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Original Article

Application of Computed Tomography in the Identification of Hollow Viscus Injuries in Blunt Trauma Patients

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ABSTRACT

Purpose: Despite advances in diagnostic and imaging technologies, the diagnosis of traumatic hollow viscus injury (HVI) remains a great challenge in clinical practice. This study aimed to determine the accuracy of computed tomography (CT) in the diagnosis of HVI in emergent blunt trauma patients.

Methods: The study was conducted on patients with abdominal trauma who were admitted to our center, regional emergency center, Kyung Hee University Medical Center, between January 2008 and December 2018. The clinical data of patients with abdominal trauma who underwent CT and abdominal surgery within 24 hours of hospitalization were analyzed to determine the diagnostic capacity of CT.

Results: In total, 156 patients were included in the study. There were 88 cases of blunt trauma. Among these patients, 27 were diagnosed with HVI using CT, and 38 patients were diagnosed with HVI in the operating room. The median injury severity score for these patients was 10.0, the revised trauma score was 7.841, and the trauma injury severity score was 0.96. The sensitivity and specificity of CT in predicting HVI in these patients were 65.8%, and 96.0%, respectively. The positive and negative predictive values were 92.6%, and 78.7%, respectively.

Conclusion: In urgent situations, CT findings alone are insufficient for diagnosing HVI. Further research on the HVI diagnostic capacity of CT is required.

Keywords: laparotomy, radiology, trauma

Introduction

With advancements in computed tomography (CT) diagnostic technology, the application of CT in the diagnosis of abdominal trauma has increased significantly [1,2]. Hollow viscus injury (HVI) is a rare but often fatal condition. The high mortality rate reflects the severity of HVI [3]. In particular, CT is known to be useful in the diagnosis of HVI and solid organ damage in cases of blunt abdominal trauma [4]. However, while the diagnostic sensitivity of CT has improved significantly as CT performance has evolved, the capacity of CT to correctly identify HVI remains controversial. Generally, it is more challenging to determine the presence of HVI when it is concomitant with solid organ injury [5]. Moreover, due to these diagnostic uncertainties, nontherapeutic laparotomies are often performed, and many complications of unnecessary surgery have been reported [6,7]. It has been reported that selective nonoperative management of blunt trauma in some patients showed a good outcome [8]. Besides, nonoperative management failure was most commonly attributed to occult HVI [9]. The usefulness of a CT based diagnosis of intraperitoneal injury has been investigated previously [10], however, despite the developments in CT technology, there are no conclusive results to date. Therefore, in order to determine how CT affects the efficacy of surgical treatment in general trauma cases, the accuracy of CT diagnosis in HVI was retrospectively analyzed in patients who underwent both CT and a laparotomy for blunt abdominal trauma.

Materials and Methods

A chart review was performed for all trauma patients who received an abdominal CT scan and underwent a laparotomy upon admission to a regional emergency center from January 1, 2008 to December 28, 2018. All adult blunt trauma patients were included who received abdominal and pelvic CT scans within 24 hours of a post-traumatic hospitalization, and then underwent abdominal surgery. Intravenous iodinated contrast was given in all cases. Patients under 18 years of age were excluded from this study. A single independent radiologist, who is a certified specialist in abdominal image interpretation, performed a review of their CT scans, however, this was not cross-checked by 2 or more radiology specialists. CT was performed using a Philips Brilliance 64 (single slice CT, Philips Healthcare, Best, the Netherlands), a Siemens Definition Flash (dual slice CT, Siemens Healthcare, Erlengen, Germany), or a Sensation 64 (single slice CT, Siemens Healthcare, Erlengen, Germany) scanner. For each patient, the required surgical procedure was decided based on the patient's condition and the clinical findings at the time of hospital admission. Chart review, laboratory data, CT results, surgical findings, and accompanying damage were analyzed. The final diagnosis of HVI was confirmed by surgical findings. In this study, HVI was defined as "a case that the surgeon determined surgical procedure was needed at the time of surgery." Sensitivity, specificity, and the positive and negative predictive values of CT in diagnosing HVI were calculated. The Fisher's exact test for categorical data was used to determine statistical significance. The Student t test and the Mann-Whitney U test were used to examine quantitative data. Statistical analysis was conducted using SPSS software (SPSS Inc., Chicago, IL, Version 21 for Windows). This study was approved by the Research Review Committee at Hallym University (approval no: HALLYM 2019-08-001), and the consent form was exempted since it was a retrospective study.

Results

A total of 156 patients had an Emergency Room visit due to trauma, and received a CT scan and underwent surgery within 24 hours. Among these patients (excluding those who visited

Table 1. Comparison of patients based on presence or absence of HVI.

