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ORIGINAL ARTICLE / ÖZGÜN ARAŞTIRMA

The diagnostic efficacy of low-dose cervical and thoracic CT in multiple trauma patients

Multipl travmada servikal ve torakal düşük doz spiral BT'nin tanısal etkinliği

Cemil Göya[1], Alpaslan Yavuz[2], Cihad Hamidi[1], Çağatay Andiç[3], Mehmet Guli Çetinçakmak[1], Memik Teke[1], Can Özkaynak[4]

ABSTRACT

Objective: The aim of this study was to evaluate the initial diagnostic efficacy of low-dose computed tomography (CT) in multi-trauma patients.

Methods: 74 patients (44 male, 30 female; average age: 36.9 years) accepted to the emergency unit with the reason of multiple trauma which is included in this study. Cervical and thoracic injury sites were initially evaluated with portable X-Ray and low-dose CT. The Patients' progress, surgical findings and additional radiologic examination results were recorded until the patients were discharged.

Results: The sensitivity and specificity of X-Ray graphies were 50% and 95% for thoracic traumatic pathologies; 0-40% and 95-100% for cervical injuries respectively. CT examination sensitivity and specificity values were 95-100% and 80-100% for thoracic injuries; 95-100% and 96-100% for cervical injuries respectively.

Conclusion: Low-dose CT examination is more sensitive than X-Ray graphs for the evaluation of cervicothoracic traumatic injuries. We recommend to prefer low-dose CT as an initial radiologic examination for managing cervicothoracic trauma cases because of its higher diagnostic capability than X-Ray graphy.

Key words: Low-dose CT, X-Ray, multiple traumas

ÖZET

Amaç: Amacımız çoklu travma hastalarının tanısında, düşük doz bilgisayarlı tomografinin (BT) değerini araştırmaktı.

Yöntemler: Acil servise çoklu travma nedeniyle başvuran 74 hasta (30 kadın, 44 erkek) çalışmaya dahil edildi. Direkt röntgen ve düşük doz BT ile servikal bölge ve toraks bölge yaralanmaları değerlendirildi. Hastalar hastaneden taburcu edilene kadar, gidişatları, cerrahi bulguları, ek olarak radyolojik bulguları kaydedildi.

Bulgular: Radyografinin duyarlılığı ve özgüllüğü sırasıyla torakal patolojilerde, %50, %95; servikal travmalarda ise %0-40 ve %95-100 idi. BT'nin duyarlılığı ve özgüllüğü sırasıyla %95-100 ve %80-100; torakal travmalarda %95-100 ve %96-100 olarak bulundu.

Sonuç: Servikotorakal travmaların değerlendirilmesinde düşük doz BT, daha duyarlıdır. Düşük doz BT ile hasta takibinin de değiştiği saptandı. Servikotorasik bölge travmalarının değerlendirilmesi ve takibinde, başlangıç olarak düşük doz BT, radyografik yönteme tercih edilebilir.

Anahtar kelimeler: Düşük doz BT, röntgen, çoklu travmalar

INTRODUCTION

Trauma is the primary cause of death in healthy young adults between 1 and 44 years of age [1,2]. The leading factor in reducing mortality and increasing the quality of life in the period of following the trauma in these patients is a rapid and precise diagnosis. There are already numerous methods in use throughout the diagnostic process beginning with the clinical examination, continuing with the radiological examination and laboratory tests, and reaching towards invasive diagnostic methods when necessary. However, there is no algorithm to date

[1] *Department of Radiology, Medical School, Dicle University, Diyarbakir, Turkey*
[2] *Department of Radiology, Medical School, Yuzuncuyil University, Van, Turkey*
[3] *Department of Radiology, Medical School, Baskent University, Adana, Turkey*
[4] *Department of Radiology, Medical School, Akdeniz University, Antalya, Turkey*

Yazışma Adresi /Correspondence: *Cihad Hamidi,*
Dicle University, Medical School, Department of Radiology, Yenişehir 21280 Diyarbakır Email: cihad5@hotmail.com
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on which a consensus has been reached by every organization [3,4]. The most commonly known guideline on this subject is the Advanced Trauma Life Support (ATLS) Student Manual published by the American College of Surgeons [5].

