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Will computed tomography (CT) miss something? The characteristics and pitfalls of torso CT in evaluating patients with blunt solid organ trauma

Bilgisayarlı tomografi (BT) bir şeyleri atlıyor mu? Künt solid organ travmalı hastaların değerlendirilmesinde, gövde BT'sinin özellikleri ve tuzakları

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BACKGROUND

Selective nonoperative management has become the standard care for blunt solid organ trauma patients, and torso computed tomography (CT) provides useful therapeutic clues. We conducted this study to determine the frequency and character of missed diagnoses in blunt solid organ trauma patients.

METHODS

We reviewed the medical records of all blunt trauma patients who underwent torso CT and who were admitted for solid organ injuries (liver, spleen and kidney) at the Chi-Mei Medical Center from August 2003 to October 2006.

RESULTS

The patients were divided into the Missed Group (24 patients) and the Unaltered Group (262 patients) according to the presence or absence of a missed diagnosis. The overall missed diagnosis rate was 8.4%. Only one unidentified bowel injury was disclosed by follow-up CT, and all of the missed injuries were revealed by laparotomy. The Missed Group had a higher Injury Severity Score, lower Glasgow Coma Scale, more Intensive Care Unit (ICU) care, and longer duration of hospitalization.

CONCLUSION

Discovery of missed diagnoses is not uncommon in patients who sustain severe trauma. Laparotomy revealed all of the missed diagnoses, and follow-up CT demonstrated a poor ability to detect unidentified injuries. We suggest laparotomy instead of follow-up CT in the nonoperative management of patients with blunt solid organ injuries if clinical deterioration occurs.

Key Words: Blunt abdominal trauma; computed tomography; laparotomy; missed injury; solid organ injury.

AMAÇ

Selektif non-operatif tedavi, künt solid organ travmalı hastalar ile ilgili standart tedavi haline gelmiştir ve bilgisayarlı vücut tomografisi (BT) yararlı terapötik ipuçları sağlamaktadır. Biz, bu çalışmayı künt solid organ travmalı hastalarda atlanan tanıların sıklığını ve karakterini belirlemek üzere yürüttük.

GEREÇ VE YÖNTEM

Ağustos 2003 ile Ekim 2006 tarihleri arasında solid organ yaralanmaları (karaciğer, dalak ve böbrek) nedeniyle Chi-Mei Tıp Merkezine yatırılan ve vücut BT'si çekilen bütün künt travmalı hastaların tıbbi kayıtları gözden geçirildi.

BULGULAR

Hastalar, atlanmış bir tanı bulunup bulunmamasına göre atlanan grup (24 hasta) ve değişmeyen grup (262 hasta) şeklinde gruplara ayrıldı. Genel atlanan tanı oranı %8,4 idi. Yalnızca tanımlanmamış bir bağırsak yaralanması takip BT'si ile açığa çıkarıldı, atlanan yaralanmaların hepsi laparotomi ile ortaya çıkarıldı. Atlanan grup, daha yüksek bir Yaralanma Şiddet Skoru, daha düşük Glasgow Koma Skalası, daha fazla Yoğun Bakım Ünitesi (YBÜ) tedavisi ve daha uzun hastanede kalma süresine sahip olmuştur.

SONUÇ

Ciddi travması uzun süre devam eden hastalarda, atlanmış tanıların ortaya çıkarılması seyrektir. Laparotomi atlanmış tanıların hepsini ortaya çıkarmış ve takip BT'si tanımlanmamış yaralanmaların saptanmasında düşük bir yeteneğe sahip olduğunu ortaya koymuştur. Klinik kötüleşme oluşması durumunda, künt solid organ travmalı hastaların non-operatif tedavisinde takip BT'si yerine laparotomi yapılmasını öneriyoruz.

Anahtar Sözcükler: Künt abdominal travma; bilgisayarlı tomografi; laparotomi; atlanan yaralanma; solid organ yaralanması.

