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Radiation exposure from computed tomography in blunt trauma patients

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ABSTRACT

Introduction. Computed tomography (CT) has many diagnostic advantages, spurring growth in the number of CT examinations. As the use of CT increases, the potential for radiation-induced adverse effects has become an issue. The primary objective of this study was to assess the liberal use of CT induced radiation exposure in patients with multiple blunt traumas. The secondary objective was to investigate the factors affecting the estimated effective dose resulting from CTs unrelated to final diagnosis.

Methods. Using data from our hospital information system, we selected patients assigned a trauma code, according to the Korean Standard Classification of Diseases, and with three or more body lesions assessed by CT at the same time in the emergency department. Each CT conducted was categorized into 'CT related to the final diagnosis' or 'CT unrelated to final diagnosis'. The characteristics and estimated effective dose of CTs unrelated to the final diagnosis were analyzed. The factors affecting the estimated effective dose of CTs unrelated to final diagnosis were investigated.

Results. More than half of all CT examinations were not associated with the final diagnosis. The additional estimated effective dose due to CTs being unrelated to the final diagnosis in each patient was a sufficient amount of radiation exposure to increase the possibility of fatal cancer.

Conclusion. A considerable number of CT scans were unrelated to the patient's final diagnosis, which exposes the patient to additional radiation exposure.

Key words: radiation, trauma, computed tomography

Introduction

Technological advances in radiological diagnosis have been developing faster than in other areas of medicines. Computed tomography (CT), in particular, is one of the diagnostic tools that has broken new ground in the field of modern medicine and has expanded its clinical usefulness since its development in 1972. As the use of CT increases, it has raised the question of radiation-induced adverse effects. (1) The National Council on Radiation Protection and Measurement has reported that the effective dose per individual in the USA population has increased from 3.6 millisievert (mSv) in the early 1980s to 6.2 mSv in 2006. Medical sources of radiation contributed only 15% of total radiation exposure in the early 1980s, while 48% of total radiation exposure was from medical sources in 2006. The main medical sources of radiation exposure were CT scans and nuclear medicine. (2)

The management of blunt trauma has been influenced by advances in the technology of CT. Non-operative management of blunt abdominal trauma evolved with CT. (3-6) CT makes it possible to characterize the patient with multiple injuries and establish management priorities based on more precise information. With the liberal use of CT for blunt trauma, whole body CT scanning, known as the 'panscan' has often been used in trauma centers to detect possible missed injuries. However, applying a panscan protocol puts the patient at risk of excess radiation exposure. (7)

Within the Organization for Economic Cooperation and Development (OECD) countries, South Korea has the third largest number of CT scanners per million people after Japan and Australasia. The annual number of CT examinations is increasing every year. (8) Liberal use of CT has been increasing for fear of a missed diagnosis and medico-legal concerns. The primary objective of this study was to assess the liberal use of CT induced radiation exposure in patients with multiple blunt traumas. The secondary objective was to investigate the factors affecting the estimated effective dose from CTs unrelated to final diagnosis.

Materials and methods

This study was a retrospective study performed for multiple blunt trauma patients visiting the Korea University Guro Hospital via emergency room from July 2012 to June 2013. This study was approved by the institutional review board of our hospital. (IRB No.: KUGH13143-001)

Our emergency department (ED) has about 60,000 visits per year. Our hospital does not have a panscan protocol for CT evaluation. In the evaluation of trauma patients, physicians in our hospital order multiple types of CT according to the body part injured. Using data from our hospital information system, we selected patients assigned a trauma code based on the Korean Standard Classification of Diseases and who underwent three or more CT scans for body lesions at the same time in the ED. Korean Standard Classification of Diseases is a system of diagnostic codes based on the International Classification of Diseases and adjusted for Korea. Two investigators reviewed the patient charts. They were blinded to the study objective. The data collected from the patient chart review were age, sex, initial vital signs, Glasgow Coma Scale (GCS), final diagnosis, Injury Severity Score (ISS), injury mechanism, mode of transportation, anatomical location of injury, route of dispatch from the ED, types of CTs done, and the reading of the CT by a radiologist. Each CT conducted was categorized into either 'CT related to final diagnosis' or 'CT unrelated to final diagnosis'. A CT was defined as being related to the final diagnosis if the reading mentioned hemorrhage, fracture, hemo-pneumothorax, organ contusion or laceration, or vascular injury. If the CT reading was 'within normal limits' or mentioned only soft tissue contusion, the CT was defined as being unrelated to final diagnosis. When two chart reviewers presented conflicting data for the relationship between the CT and final diagnosis, the patient was excluded from the study. The dose length product (DLP), depending on the type of CT, was also examined by review of the Picture Archiving and Communication System (PACS) for each patient.

