Original Article

The Diagnostic Value of Chest and Abdominopelvic Computed Tomography in Detecting Thoracolumbar Fractures among Patients with Blunt Trauma

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Abstract

Background: Thoracolumbar fracture (TLF) is one of the common problems associated with trauma. This study evaluated the diagnostic value of chest and abdominopelvic computed tomography (CT) in detecting TLFs among patients with blunt trauma. **Methods:** This prospective diagnostic assessment study was conducted during 2016-2017. Participants were 256 patients above 18 years with blunt multiple trauma who had undergone chest and abdominopelvic CT at their admission to the emergency department and were subjected to thoracolumbar CT (TL CT) for the further assessment of TLFs. The sensitivity, specificity, and positive and negative predictive values of chest and abdominopelvic CT were calculated based on TL CT findings. **Results:** The total sensitivity, specificity, and positive and negative predictive values of chest and abdominopelvic CT in detecting TLFs were 89.55%, 100%, 100%, and 89.71%, respectively. These values were, respectively, 95.56%, 100%, 100%, and 98.39% in detecting transverse process fractures; 50%, 100%, 100%, and 91.04% in detecting vertebral body fractures; and 80%, 100%, 100%, and 65.24% in detecting vertebral body and posterior element fractures. Chest and abdominopelvic CT sensitivity and specificity were, respectively, 97.5% and 100% among patients younger than 40 years and 77.4% and 100% among patients older than 40 years. There was a significant agreement between chest and abdominopelvic CT and TL CT findings (kappa coefficient = 0.896; $P < 0.001$). **Conclusion:** Chest and abdominopelvic CT has acceptable sensitivity and specificity in detecting TLFs. However, due to low sensitivity and specificity in detecting vertebral body fractures without posterior element involvement and clinical importance of these fractures, image reformatting is suggested. Of course, TL CT can be used in case of suspicious fractures or older patients.

Keywords: Blunt trauma, chest, abdominopelvic, thoracolumbar, computed tomography, spinal fracture

Introduction

Blunt trauma is the main cause of death in industrial nations. Spinal fractures may occur in blunt trauma and have serious consequence such as spinal cord injury. The overall prevalence of spinal injury varies worldwide and is highest in the United States.[1] The incidence rate of spinal injury in Iran is 16.35/100,000 people.[2] Thoracolumbar fracture (TLF) is one of the common consequences of trauma, and about 50% of vertebral fractures occur in the thoracolumbar area.[3] The prevalence of TLF among patients with blunt trauma is 6.9%.[1] The risk of TLF is greater in high-energy trauma, such as motor vehicle accident and falling injury.[4]

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Delayed or missed diagnosis of TLFs can result in neurological deterioration; therefore, it is important for clinicians to reach prompt diagnostic decisions.[5] Clinical examination for evaluation of TLF is not adequate,[6] and most TLFs are currently diagnosed using imaging techniques. Computed tomography (CT) is the first-line modality in patients with spinal fracture. It is more sensitive and accurately than plain X-ray films for spinal assessment.[7,8]

CT scan provides the best image of bone fragments in the vertebral canal, soft-tissue abnormalities, including disc herniation, significant epidural hemorrhage, and other injuries in a trauma patient.[9] Moreover, it is effective in diagnosing injuries to the posterior neural arch and posterior element and measuring the strength of the spine, subluxations, and burst fracture.[10,11] Yet, compared with radiography, CT exposes patients to higher doses of ionizing radiation.[12]

On the other hand, most patients with blunt trauma will undergo CT scans of the chest, abdomen, and pelvis CT (CAP CT) to evaluate for other injuries.[13] In such cases, the coverage of those scans should be modified to involve the spine and eliminate double radiation.[7]

Diagnostic CT of the abdominopelvic and chest typically generates about 6 mSv of radiation exposure[14] the same as spinal CT.[15] Therefore, in case of diagnosis of fractures in the CAP CT, the patient's additional dose of radiation and missed injury can be prevented. In addition, diagnostic and therapeutic costs will be reduced and patient care and treatment will begin sooner.