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Selective nonoperative management (NOM) of solid organ injuries (SOIs) has become the standard of care for two decades. The success of NOM relies on the following criteria: accurate diagnosis of SOIs, maintenance of hemodynamic stability by administration of a limited amount of fluid and absence of associated injuries.[1,2] Thus, trauma surgeons need a diagnostic tool to discover SOIs and to exclude associated injuries. In the early 1980s, computed tomography (CT) became available and improved the diagnosis of SOI in blunt trauma patients. Management decisions may therefore be based on the results of CT. Especially those patients who have sustained a blunt SOI and undergo NOM, torso CT performed in the emergency department (ED) provides most therapeutic guides. Therefore, trauma surgeons need to understand the types of visceral injuries that might be missed by CT, and whether these missed diagnoses might influence the management and the prognosis of the patients. The missed diagnoses could be discovered by a second CT scan or by other diagnostic tools. Accordingly, we conducted a retrospective study to determine the frequency and character of missed diagnoses after CT in blunt solid organ trauma patients.

MATERIALS AND METHODS

We reviewed the medical records of all trauma patients admitted to the Chi-Mei Medical Center from August 2003 to October 2006. Patients sustaining penetrating injuries and those did not have a torso helical CT scan (Four Slice: HiSpeed CT, GE) in the ED were excluded. All reports of the CT scans performed in the ED were reviewed, and only patients with SOI (liver, spleen and kidney) were included in the study. Patients who were diagnosed with SOI based solely on clinical suspicion and patients who sustained internal injuries to organs other than the liver, spleen and kidney were also excluded from the study. The hospital course, follow-up imaging studies and subsequent surgical interventions were studied. Any alteration of the diagnosis resulting from further imaging studies and surgical findings were recorded, and the laparotomy results were considered authoritative if the imaging reports contradicted the surgical findings. An unidentified injury that was not identified in the ED but was identified during the hospital stay was defined as an under-diagnosis, and an initial diagnosis of SOI that was excluded during admission was regarded as an over-diagnosis.

Patients who had at least one missed diagnosis were categorized as the Missed Group, and patients whose diagnoses were unaltered were categorized as the Unaltered Group. Patient age and gender, Glasgow Coma Scale (GCS) in ED, mechanisms of trauma, number of internal organ injuries, requirements of laparotomy or arterial embolization, hospital course, duration of intensive care unit (ICU) and hospital stays, rate of ICU admission and mortality, and the Injury Severity Score (ISS) of all patients were collected for statistical analysis. Fisher's exact test was used to compare the rates of ICU admission, GCS <13, head Abbreviated Injury Scale (AIS) >2, presence of more than two organ injuries, mortality, laparotomy, and arterial embolization between the Missed Group and the Unaltered Group. We compared the ISSs, number of days in the ICU and number of days in the hospital of the two groups using the Wilcoxon rank-sum test. All statistical analyses were performed at the two-tailed significance level of 0.05 using the SPSS software package (SPSS 12.0).

RESULTS

The cases of 286 patients were reviewed in this study, including 24 patients who had at least one missed diagnosis (Missed Group) and 262 patients whose diagnoses were unaltered (Unaltered Group). The general characteristics of the study population are presented in Table 1. There were no statistical differences in age and gender between the two groups.

In the Missed Group, 2 patients underwent follow-up CT scans before laparotomy. One patient had an unidentified bowel injury disclosed by follow-up CT, and the lesion was confirmed further by surgery. For the other patient whose follow-up CT scan did not reveal any additional abnormality, subsequent laparotomy discovered an unidentified liver injury. All 24 patients in the Missed Group required a laparotomy. In the Unaltered Group, 177 patients received only a CT scan. Twenty-six patients had follow-up CT, and 59 patients underwent laparotomy. The numbers and the results of follow-up CT and the laparotomy in the study cohort are illustrated in Fig. 1.