The total number of initial CT scans conducted per patient and estimated effective dose, depending on the type of CT, was investigated. The estimated effective dose was calculated as the DLP multiplied by a "k" conversion factor. The reference for the conversion factor was the American Association of Physicists in Medicine (AAPM) report No. 96. (9) The characteristics and estimated effective dose of CTs unrelated to final diagnosis were also analyzed. Finally, we investigated the factors affecting the estimated effective dose of CT scans unrelated to the final diagnosis.

Statistics

Using SPSS 17.0 software package (IBM, Chicago, IL, USA), the Mann-Whitney U test was used to compare the mean value of estimated effective dose and the number of CTs. We also performed a multivariate logistic regression test to analyze the factors of the estimated effective dose from CTs unrelated to final diagnosis. Data were presented as mean ± standard deviation.

Results

1. Clinical data of the included patients and their injury details (tables 1, 2).

Table 1. Clinical data of included patients (n=105).

Male:Female ratio	67:38
Age in years (mean±SD)	46.8±19.4
Glasgow coma scale	No. of patients (%)
3-7	6 (5.7)
8-13	24 (22.9)
14-15	75 (71.4)
Injury severity score	No. of patients (%)
<15	63 (60.0)
>15	42 (40.0)

SD, standard deviation

A total of 117 eligible patients were identified in the database of the hospital information system during the study period. Five patients were excluded because the DLP data could not be found in the PACS and 7 patients were excluded because conflicting data were presented for the relationship between the CT and the final diagnosis. One hundred and five patients were included in the end. The included patients underwent radiographic evaluation using a 16-slice CT scanner (Somatom Sensation 16, Siemens, Forchheim, Germany). Thirty patients (28.6%) had an initial GCS score under 14 and 63 (60%) patients had an ISS score under 15.

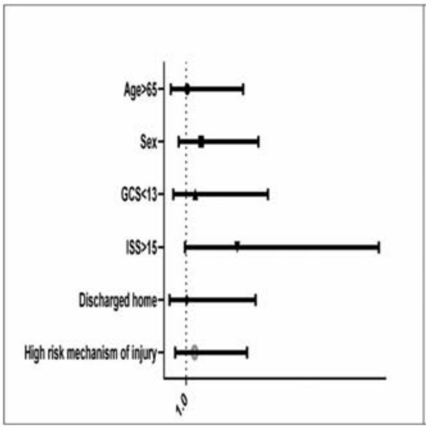
The most common injury mechanisms were falls and pedestrian or cyclist injuries. They comprised 60 cases (57.1%). Ninety two patients (87.6%) were transported to the emergency department by the emergency medical service (EMS), and only 13 patients visited ED via a method other than EMS. The head and limbs were the major anatomical locations of injury. The route of dispatch from the ED was transfer, intensive care unit, general ward, discharged home, operating room, and death, in that order of frequency.

2. The characteristics of initial CT (tables 3, 4).

The 105 patients received a total 408 CT scans initially. The main types of CT conducted were head, chest, and abdomen scans. The estimated effective dose, depending on the type of CT, was within the level of the typical effective dose in the AAPM report 96. The number of patients receiving an

Table 2. Injury details of patients.