Different studies have been conducted on patients with blunt trauma in order to assess the diagnostic value of radiologic imaging techniques. Most of these studies compared the findings of CT with radiography or reformatted CT images. For instance, a study reported that abdominopelvic CT was effective in accurately diagnosing 99.3% of fractures, and its diagnostic sensitivity was 99% for cervical spinal fractures, 98.5% for thoracic spinal fractures, and 100% for lumbar fractures. Moreover, that study reported contrast-enhanced CT as a sensitive diagnostic test to detect spinal fractures, and hence, routine spinal radiography is no longer necessary for the diagnosis of spinal fractures.[16] Another study into the accuracy of abdominopelvic CT and radiography for the diagnosis of spinal fractures found the greater diagnostic value of abdominopelvic CT. The sensitivity and the specificity of abdominopelvic CT in that study were 97% and 99%, while the sensitivity and the specificity of usual radiography were 58.7% and 93%, respectively.[17] Another study reported that the sensitivity, specificity, and positive and negative predictive values of abdominopelvic CT for fracture detection were 80.5%, 95%, 97.1%, and 70.3%, respectively. In that study, 19.5% of fractures were detected after reformatting of CT images.[18]

Currently, a large number of patients with blunt trauma are assessed for thoracoabdominal injuries using CAP CT. Then, for more careful assessment of TLFs, they are subjected to thoracolumbar CT (TL CT). Conducting TL CT after CAP CT re-exposes patients to ionizing radiation and its associated problems. Moreover, it imposes heavy costs on health-care systems. Therefore, considering controversial results on accuracy of CAP CT, the present study was conducted to determine the diagnostic value of CAP CT in detecting TLFs among patients with blunt trauma.

Methods

Participants and sampling

This prospective diagnostic assessment study was conducted in 2016–2017. Participants were 256 patients aged more than 18 years with blunt chest and abdominopelvic trauma who had undergone CAP CT during their stay in the emergency department and were subjected to TL CT for the further assessment of spinal involvement such as patients with pain, tenderness, positive neurologic findings, loss of consciousness, and multiple trauma. Patients with previous history of spinal fracture were excluded. Convenience sampling was used for data gathering. Participants' medical records were assessed to determine trauma mechanism and severity, physical and clinical findings, level of consciousness, and treatments.

Procedures

CAP CT and TL CT were performed for all participants using an identical protocol and an identical multidetector 16-slice CT scanner (Toshiba, Alexion). All TL CT and CAP CT scans were reviewed and evaluated by the same radiologist using the Picture Archiving and Communication System (MARCOPACS, Iran). CAP CT was performed with 5-mm axial and sagittal cuts without reformatting. TL CT with 2-mm cuts was considered as the gold standard for the definite diagnosis of TLFs. The type and the location of all fractures detected in TL CT and CAP CT were documented. Fractures were classified as the fractures of vertebral body, posterior element, and transverse process. Vertebral body fractures were further classified into the two subgroups of vertebral body fracture with posterior element involvement and vertebral body fracture without posterior element involvement.

Data analysis

Data were analyzed through the SPSS software. Continuous variables were described using mean and standard deviation, while categorical variables were described using frequency tables. The diagnostic value of CAP CT was determined through the comparison of its findings with TL CT and calculating its sensitivity, specificity, positive and negative predictive values, positive and negative likelihood ratio, accuracy, and diagnostic OR. The agreement and association between CAP CT and TL CT findings was tested through the kappa coefficient and McNemar's test.

Ethical considerations

This study was approved by the Ethics Committee of Kashan University of Medical Sciences, Kashan, Iran. Participants' data were managed confidentially. As the study was noninterventional, it had no ethical limitation.