Trauma patients have various features, which make a timely and precise diagnosis difficult. The clinical examination methods which lead to accurate diagnoses in conscious patients are rendered invalid in unconscious patients [6] Also, the fact that more than one system has been subjected to the trauma increases the number of the diagnostic methods required and the time spent for the diagnosis. Problems that are more prominent may mask less obvious problems such as intra-abdominal pathologies, which are not recognizable at first sight but may turn out life threatening. All these reasons necessitate a more objective diagnostic method that may be used as a standard.

CT is already in use in emergency trauma patients. There are already a number of studies about its application with or without contrast agents for the diagnosis and the prediction of the posttraumatic process in cervical spinal trauma [7-9], thoracic trauma [10-14], and abdominal trauma [15-18].

Low-intensity helical CT has first been used as a scanning method for the early diagnosis of lung cancers [19,20]. Having the advantages of CT like low radiation levels and short scanning time, this method has been found to be superior to postero-anterior (PA) lung radiography as a scanning method [20].

In this study, the current approach to the neck and thorax comprising the clinical examination and radiographic methods described in the ATLS Student Manual [5] is compared with the low-dose CT scans used in the primary evaluation of emergency trauma patients.

METHODS

Patients who were presented to the emergency room due to multiple trauma injuries were clinically evaluated and the obtained data were recorded. The recorded clinical data of the patients included the age, sex, systolic and diastolic blood pressure, heart rate, respiratory rate and the Glasgow coma scale.

A total of 114 patients who were presented to the emergency department due to multi-trauma were included in the evaluation. Among these patients, 40 were excluded due to inadequate CT or radiographic image quality or shortcomings in the clinical follow-up, leaving a total of 74 study patients. A total of 74 patients (44 males and 30 females) were enrolled in the study. The ages of the patients varied between 12 and 78 (mean age, 36.9 years).

For the initial radiographic assessment, lateral cervical and AP chest radiographs were obtained in the supine position using a portable X-ray device. In cases where the patient's condition necessitated, antero-posterior and oblique cervical, and antero-posterior thoracolumbar radiographs were later added to the standard procedure. However, the results of these radiographs are not included in the study, since our aim was to compare the CT images with the radiographs, which are considered standard for the patient under emergency conditions.

The parameters used in the Shimadzu portable X-ray device were 6.3 mAs and 64-72 kV for the cervical radiographic assessments and 10-20 mAs and 70-80 kV for the AP radiographs.

The CT images were taken with the Toshiba Xpress and Xvision (Toshiba Medical, Tokyo, Japan) devices in all the patients included in the study.

The cervical low dose helical CT was assessed with a primary helical volume of 110 mm (120 kV, 50 mA), followed by a secondary helical volume of 60 mm (120 kV, 100mA). The mA value in Xpress was the lowest value authorized by the device. The first helical volume comprised the upper and mid-cervical region while the second cervical helical volume was planned to include the area of the shoulder joint and the claviculae. Possible artefacts were tried to be prevented with higher mA values. For the cervical CT, a rate of 7 mm/rotation and 5 mm collimation were chosen and the cross-sections were reconstructed with 3 mm distance.

For the thoracic low-dose helical CT, the parameters were selected as 120 kV and 50 mA. The thorax was scanned on a single helical volume at a rate of 20 mm/rotation and 10 mm collimation; and the cross sections were reconstructed with 8 mm distance. Thus, the pitch values were selected as 1.4 for cervical CT and 2 for thoracic CT. No oral or intravenous agents were used.

The time elapsed between the request of the radiographic examination and the start of the X-ray procedure was 95 seconds. The total duration of the lateral cervical and AP chest radiographs was 60 seconds. The time until the patient arrived to the CT was 120 seconds and the duration of the CT scan was approximately 60 seconds including all 3 helical volumes.

The X-rays and CT images were independently evaluated by two radiologists in case of differing interpretations, consensus was sought between the radiologists.

The clinical, CT and radiographic data of the patients were entered to the Statistical Package for Social Science (SPSS) (Version 10.0) software. In the neck area, patients were assessed under the subheadings cervical injury, cervical vertebral fracture, cervical soft tissue injury and cervical vertebral dislocation. Under the thoracic trauma heading, assessments were made under the costal fracture, clavicular fracture, scapular fracture, sternal fracture, thoracic vertebral compression fracture, transverse process fracture, vertebral instability, pneumothorax, hemothorax, mediastinal injury (pneumomediastinum, hemomediastinum, esophageal injury), pulmonary contusion and subcutaneous emphysema subheadings. Imaging was carried out using low dose helical CT and radiography, and the data obtained from these two methods were compared with the help of McNemar's test.