Injury mechanism	No. of patients (%)
pedestrian or cyclist hit	36(34.3)
high speed car or motorcycle collision (>50 kph)	17(16.2)
low speed car or motorcycle collision (<50 kph)	6(5.7)
fall from an unkown or >3 m height	24(22.3)
slip and fall	10(9.5)
assault	6(5.7)
other	6(5.7)
Mode of transportation	**No. of patients (%)**
emergency medical service	92 (87.6)
self transport by vehicle	8 (7.6)
walking	5 (4.8)
Anatomical location of injury	**No. of patients (%)**
head	30 (28.6)
neck	21 (20.0)
chest	24 (22.9)
abdomen	23 (21.9)
pelvis	12 (11.4)
thoracolumbar spine	14 (13.3)
limb	30 (28.6)
Route of dispatch from the emergency room	**No. of patients (%)**
operating room	5 (4.8)
intensive care unit	26 (24.7)
general ward	22 (21.0)
discharged home	15 (14.3)
transferred	32 (30.5)
death	4 (4.8)



	Odds ratio	95%CI	p
Age>65	1.050	(0.309-3.573)	0.937
Sex	1.678	(0.661-4.258)	0.276
GCS<13	1.413	(0.426-4.688)	0.572
ISS>15	3.306	(0.951-9.694)	0.061
Discharged home	1.031	(0.257-4.133)	0.965
High risk mechanism of injury	1.384	(0.511-3.748)	0.522

Figure 1. Multivariate logistic regression analysis for receiving an estimated effective dose > 10 mSv unrelated to final diagnosis. GCS, Glasgow Coma Scale; ISS, Injury Severity Score.

estimated effective dose over 20 mSv was 59 (56.2%). The number of CT examinations unrelated to the final diagnosis was 247 (60.7%). Each patient received 2.35±1.26 CT scans unrelated to their final diagnosis. Accordingly, the estimated effective dose due to CT unrelated to final diagnosis was 12.80±8.54 mSv.

3. The factors affecting the estimated effective dose unrelated to final diagnosis (figure 1).

The estimated effective dose according to sex, age, GCS, ISS, route of dispatch, and injury mechanism was investigated. For the analysis of the multivariate regression test, we condensed age (<65 and ≥65), GCS (<13 and ≥14), route of dispatch (discharged home or dispatched elsewhere) and injury mechanisms into dichotomous variables. The mechanisms of injury were divided into high risk mechanisms and low risk mechanisms. High risk mechanisms of injury included pedestrian or cyclist injuries, high speed car or motorcycle collision (>50 kph), and fall from an unknown or >3 m height. Low risk mechanisms of injury included slip and fall, low speed car or motorcycle collision (<50 kph), assault, or miscellaneous. None of the factors were found to affect the estimated effective dose >10 mSv unrelated to the final diagnosis statistically.

Discussion

Primary and secondary surveys in trauma patient management are very important. There is always some possibility for hidden and missed injuries. If the mental status of a trauma patient is not clear, the symptoms and physical findings may not be a reliable basis for diagnosis. In that case, physicians have a tendency to depend on CT for fear of a missed diagnosis and medico-legal concerns. In the developed nations, such as the USA, Japan, and the European countries, whole body CT scans have become widely used in the management of blunt trauma patients. (10-14) Computed tomography has many advantages as a diagnostic tools, including short examination time, repeatability, reliability, and convenience, leading to an increasing the number of CT examinations.

The Health Insurance Review and Assessment Service in Korea also reported that the total number of CT scans has more than doubled from 2003 to 2007. (8) The cost of CT including head, chest, and abdominopelvic scans altogether are about US $800 in Korea, and most of that is covered by various systems such as national health insurance, automobile insurance, and industrial accident compensation insurance.

Table 3. The initial computed tomography (CT) conducted and estimated effective dose.

	Initial CT scans conducted (n)	Estimated effective dose (mSv) †
Type of CT		
brain	103	1.74±0.55
facial bone	46	1.52±0.75
cervical spine	49	5.20±1.23
chest	91	6.38±1.84
abdominopelvic	95	9.69±3.52
other	24	11.19±3.52
Total	408	22. 49±8.47

† Data are presented as mean ± standard deviation.