Variables	No HVI (n = 50)	HVI (n = 38)	Total (n = 88)	p
Average, age (y)	47.1	47.2	47.1	0.984
Sex: females, n (%)	10 (20.0)	4 (10.5)	14 (15.9)	0.257
Trauma score (IQR)				
ISS	13.1 (5.8-17.8)	10.0 (8.25-10)	10 (7.25-17)	0.044
RTS	7.160 (6.904-7.841)	7.841 (7.841-7.841)	7.841 (7.658-7.841)	0.011
		0.96 (0.96-0.97)	0.96 (0.91-0.97)	
TRISS	0.88 (0.87-0.98)			0.039
Initial lab data (IQR)				
WBC (×103/uL)	15,300 (8,825-15,550)	11,500 (8,650-14,820)	11,400 (8,700-15,4050)	0.863
Hb (g/dL)		14.3 (13.1-15.3)	13.7 (12.6-14.8)	
BE (mEq/L)	13.4 (12.0-14.5)	-4.1 (-6.4 - -2.6)	-5.3 (-7.7 - -3.1)	0.011
	-6.0 (-9.9 - -3.7)			0.025
Vital signs (IQR)				
SBP (mmHg)	110 (82.5-130)	125 (110-140)	120 (100-130)	0.012
DBP (mmHg)	70 (50-80)	80 (70-90)	80 (60-80)	0.013
PR (/min)	86 (76-109.8)	86 (72-91.5)	86 (72-102)	0.294
HVI on CT, n (%)	2 (4.0)	25 (65.8)		> 0.000
Co. injury, n (%)	28(56.0)	19 (50.0)	47 (53.4)	0.668

BE = base excess; Co. injury = combined injury; CT = computed tomography; DBP = diastolic blood pressure; Dx = diagnosis; Hb = hemoglobin; IQR = Interquartile range; ISS = Injury Severity Score; Lab = laboratory; PR = pulse rate; RTS = Revised Trauma Score; SBP = systolic blood pressure; TRISS = Trauma Injury Severity Score; WBC = white blood cell count.
The initial laboratory data and vital signs are presented as median values.

Table 2. Diagnosis of HVI on a CT scan and during a laparotomy.

Diagnosis (*n*)	HVI at laparotomy (*n*)	No HVI at laparotomy (*n*)	Total (*n*)
HVI on CT	25	2	27
No HVI on CT	13	48	61
Total	38	50	88

CT = computed tomography; HVI = hollow viscus injury.

Table 3. Site of injury.

Site of injury	*n* (%)
Stomach	0 (0.0)
Duodenum	2 (5.0)
Small Bowel	28 (74.7)
Colon	5 (13.1)
Small Bowel + Colon*	2 (5.2)
Stomach + Colon†	1 (2.6)
Total	38

* Injury occurred at the same time in the small bowel and colon.
† Injury occurred at the same time in the stomach and colon.

Table 4. CT scan values in the diagnosis of HVI

Sensitivity	65.80%
Specificity	96.00%
Positive predictive value	92.60%
Negative predictive value	78.70%

Table 5. Intra-abdominal injury (except HVI) observed during the laparotomy.

Type of injury (*n*)	With HVI (*n*)	Without HVI (*n*)
Spleen	0	3
Liver	0	4
IVC	1	0
Renal artery	0	2

HVI = hollow viscus injury; IVC = inferior vena cava.

the hospital with trauma due to a penetrating mechanism, and patients who were not adults), a total of 88 patients were included in this study. Of these patients, 74 were male and 14 were female. The average age of the patients was 47.1 years. Among the total patients, 38 were diagnosed with HVI in the operating room. There were 27 patients who were diagnosed with HVI based on the CT scan performed at admission, and 2 of them did not present with HVI when checked in the operating room (Table 2). Median vital signs of the patients were taken including systolic blood pressure (SBP), diastolic blood pressure, pulse rate, white blood cell count, hemoglobin (Hb), and base excess (Table 1). The median injury severity score (ISS) for these patients was 10.0, the revised trauma score (RTS) was 7.841, and the trauma ISS was 0.96. Patients diagnosed with HVI had statistically significantly higher SBP (p = 0.012), base excess (p = 0.025), Hb (p = 0.011), RTS (p = 0.011), and trauma ISS (p = 0.039) compared with patients who were not diagnosed with HVI. However, ISS was higher in the no HVI group (p = 0.044; Table 1). The variables investigated in this study were presented as median values because they did not pass the test of normality.

The most common HVI site was the small bowel (28 cases), followed by the colon (5 cases; Table 3). The positive predictive value, and negative predictive value of CT was 92.6%, and 78.7%, respectively. The sensitivity, and specificity of CT in predicting HVI in the included patients were 65.8%, and 96.0%, respectively (Table 4). Additionally, common intra-abdominal injuries (except HVI) were spleen, and liver injury (Table 5).