RESULTS

According to the final clinical outcomes, the pathological findings detected in the cervical area were cervical vertebral fractures in 5 patients, soft tissue injuries of the neck in 8 patients, cervical dislocation in 5 patients and other injuries classified under the heading of cervical injury in 12 patients. The majority of these pathological findings could not be diagnosed using radiography (only 8% could be diagnosed), while almost all of them were detected through CT (100%). Some pathological imaging findings were given in Figure 1-4. The findings are summarized in Table 1.

When evaluated according to the final clinical outcomes, the cervical radiological examinations had a 0-40% sensitivity and 95-100% specificity. The findings are summarized in Table 2.

When thoracic pathologies were assessed in general, the sensitivity of radiography was found as 50% while its specificity was 95%. When these values are assessed in detail, the sensitivity values among the thoracic pathologies were found as 50% in costal fractures, 4% in hemothorax, 21% in pneumothorax, 38% in pulmonary contusions, and 17% in subcutaneous emphysema; while the sensitivity and specificity in scapular and sternal fractures and mediastinal injuries were inadequate. The specificity of CT in these pathologies was 98%, 100%, 96%, 100%, 92% and 100%, respectively. The other details of the findings including the CT values are presented in Table 2.

Table 1. Computerized tomography (CT) and X-Ray radiography pathologic findings

	CT	X-Ray Radiography	Final Clinical Outcomes
Cervical injury	12	1	12
Cervical vertebra fracture	5	2	5
Cervical soft tissue injury	5	0	5
Cervical dislocation	5	1	5
Thoracic trauma	33	17	34
Rib fracture	21	7	22
Claviculae fracture	9	5	9
Scapula fracture	5	0	5
Sternum fracture	2	0	2
Vertebra trauma	17	0	17
Burst fracture	5	0	5
Transvers process fracture	11	0	11
Vertebral instability	1	0	1
Pneumothorax	14	3	14
Hemothorax	23	1	23
Mediastinalinjury	4	0	4
Pulmonary contusion	21	8	21
Subcutaneous emphysema	11	4	11

We investigated the difference between radiography and CT in terms of the final clinical outcome according to the McNemar's test and summarized the results we obtained in Table 2.

The p-values were calculated as $p = 0.625$ for cervical vertebral fractures, $p = 0.219$ for cervical dislocations, and as $p = 0.006$ for cervical injuries. In the comparison of the remaining cervical soft tissue injuries, no appropriate p-value could be obtained since no pathological findings were detected through radiography (Table 2).

In terms of the thoracic injuries, a value of p = 0.063 was observed in clavicular fractures, while this value was p = 0.125 in mediastinal injuries. Thus, both values were found to be statistically insignificant. On the other hand, a value of p = 0.001 was calculated in costal fractures, pneumothorax, hemothorax and pulmonary contusions; while this value was p = 0.004 in subcutaneous emphysema. These p-values pointed to a statistical significance.

Table 2. Sensitivity, specificity and P values of Computerized tomography (CT) and X-Ray Radiography to final clinical outcome

Pathologic Entity	X-Ray Radiography		CT		P Value
	Sensitivity %	Specificity %	Sensitivity %	Specificity %	
Cervical injury	8	95	100	97	0.006
Cervical vertebra fracture	40	99	100	100	0.625
Cervical soft tissue injury	0	100	100	96	----
Cervical dislocation	20	99	100	99	0.219
Thoracic trauma	50	95	97	80	0.001
Rib fracture	32	98	95	100	0.001
Clavicula fracture	50	100	100	98	0.063
Scapula fracture	0	100	100	100	----
Sternum fracture	0	100	100	100	----
Vertebra trauma	0	100	100	96	----
Burst fracture	0	100	100	100	----
Transvers process fracture	0	100	100	97	----
Vertebral instability	0	99	100	100	----
Pneumothorax	21	100	100	97	0.001
Hemothorax	4	96	100	90	0.001
Mediastinal injury	0	99	100	97	0.125
Pulmonary contusion	38	92	100	83	0.001
Subcutaneous emphysema	17	100	100	97	0.004