Table 4. The characteristics of computed tomography (CT) depending on final diagnosis.

	Related to final diagnosis	Unrelated to final diagnosis
Type of CT	N(%)	N(%)
brain	34(33.0)	69 (67.0)
facial bone	23(50.0)	23 (50.0)
cervical spine	22(44.9)	27 (55.1)
chest	38(41.8)	53 (58.2)
abdominopelvic	30(31.6)	65 (68.4)
others	14(58.3)	10 (41.7)
Total	161(39.5)	247 (60.5)
Mean number of CT scans in each patient†	1.70±1.38*	2.35±1.26*
Estimated effective dose in each patient†	9.69±10.44 mSv**	12.80±8.54 mSv **

† Data are presented as mean±standard deviation. *p<0.001, **p<0.05

However, there is another issue resulting from liberal use of CT scans. Exposure to ionizing radiation from medical diagnostic and therapeutic procedures is increasing. The United Nations Scientific Committee on the Effects of Atomic Radiation reported that the annual ionizing radiation dose was increasing and computed tomography scanning was a major cause of increasing annual collective doses of ionizing radiation. (2,15) Although CT has been recognized as an essential clinical diagnostic tool, about 30% of radiologic evaluations, including CT, were found to be unnecessary and did not provide useful information according to the Canadian Association of Radiologists. (16) These results suggest that there is overuse of CT in medical practice.

We investigated the current status of the liberal use of CT in blunt trauma patients and the associated exposure to radiation. The most common causes of injury were pedestrian or cyclist hit and falls. Among all of the patients, 30.5% were transferred. Most of them only needed conservative management and did not have major injuries. About half of the included patients were either discharged or transferred. In addition, considering that more than half of the patients had a GCS >13 and ISS<15, significant numbers of patients had only minor injuries and were administered three or more types of CT scan. Altered mental status and high risk mechanism of injury were found not to be associated with an estimated effective dose of over 10 mSv unrelated to the final diagnosis by multiple regression analysis. These findings mean that physicians were readily choosing to take multiple types of CT (in the sense of a panscan) regardless of patient condition and injury mechanism. Although the panscan protocol in trauma patients reduces mortality, radiation exposure must be considered. (17-19) On the other hand, some investigators have reported that whole body CT did not decrease mortality but did increase radiation exposure. (18,20)

In this study, the average estimated effective dose from each type of CT was within the level of the typical effective dose in the AAPM report 96. Among a total of 408 CT scans provided to patients, 247 CT scans were unrelated to the final diagnosis. The mean number of CT scans unrelated to the final diagnosis was 2.35±1.26 in each patient, which caused an additional exposure of 12.80±8.54 mSv to each patient.

A CT examination with an effective dose of 10 mSv may increase the possibility of fatal cancer to odds of approximately 1 in 2000. Some of the Japanese survivors of the atomic bombs received 5 to 20 mSv, and they have demonstrated an increased radiation-related excess relative risk for cancer mortality. (21) Brenner and Hall also suggested that 1.5% to 2% of cancers in the US might now be attributable to

CT scans. (1) From this point of view, it is true that radiation exposure due to CT unrelated to final diagnosis makes some contribution to cancer risk.

Limitations

Some limitations must be taken into consideration in analyzing the results of this study. It is certain that CT is essential in evaluating blunt trauma patients. Just because 60% of CT scans provided to multiple trauma patients were unrelated to final diagnosis does not mean that those examinations were completely unnecessary. Some of them should be done with the purpose of ruling out traumatic injury, although not for definite diagnosis. Nevertheless, physicians should take care not to overuse CT. In addition, clinical practice in trauma patient work up is not well standardized. These study results were only for one hospital. A multicenter study is needed to investigate the overall status of CT overuse in multiple trauma patients.

Conclusion

A considerable number of CT scans were unrelated to the patient final diagnosis, which exposes the patients to additional radiation. Although CT scans are essential for evaluating blunt trauma, the radiologic risk from multiple CT scans should be considered when evaluating trauma patients.

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