The overall missed rate of the study population was 8.4%. Eighty-three patients underwent laparotomy, and missed diagnoses were revealed in 24 patients. Twenty-eight percent of laparotomies discovered unidentified internal organ injuries, whereas only 1 of the

Table 1. General characteristics of the patient population

	Unaltered group (n=262)	Missed group (n=24)	p
Age	33.5±16.7	36.8±13.6	NS
Gender			NS
Female	103 (39.3%)	12 (50.0%)	
Male	159 (60.7%)	12 (50.0%)	
Mechanisms			
Traffic accident	215 (82.1%)	21 (87.5%)	
Fall	29 (11.1%)	2 (8.3%)	
Assault	10 (3.8%)	1 (4.2%)	
Others	8 (3.1%)	0 (0%)	

NS: Nonsignificant.

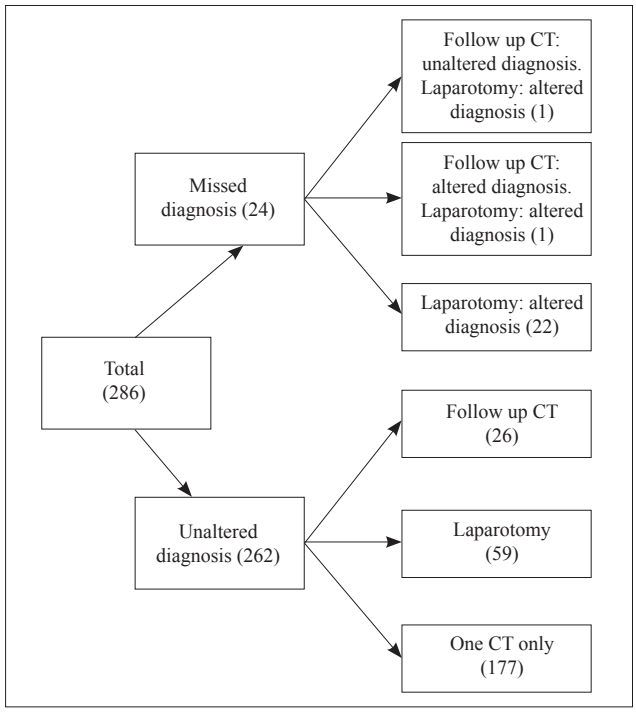

Fig. 1. The numbers and results of follow-up CT and laparotomy in the study population.

28 follow-up CT scans led to an altered diagnosis. The capability of laparotomy and follow-up CT to detect a missed diagnosis is compared in Fig. 2.

Twenty-two under-diagnoses and 6 over-diagnoses were found in the Missed Group. Two patients had 2 under-diagnoses, and 2 patients had both an over- and an under-diagnosis. Hollow viscus injuries were the most common causes of under- diagnoses, including 8 bowel and mesentery injuries, 2 diaphragm perforations, 1 gallbladder hematoma, 1 urinary bladder rupture, and 1 left atrium perforation. The over-diagnoses comprised 3 splenic injuries, 2 hepatic injuries and 1 renal injury. The initial diagnoses and over-diagnoses are presented in Fig. 3. The revised diagnoses and under-diagnoses are shown in Fig. 4.

Comparing the Missed Group and the Unaltered Group, there were no statistically significant differences in the mortality rate, head AIS >2, the requirement for arterial embolization, and the presence of more than two organ injuries. However, patients in the Missed Group had a higher rate of GCS <13 in the ED and requirement for ICU admission (Table 2). Comparing the durations of hospital and ICU stays and the ISSs between the two groups, the Missed Group had longer hospital and ICU stays and higher ISSs (p=0.002, p<0.001, and p<0.001, respectively) (Fig. 5).