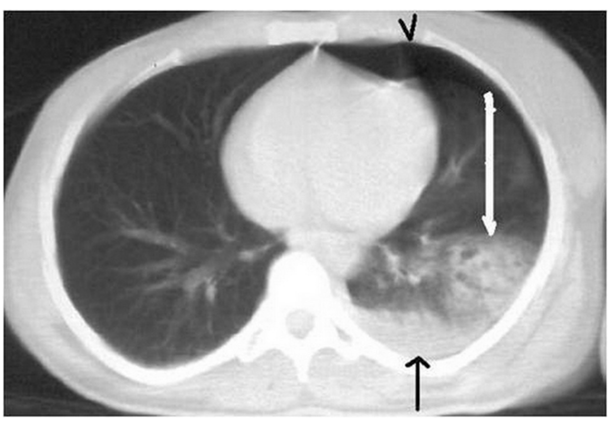

Figure 1. Left hemithorax sited minimal pneumothorax (arrowhead), contusion (white arrow) and pleural effusion (black arrow) were detected by low-dose CT

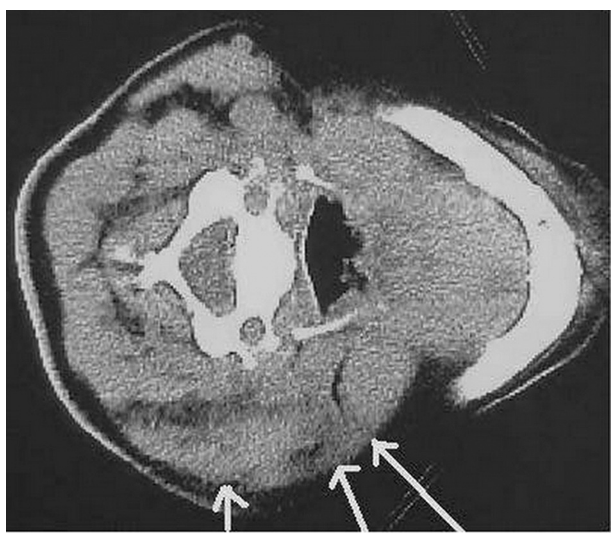

Figure 2. Soft tissue injury and edema at left side of the neck (white arrows)

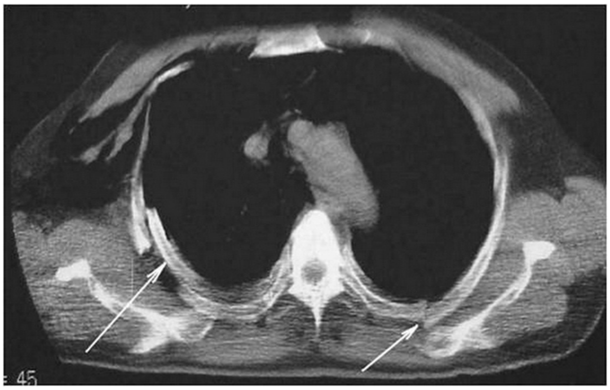

Figure 3. Rib fracture detected by low-dose CT (black arrow)

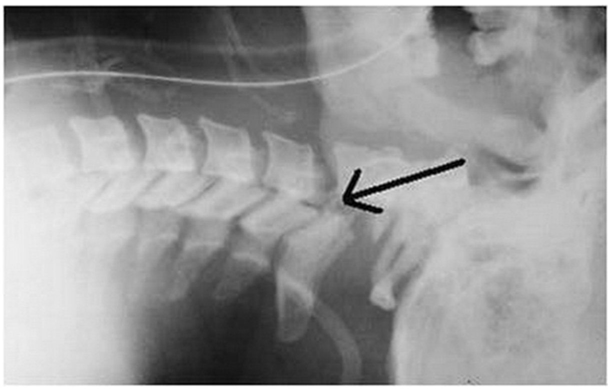

Figure 4. Fracture and subluxation at C2 vertebra (black arrow)

DISCUSSION

In the assessment of the trauma patients, conventional CT is a great development in comparison to radiography. However, helical CT and Multi-Detector Computed Tomography (MDCT) provide even greater advantages than conventional CT in patients with severe trauma. These advantages include the shorter duration of the scan and reconstruction, optimal vascular enhancement, and less misregistration- and motion artifacts. Also, the reformat and 3-dimensional reconstruction images are of a higher quality [21]. On the other hand, the low-dose CT is superior to the standard CT in terms of both the dose and the duration.