Results

This study was conducted on 256 patients, with a mean age of 41.18 ± 18.21 years. Most of them were male (85.5%) and Iranian (84.8%). The most common trauma mechanism was car–motorcycle accident (33.6%). Most participants complained of vertebral tenderness (83.6%), and 65.2% of them were managed medically. The most common surgical procedure for the remaining 34.8% of the participants who were surgically managed was laminectomy and fusion (59.46%).

As Table 1 shows, none of the participants with no fracture in TL CT had fracture in CAP CT. Moreover, 89.6% of participants with fracture in TL CT had fracture in CAP CT. A significant agreement and association was observed between the findings of TL CT and CAP CT (kappa coefficient = 0.896; $P < 0.001$).

The most common fracture observed in CAP CT and TL CT was vertebral body fracture with posterior element involvement [43% and 48.5%, respectively; Table 2].

The sensitivity, specificity, and positive and negative predictive values of CAP CT for TLF detection were 89.55%, 100%, 100%, and 89.71%, respectively. Based on the location of fracture, the lowest and the highest sensitivity of CAP CT was related to vertebral body fracture (50%) and transverse process fracture (95.56%), respectively [Table 3].

The sensitivity and the negative predictive value of CAP CT in TLF detection among participants aged <40 years were greater than participants aged 40 years or more [Table 4].

Discussion

Findings revealed that the most common fracture detected in CAP CT and TL CT was vertebral body fracture with posterior element involvement (43% and 48.5%, respectively). The prevalence of vertebral body fracture with posterior element involvement in a former study was 20% before reformatting CT images and 18% in reformatted images.[18] The prevalence rate in that study is less than our study probably due to the fact that the gold standard in that study was reformatted images. The most prevalent fracture in another study was vertebral body fracture, with a prevalence of 65.2%.[19] The higher prevalence rate in that study compared with our study is due to the report of all vertebral body fractures without any distinction among its different types. However, a study reported that the most common fractures were transverse process fracture (55%) and vertebral body fracture without posterior element involvement (31.8%).[20]

The sensitivity, specificity, and positive and negative predictive values of CAP CT in detecting TLFs in the present study were 89.55%, 100%, 100%, and 89.71%, respectively. Moreover, findings revealed agreement between CAP CT and TL CT findings (kappa coefficient = 0.896; $P < 0.001$), and association between CAP CT and TL CT findings based on McNemar's test was significant ($P < 0.001$). In most previous studies, the diagnostic value of CAP CT had been assessed based on radiographic or reformatted images. For instance, a study compared the diagnostic value of abdominopelvic CT in detecting lumbar fractures based on simple radiographic images and reported that the prevalence of undetected fractures was 23.2% in abdominopelvic CT and 12.7% in anteroposterior and lateral radiographies. Yet, 46% of patients with fractures not detected in abdominopelvic CT and 50% of patients with fractures not detected in radiography needed splint or surgery.[21]

Most previous studies reported that abdominopelvic CT sensitivity was 94%–100%[16,17,19,20,22] and its specificity was 98%–100%.[17,19,22] These sensitivity and specificity values are greater than the values found in our study probably due to the differences in CT scanners, CT cuts and sections, and gold standards. For instance, a study used a multidetector 64-slice scanner to create abdominopelvic CT images with 3.75-mm axial cuts and 2-mm sagittal and coronal cuts, besides reformatted TL CT images with 3-mm axial and 2-mm sagittal and coronal cuts.[20] In another study, a multidetector four-slice CT scanner was used with 5-mm axial cuts and 3-mm sagittal and coronal cuts.[16] Moreover, another study used a multidetector 64-slice device and 5-mm axial cuts with 3-mm coronal and sagittal reformatting as well as reformatted scans with 2.5-mm axial cuts and 3-mm sagittal and coronal cuts, while reformatted CT scan was considered as the gold standard.[19] However, in the present study, CAP CT nonreformatted images were created using a spiral multidetector 16-slice scanner with 5-mm axial cuts and the gold standard was TL CT.

