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Effects of a radiation dose reduction strategy for computed tomography in severely injured trauma patients in the emergency department: An observational study

Soo Hyun Kim[1], Seung Eun Jung[2], Sang Hoon Oh[1], Kyu Nam Park[1] and Chun Song Youn[1*]

Abstract

Background: Severely injured trauma patients are exposed to clinically significant radiation doses from computed tomography (CT) imaging in the emergency department. Moreover, this radiation exposure is associated with an increased risk of cancer. The purpose of this study was to determine some effects of a radiation dose reduction strategy for CT in severely injured trauma patients in the emergency department.

Methods: We implemented the radiation dose reduction strategy in May 2009. A prospective observational study design was used to collect data from patients who met the inclusion criteria during this one year study (intervention group) from May 2009 to April 2010. The prospective data were compared with data collected retrospectively for one year prior to the implementation of the radiation dose reduction strategy (control group). By comparison of the cumulative effective dose and the number of CT examinations in the two groups, we evaluated effects of a radiation dose reduction strategy. All the patients met the institutional adult trauma team activation criteria. The radiation doses calculated by the CT scanner were converted to effective doses by multiplication by a conversion coefficient.

Results: A total of 118 patients were included in this study. Among them, 33 were admitted before May 2009 (control group), and 85 were admitted after May 2009 (intervention group). There were no significant differences between the two groups regarding baseline characteristics, such as injury severity and mortality. Additionally, there was no difference between the two groups in the mean number of total CT examinations per patient (4.8 vs. 4.5, respectively; $p = 0.227$). However, the mean effective dose of the total CT examinations per patient significantly decreased from 78.71 mSv to 29.50 mSv ($p < 0.001$).

Conclusions: The radiation dose reduction strategy for CT in severely injured trauma patients effectively decreased the cumulative effective dose of the total CT examinations in the emergency department. But not effectively decreased the number of CT examinations.

Keywords: radiation dosage, computed tomography, multiple trauma

Background

Over the last decade, the use of computed tomography (CT) scanning has approximately doubled, and CT scanning represents approximately two thirds of the total effective radiation dose in the United States [1]. Particularly in trauma patients, CT has become an essential diagnostic tool for treatment. Accordingly, the utilization of CT has increased over time in severely injured trauma patients [2]. The biological effects of ionizing radiation have been investigated and debated for more than a century [3]. Among them, the harmful effects of ionizing radiation have been well documented. More specifically, radiation exposure has been clearly linked to the development of cancer [4].

(1)

* Correspondence: ycs1005@catholic.ac.kr
[1]Department of Emergency Medicine, College of Medicine, The Catholic University of Korea, Seoul, Korea
Full list of author information is available at the end of the article

The liberal use of CT scanning has raised concerns about issues ranging from inappropriate resource use to the consequences of radiation exposure in trauma patients. For perspective, recent studies have shown that the median cumulative effective dose of ionizing radiation can be as high as 40.2 mSv for CT scans of blunt trauma patients [5]. According to our previous study, severely injured patients were exposed to extremely high (73.8 mSv) cumulative effective doses from CT scans in the emergency department [6].

With the increasing concerns about radiation exposure with the use of CT, several groups have proposed that guidelines should be established for a more selective use of CT and low-dose radiologic CT techniques [7,8]. However, the ability of such guidelines to reduce radiation exposure has not yet been clarified. We have proposed and implemented a radiation dose reduction strategy for severely injured trauma patients. The purpose of this study was to identify the effects of a radiation dose reduction strategy for CT in severely injured trauma patients in the emergency department through a comparison of retrospective data (from before the implementation of the radiation dose reduction strategy) and prospective data (from after implementation of the strategy).

Materials and methods

Patients

This prospective observational study was conducted in a tertiary urban educational hospital, the Seoul St. Mary's Hospital. The study was designed to collect data from patients who met the inclusion criteria during the year-long prospective study from May 2009 to April 2010 (Intervention group). These data were compared with data collected retrospectively during the year prior to the implementation of the radiation dose reduction strategy, from May 2008 to April 2009 (Control group). This study was approved by our institutional review board. Patients whose conditions resulted in the activation of the trauma team were included in the study if they were 18 years or older and were not transferred from or to another acute care facility. Patients who did not undergo any CT scans were excluded from the study. Trauma team activation occurred when at least one physical examination item and one degree of injury item were satisfied (Additional File 1).

Data Collection

Medical records were collected from the patients who triggered trauma team activation. The following demographic and clinical information was collected for each patient: age, sex, mechanism of injury, injury severity score (ISS), revised trauma score (RTS), Glasgow Coma Scale (GCS) score, mean arterial pressure at admission, heart rate at admission, initial disposition and outcome. The ISS was categorized as moderate injury (9-15), severe injury (16-24), or very severe injury (> = 25). The GCS score was categorized as mild injury (13-15), moderate injury (9-12), or severe injury (3-8) [9]. Established clinical definitions were used for the physiological vital signs at admission, and hypotension was defined as < 90 mmHg in systolic blood pressure. Outcomes were defined as follows: emergency department length of stay (LOS) was defined as the time from admission to departure from the emergency department, intensive care unit LOS, hospital LOS and mortality was defined as the mortality status at hospital discharge.

CT Scanning Parameters

All the recorded CT scans conducted during admission to the emergency department were included in the study. Two 64-channel scanners (LightSpeed VCT; GE HealthCare, Milwaukee, Wisconsin, USA and Somatom Sensation 64; Siemens Medical Solutions, Erlangen, Germany) were used for all the CT studies performed before implementation of radiation dose reduction and Somatom Senstation was used after implementation of radiation dose reduction. The general scan parameters for each trauma location before the implementation of dose reduction strategy were a) head trauma: helical acquisition, 120 kVp, 400 mA, 112 effective mAs, 1, 46 sec of rotation time, 3.8 mm slice thickness, and standard of convolutional kernel for LightSpeed VCT and 120 kVp, 390 effective mAs, 1 sec of rotation time, 5 mm slice width, and H31s of convolutional kernel to spiral mode; b) spine: helical acquisition, 120 kVp, 335 mA, 8 effective mAs, 1, 46 sec of rotation time, 2 mm slice thickness, and standard of convolutional kernel for LightSpeed VCT; (c) chest: Helical acquisition, 120 kVp, 250 mA, 15 effective mAs, 0.5 sec of rotation time, 5-mm slice thickness and high resolution kernel for lung window setting for non-enhanced scan and standard convolutional kernel for mediastinal setting on contrast enhanced scan. Two phases of before and after contrast administration were obtained; (d) abdomen and pelvis: helical acquisition, 120 kVp, 304 mA, automatic tube current modulation (SmartmA), 0.5 sec of rotation time, 5-mm slice thickness and standard convolutional kernel. Two phases of arterial phase and portal venous phase after contrast administration with bolus tracking were obtained. When we obtained both chest CT and abdominopelvic CT, we obtained each body parts scanning according to each protocol. The upper abdomen was overlapped in chest CT and abdominopelvic CT.

After implementation of dose reduction strategy, a) head trauma: helical acquisition, 120 kVp, 390 effective mAs, 0.5 sec of rotation time, 5 mm slice width, and H31s of convolutional kernel; b) spine: helical