians may have additional incentive and justification to forego CT. Documentation of patient preference may serve to reduce physician anxiety and liability risk in the event of a missed injury. In addition, if reproducible population-based acceptable risk thresholds can be identified in larger studies, clinicians might apply these thresholds toward imaging decisions when individual risk discussions are not feasible.

Reflex or protocol-driven imaging does not improve outcomes and, in low risk situations, diagnostic testing does not generally reassure patients or decrease their anxiety [22]. Informing patients about CT radiation risk and generating acceptable risk thresholds may promote a new paradigm of shared decision making in the following manner: Clinicians would apply a decision rule to generate an objective estimate of the chance that CT will detect an injury. When feasible, clinicians would discuss these probabilities (along with radiation risks and perhaps costs) to fully inform their patients and come to a shared decision. In fact, given that diagnostic CT carries the potential for cancer-induction and that many trauma (and other) CT scans are not truly emergent, physician-patient discussions regarding CT risks may very well become a standard, mandated practice. The aforementioned cancer-induction risk may be, in some cases, comparable to the risk of acquiring infection from a blood transfusion (a procedure for which we routinely obtain informed consent from patients), and so written, informed consent for CT may even be warranted.

The few ED studies examining provision of patients with risk probabilities and engagement in shared decision making have shown feasibility and promise of this approach [23]. Yamamoto and colleagues demonstrated an overwhelming patient preference for involvement in decisions about pediatric occult bacteremia work-ups and about sedation for laceration repair, with associated improvements in knowledge and satisfaction levels [14,24]. Other investigators have found decreased health care utilization without evidence of harm from missed diagnoses in patients presenting with chest pain [25]. Investigators are currently evaluating the provision of risk and outcome probabilities to acute stroke patients with regards to decisions about thrombolysis [12].

Limitations

Our queries regarding preferences about discussions of radiation risk were straightforward and not likely affected by poor understanding, but the most significant limitation of our study was the possibility that subjects did not understand the concept of balancing radiation risk and detection of life-threatening injury. We found progressive, incremental drops

in group preference for CT with lower risk of LTI, indicating that most subjects did grasp this idea. However, in a few cases subjects responded inconsistently or illogically to the LTI scenarios, indicating a higher preference for CT in lower risk situations. We kept the survey and scenarios brief and simple for two reasons: (1) to replicate realworld trauma situations in which detailed discussions with patients are unlikely; and (2) an extensive paragraph or dialogue describing radiation exposure and patient risk might introduce social desirability (and other) bias, inappropriately inflating the percentage of patients declining CT. Future investigations may construct and validate instruments in a more robust manner beyond our pilot-testing.

Given that we only presented one out-of-pocket cost/low LTI case, we could not identify the true inflection point at which a majority of patients would decline CT if a cost was associated with it. Nevertheless, considering the incremental decreases in desire for CT with decreased LTI and the apparent large impact of the potential out-of-pocket expense, several preference thresholds combining acceptable risk and cost could likely be identified with a more granular survey instrument.

The expense of \$1000 for CT in our scenario may not accurately reflect most patients' out-of-pocket charges. However, the mean charge for trauma protocol chest CT at the four institutions involved in this study was \$3323, and up to 22.3% of trauma patients do not have insurance [26,27]. We therefore felt that this expense was a reasonable estimate of charges for some patients for this question.

Finally, ethical and feasibility issues mandated that we exclude critically ill trauma patients and those receiving CT in the ED. It is possible that, when faced with true decisions about CT and the detection of life-threatening injuries, patients may prefer a more conservative approach with more CT imaging. Although we surveyed a broad population at four bicoastal U.S. trauma centres, it is possible that the preferences and acceptable risk thresholds of other patient populations may differ.

Conclusions

Most non-critically injured ED patients prefer to discuss radiation risks and costs of CT prior to receiving imaging for trauma. As the odds of detecting LTI decrease, fewer patients prefer to have CT, and at an LTI threshold risk of <2%, approximately half of patients would prefer to forego imaging. Only one-third of patients desired CT imaging when out-of-pocket costs of \$1000 were coupled with LTI risk <2%. Clarification of patient preferences may establish a new paradigm in advanced trauma imaging, promote the development of patient-centred assessments and shared decision-making, and establish acceptable risk thresholds for selective imaging decision instruments.

Author contributions

All authors contributed to the study design and implementation. All authors collected data, participated in ongoing site monitoring and provided supervision for the study. RMR, CLA, TH, and AR performed the data analysis. All authors contributed to interpretation of the analyses. RMR, TH and AR wrote the initial manuscript draft and all authors reviewed and contributed to its revision.

Conflict of interest statement

The authors have no conflicts of interest to declare regarding this research.

Appendix A. Supplementary data

Supplementary material related to this article can be found, in the online version, at <http://dx.doi.org/10.1016/j.injury.2014.03.011>.

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