DISCUSSION

There are opposing views regarding the effectiveness of CT scans in trauma patients. Two studies

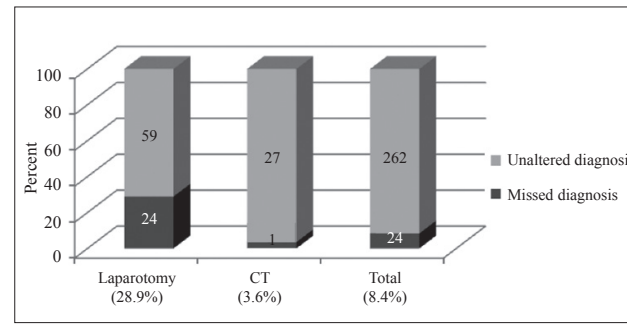

Fig. 2. Comparison of the ability of laparotomy and follow-up CT to detect missed diagnoses.

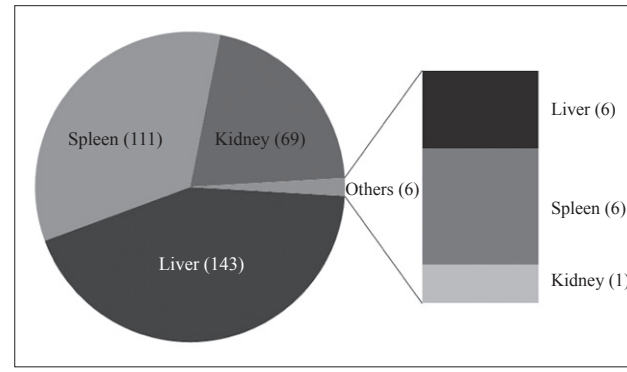

Fig. 3. Initial diagnoses based on the CT in the ED of the study cohort. "Others" represents the over-diagnoses.

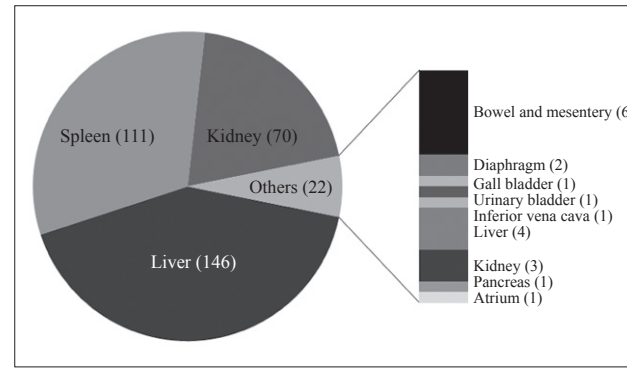

Fig. 4. Revised diagnoses of the study cohort. "Others" represents the under- diagnoses.

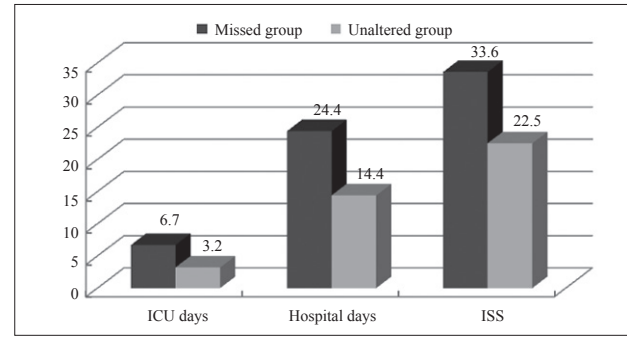

Fig. 5. Comparison of Injury Severity Scores (ISSs) and the duration of intensive care unit (ICU) and hospital stays between the Missed Group and the Unaltered Group.

Table 2. Rates of mortality, requirement of arterial embolization, presence of more than two organ injuries, head AIS >2, GCS <13, and intensive care unit admission

Characteristics	Missed group	Unaltered group	p
Mortality	3/24 (12.5%)	15/262 (5.7%)	NS
Arterial embolization	1/24 (4.2%)	8/262 (3.1%)	NS
> Two organ injuries	6/24 (25.0%)	36/262 (13.7%)	NS
Head AIS > 2	4/24 (16.7%)	26/262 (9.9%)	NS
GCS < 13	14/24 (58.3%)	94/262 (35.9%)	0.046
ICU admission	22/24 (91.3%)	187/262 (71.4%)	0.031