The sensitivity, specificity, and positive and negative predictive values of CAP CT in detecting fracture in an earlier study were,

Table 1: The agreement between chest, abdomen, and pelvis computed tomography and thoracolumbar computed tomography findings

CAP CT	TL CT				
	No fracture, *n* (%)	Fracture, *n* (%)	Total, *n* (%)	Kappa agreement coefficient	McNemar's test
Fracture	0	120 (89.6)	120 (46.9)	0.896	<0.001
No fracture	122 (100)	14 (10.4)	136 (53.1)		
Total	122 (100)	134 (100)	256 (100)		

CAP CT: Chest, abdomen, and pelvis computed tomography, TL CT: Thoracolumbar computed tomography respectively, 80.5%, 95%, 97.1%, and 70.3%, and 19.5% of fractures were diagnosed after reformatting of CT images.[18] In another study, the sensitivity of CAP CT in detecting fractures was 87%.[13] The sensitivity and specificity values in these studies are less than our study probably due to the fact that these studies used reformatted images as the gold standard, while the gold standard in our study was TL CT.

Study findings also showed that CAP CT detected transverse process fractures with a sensitivity of 95.56%, a specificity of 100%, a positive predictive value of 100%, and a negative predictive value of 98.39%. Similarly, an earlier study reported that the sensitivity of reformatted abdominopelvic CT in detecting the fractures of the spinous and the transverse processes was 93%.[13] Another study also reported that abdominopelvic CT detected 78 cases of transverse process fractures among eighty patients with this fracture.[22] However, a study reported that 40% of undetected fractures were related to the fractures of the spinous and the transverse processes, and hence, the sensitivity of reformatted CAP CT in detecting these fractures was 79%. This rate is lower than CAP CT sensitivity in our study because the golden standard in that study was reformatted CT images.[20] Another study also reported that most undetected spinal fractures were related to the spinous and the transverse processes which are not of clinical importance.[23]

We also found that the sensitivity, specificity, and positive and negative predictive values of CAP CT in detecting vertebral body fracture without posterior element involvement were 50%, 100%, 100%, and 91.04%, respectively. Similarly, a previous study showed that 22% of undetected fractures were related to vertebral body fractures without posterior element involvement, and the sensitivity of abdominopelvic CT in detecting this type of fracture was 72%,[13] which is higher than CAP CT sensitivity in our study. This difference is attributable to the fact that we used a 16-slice CT scanner without reformatting and with 5-mm axial cuts, while CT in that study was performed using a 64-slice scanner with 5-mm axial cuts and 4-mm coronal and sagittal cuts. Another study also reported that 57% of undetected fractures were related to vertebral body fractures without posterior element involvement. CAP CT sensitivity for the detection of vertebral body fractures without posterior element involvement in that study was 45%.[20] Thus, compared with our study, the rate of undetected fractures in that study was higher and CT sensitivity was lower probably due to considering reformatted CT images as the gold standard in that study. As the vertebral body fractures have clinical significance and need medical or surgical treatments, it is recommended to the use of reformatted images for better detection of body fractures and also more precise clinical decision on patient's treatment.

The sensitivity, specificity, and positive and negative predictive values of CAP CT in detecting vertebral body fractures with posterior element involvement in the present study were 80%, 100%, 100%, and 65.24%, respectively. Several earlier studies reported that with a sensitivity of 100%, abdominopelvic CT helped detect all fractures of vertebral body with posterior element involvement.[13,19,22] Abdominopelvic CT sensitivity

Table 2: Chest, abdomen, and pelvis computed tomography and thoracolumbar computed tomography findings respecting the location of thoracolumbar fractures

Location	CAP CT, *n* (%)	TL CT, *n* (%)
Vertebral body	23 (19.5)	24 (18)
Vertebral body and posterior element	52 (43)	65 (48.5)
Transverse process	45 (37.5)	45 (33.5)
Total	120 (100)	134 (100)