In spite of all the radiological developments, routine radiography is still the primary method used in multiple trauma patients in emergency rooms [22]. The approach described in the ATLS Student Manual published by the American College of Surgeons5 also features lateral cervical radiograph, AP chest radiograph and AP pelvic radiograph.

However, some authors report that in the evaluation of the cervicothoracic region, radiography leads to a diagnostic result in only 50% to 70% of the cases. Some others report a failure rate of 23% to 57% in the diagnosis of cervical vertebral fractures [23]. Although no significant difference between radiography and CT was observed in the cervical vertebral fractures, CT was still numerically superior in terms of the dislocations and soft tissue injuries in our study.

The diagnostic sensitivity of X-Ray exams for spinal trauma cases (especially for cervical trauma) were between 39% and 94% (with variable specificity values) in previously published studies in the literature [24-30]. Pia et al. reported that; plain X-Ray graphy as an initial radiologic examination for clinically significant cervical injuries caused delays for an accurate diagnose in 5-23% of cases [31]. MDCT is the most effective method to evaluate the cervical bone injuries of blunt trauma patients today [21,31-37]. In our study; there was no statistical significant difference between the sensitivity and specificity of plain films and CT for determination of cervical vertebra fracture, dislocation and cervical soft tissue injuries (P values) but CT has the numerical superiority.

Among the spinal cord injuries, 85% occur at the time of the trauma, while 5-10% occurs immediately after the trauma [23]. Therefore, the examinations must be carried out without moving the patient. However, this is practically impossible in radiography. On the other hand, the entire scan of the cervicothoracic region may be completed in a single position in the CT.

Also, although it is a known fact that although the cervicothoracic region is one of the most important areas in terms of the evaluation of the trauma, radiography may have shortcomings in that area due to the dose and superposition. Low-dose helical CT prevents superpositions and minimizes shoulder artifacts.

CT is known to be more successful in the characterization of possible intrathoracic pathologies (e.g. injuries of the aorta, heart, pericardium, mediastinum, diaphragm and lungs).38In our study, CT led to a statistically significantly difference in all the intrathoracic finding groups except for one. All of these are important in terms of the treatment (pneumothorax, hemothorax, pulmonary contusions). The fact that no statistical difference was observed in the group of mediastinal injuries was a result of the limited number of the patients; and all the four patients were correctly diagnosed through CT, while this number was zero with radiography.

Conventional radiography is generally accepted the primary diagnostic process for chest trauma patients today 39-40 but other studies reported that CT is more effective as a beginning scanning method for management of emergency chest trauma cases [41-45]. In polytrauma patients, it is difficult to get direct radiographs and the results are nondiagnostic. The method has limitations originating from the superposition of the structures forming the thoracic wall, the dose and reasons related to the trauma patient (the position of the patient and the restricted mobility, etc.). The best examples of this are the vertebral, sternal and scapular fractures. Any pathological findings in these groups are reason to modify the treatment modality. In a retrospective study, it has been observed that 22% of the thoracic vertebral fractures were overlooked.38In our study, CT led to a statistically significant difference compared to radiography in costal fractures. Although there was no statistically significant difference in the other groups (Table 2), a clear difference is visible in the number of the patients (Table 1). While CT could reveal all the cases in scapular, sternal and vertebral fractures, radiography could not show any of the conditions.

In this study, there was no significant difference between the time that elapsed until the radiography and the CT. Keeping in regard the diagnostic opportunities provided by the CT, this point may represent a superior aspect of the method.

Regarding from a financial point of view, radiography is doubtlessly cheaper than CT. However, the diagnostic superiority of CT may influence the treatment positively and may indirectly reduce the length of the hospital stay by preventing complications. In addition, polytrauma patients are usually in an altered mental state and therefore undergo computed brain tomographies. Similarly, thoracic instability or pelvic fractures are also indications for CT. Performing the cervicothoracic examination within the same CT session may be more time-efficient.

The limitation of this study was; our department has helical CT, which was used in this report thus we could not have the chance to take technical advantages of most widely-used MDCT machines. Low-dose protocols can be easily applied to MDCT and similar studies can be work out with different parameters. In certain centers, CT scans performed on various systems in severe trauma patients are preferred to an examination starting with radiography. However, the number of the studies considering cost-effectiveness is still inadequate [38].

In conclusion, in the traumas of the cervicothoracic region, low-dose helical CT may be preferred to radiography due to the diagnostic superiorities as a starting method.

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