AIS: Abbreviated Injury Scale; GCS: Glasgow Coma Scale; ICU: Intensive Care Unit; NS: Nonsignificant.

have suggested that a blunt trauma patient could be discharged safely after a negative CT examination.[3,4] However, another study compared the results of CT and autopsy in 113 trauma patients and found that CT had a high rate of missed diagnoses of abdominal organ injuries.[5] In addition, CT has proven to be less useful in detecting hollow viscus injuries.[6,7] Even with the introduction of helical CT, the diagnostic accuracy of CT is still debated.[8,9] Many studies have emphasized the importance of physical examinations to offset the shortcomings of CT.[10,11] Nevertheless, the findings upon physical examination are often prejudiced by the presence of torso contusions or bony fractures and by reduced consciousness because of drugs and brain injuries. Thus, it is imperative for trauma surgeons to know the advantages and pitfalls of torso CT in the evaluation of trauma patients.

In this study, a small but significant portion (8.4%) of patients sustaining blunt abdominal SOI had a missed diagnosis. However, we believe that the missed rate might have been underestimated because only 29% of the patients received a laparotomy and most missed diagnoses were revealed by surgery. With the trend of decreased surgical intervention for blunt SOI, there will be more internal organ injuries that are not discovered on CT images. Several studies have proposed that patients with more than two organ injuries have a high rate of NOM failure associated with more hollow viscus injuries.[12,13] However, the differences were not obvious in our study.

The severity of the trauma had an obvious impact on the occurrence of missed diagnoses. The patients with missed diagnoses had higher ISS, lower GCS in the ED, needed more ICU care, and stayed longer in the hospital and ICU. The presence of distracting injuries and reduced consciousness impeded the patients' expression and the reliability of the physical examination.

Follow-up CT had a poor ability to detect unidentified injuries. The impaired performance may contribute to the limited ability of CT to detect hollow viscus injuries, and some of the diagnostic signs were obscured by adjacent organ injuries. In our study, the majority of under-diagnoses were hollow viscus injuries, which are easily overlooked in CT images. Several studies have suggested that CT is a reliable modality to evaluate hollow viscus injuries.[8,9,14] Nevertheless, the ability of doctors to identify hollow viscus injuries based on a CT scan relies on some non-specific CT findings such as free intra-abdominal fluid, visceral wall thickening or increased fat infiltration.[15-17] In patients who had sustained SOI, these indirect signs cannot represent the concomitant presence of hollow viscus injuries.

Routine follow-up CT is no longer suggested for NOM of patients with SOI. It increases medical expenses and usually does not affect patient management.[18,19] Even in patients undergoing NOM who experience clinical deterioration, we suggest conducting a laparotomy instead of a follow-up CT scan. Clinical deterioration may result from failed NOM of SOI or unidentified concurrent internal organ injuries, and follow-up CT does not perform well in detecting missed lesions. Laparotomy can reveal the missed injuries and accomplish therapeutic goals. Thus, follow-up CT has a limited role and should be used only in those patients who are unwilling or unable to undergo surgery who present with new abnormal findings on physical examination or signs of hemodynamic instability.

The limitations of the study come mainly from the retrospective design. First, the criteria for follow-up CT and laparotomy were based on the subjective judgments of each trauma surgeon; therefore, there were no uniform rules to decide who should undergo follow-up CT and laparotomy or when the follow-up procedure should be conducted. Second, the CT findings were based on the radiologists' reports instead of the readings of trauma surgeons. However, the official reports are usually unavailable, and the real-time opinions of the trauma surgeons are crucial for decision-making. This mismatch might have influenced the results of the study.

Discovery of missed diagnoses is not uncommon in patients who sustain severe trauma. All missed diagnoses could be discovered during laparotomy, and fol-

low-up CT provided little information about the missed injuries. The majority of the missed diagnoses were hollow viscus injuries. We suggest that laparotomy be performed instead of repeat CT if clinical deterioration occurs during NOM of patients with blunt SOI.

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