CAP CT: Chest, abdomen, and pelvis computed tomography, TL CT: Thoracolumbar computed tomography

Table 3: The diagnostic value of chest, abdomen, and pelvis computed tomography in the detection of thoracolumbar fractures according to fracture location

Fracture in CAP CT	Sensitivity (%)	Specificity (%)	Positive predictive value (%)	Negative predictive value (%)	LR+	LR− (%)	Diagnostic OR	Accuracy (%)
Total	89.55	100	100	89.71	∞	10.45	∞	94.53
Vertebral body	50	100	100	91.04	∞	50	∞	91.8
Vertebral body and posterior element	80	100	100	65.24	∞	20	∞	93
Transverse process	95.56	100	100	98.39	∞	4.44	∞	98.8

CAP CT: Chest, abdomen, and pelvis computed tomography, OR: Odds ratio, LR: Likelihoods ratio

Table 4: The diagnostic value of abdominopelvic computed tomography in the detection of thoracolumbar fractures according to age groups

Fracture in CAP CT	Sensitivity (%)	Specificity (%)	Positive predictive value (%)	Negative predictive value (%)	LR+	LR− (%)	Diagnostic OR
<40	97.53	100	100	97.06	∞	2.47	∞
40 and more	77.36	100	100	82.35	∞	22.64	∞

CAP CT: Chest, abdomen, and pelvis computed tomography, OR: Odds ratio, LR: Likelihoods ratio in these studies is greater than our study probably due to differences in CT scanners and cuts. However, a study reported that 8% of undetected fractures were related to the fractures of vertebral body with posterior element involvement, so that abdominopelvic CT sensitivity in detecting this fracture was 82%,[20] which is almost similar to our study.

Finally, our findings revealed that the sensitivity, specificity, and positive and negative predictive values of CAP CT among patients younger than 40 years (97.53%, 100%, 100%, and 97.06%, respectively) were greater than patients older than 40 years (77.36%, 100%, 100%, and 82.35%, respectively). Of course, there was a significant agreement between the findings of CAP CT and TL CT in both age groups. Given the lower sensitivity and the lower negative predictive value of CAP CT among patients older than 40 years, TL CT with coronal and sagittal reformatting is recommended for the detection of suspicious TLFs among older patients. Furthermore, in under 40-year-old patients, the sensitivity and negative predictive value of CAP CT become close to the gold standard, and it can be applied for them instead of the thin-slice thoracolumbar spine CT scan, by which reducing radiation exposure in this sensitive group of patients.

The strength of our study was its prospective nature that enables us to evaluate more accurately. Furthermore, the CAP CT and TL CT were performed with a short time interval, so the study results could not have been influenced by interval change, and therefore, it is expected that the accuracy of thoracolumbar spine evaluation using CAP CT would be improved. Our study had some limitations. First, it was a single-center study and second relatively low sample size.

Conclusion

This study suggests that CAP CT has acceptable sensitivity, specificity, and positive and negative predictive values in detecting TLFs among patients with blunt chest and abdominopelvic trauma. The highest CAP CT sensitivity and specificity are related to the detection of transverse process fracture, while its lowest sensitivity and specificity are related to the detection of vertebral body fracture without posterior element involvement. Therefore, due to lower cost and lower dose of radiation in CAP CT than TL CT, it is suggested to use the reformatted sagittal and coronal imaging for better detection of vertebral body fractures and then TL CT in clinical suspicion. Moreover, CAP CT has greater sensitivity and specificity among patients younger than 40 years, and hence, TL CT with 2-mm cuts is recommended in case of suspicious fractures among older patients. A coherent CAP CT interpretation protocol should be developed for the rapid and accurate diagnosis of TLFs and minimization of the number of undetected fractures.

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Conflicts of interest

There are no conflicts of interest.

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