Discussion

This study investigated how well CT aided the diagnosis of HVI. A comparison was made between CT findings and surgical results which were conducted early, in the admission. We observed that the sensitivity of CT was lower than its specificity. A correct diagnosis of HVI is especially important in cases of blunt abdominal trauma where bleeding and organ damage are often mixed. Bleeding in the abdominal cavity of trauma patients should be identified and resolved immediately to help stabilize the patient's vital signs, and thus promote recovery. However, internal abdominal damage of an organ is not limited to bleeding alone. In particular, bowel perforation due to HVI can cause contamination of the abdominal cavity, resulting in sepsis, which then leads to a poor prognosis. Therefore, it is very important to detect HVI during the patient's initial assessment [11,12]. However, making an accurate diagnosis of HVI can be difficult when it is accompanied by a solid organ injury in the abdominal cavity. Generally, CT is the examination method used to determine the condition of the intraperitoneal organs, and is currently being used in many centers to detect intraperitoneal damage [10]. Furthermore, the development of CT diagnostic technology is rapidly progressing. In particular, multislice CT has recently emerged as an important imaging

technique for diagnosing traumatic blunt abdominal injuries. The main purpose of performing a CT scan may be to identify the type and grading of solid organ injuries, to make a diagnosis of intestinal or severe injuries, or to determine injuries requiring surgical intervention [13,14].

This study aimed to verify the diagnostic capacity of CT in an urgent situation by comparing CT results with laparotomy findings. The results of this study indicated that the use of CT for HVI screening is difficult to justify. CT showed a low sensitivity and high specificity in the diagnosis of HVI, and these results were similar to those of previous studies [5,15,16]. However, differences in the CT protocols used in each study should be taken into account. In another study, the use of oral contrast in CT resulted in a high sensitivity, as opposed to the results of this current study (where intravenous (IV) contrast was used) [14]. Thus, CT diagnostic capacity differs depending on the use of contrast and the route of contrast administration, and this should be acknowledged. In fact, in the abdominal trauma treatment protocol used at our center, CT is primarily performed using intravenous contrast, and the use of oral contrast is not considered. With regard to diagnosing HVI by CT, some studies have been conducted on the importance of free air, but there are varying views on these results. In such cases, surgery is often performed when the vital signs are unstable, and HVI can be easily identified during the surgical process. However, most trauma treatment protocols are oriented towards selective operative management with the recent development of imaging techniques. Therefore, the diagnosis of associated HVI through laparotomy is becoming more difficult. The diagnosis of HVI is particularly difficult when considering nonsurgical screening being performed using interventional radiology. In this study, the HVI patient group confirmed by surgery had statistically higher values for SBP, Hb, and RTS, compared with the patients in the no HVI group (Table 1). When the characteristics of the patients were investigated, it seemed that the no HVI group had a higher ISS compared with the HVI group, apparently due to fewer combined injuries in the HVI group (Table 1). In the early stage of HVI, it is rare for HVI alone to rapidly affect the vital signs. The ISS of the HVI group was lower compared with the group with other organ damage. Thus, there is a possibility that HVI may not affect the patient's initial condition. However, as mentioned earlier, delays in the appropriate treatment of HVI can cause septic shock due to peritonitis, increasing late mortality in trauma patients. The results of this study suggest that CT can play a significant role in diagnosing HVI with high specificity in urgent situations. Despite this, the debate remains as to whether to rely entirely on CT to decide whether to perform an operation or implement nonoperative management in patients suspected of organ damage in the abdominal cavity. The low sensitivity of CT observed in this study would make it difficult to completely rule out a diagnosis of HVI via CT alone. Some studies suggest that advances in diagnostic technology such as multislice CT, can improve CT diagnostic capacity and can determine HVI more accurately compared with the previous CT methods [17,18]. However, the application of CT alone in emergency situations remains insufficient, as indicated by the results of this current study. As mentioned previously, delayed treatment of HVI can be fatal. Therefore, the use of only CT for diagnosing HVI early in the patient's visit is inadequate. Some other studies have also reported that CT has limitations in diagnosing HVI, similar to the findings of this current study [5,19]. Perhaps one of the main causes of these conflicting results is the variety of CT protocols followed and the different situations in which CT was performed. This study was targeted at cases wherein CT was used for initial diagnostic purposes in blunt trauma patients within 24 hours, to examine the validity of CT application in situations considered urgent.

This study has several limitations. Firstly, as it was a retrospective study, patient selection could possibly be biased, particularly when the patient presented to the hospital with unstable vital signs, making it difficult to decide whether to use CT. Furthermore, due to the limitations of research design, it is difficult to accurately determine impetus for decisions made to perform a laparotomy, which may also bring about selection bias. Therefore, it was difficult to fully understand the extent to which CT influenced the decision to perform a laparotomy. Secondly, the association between CT and laparotomy is ambiguous in our study. In addition, this ambiguity is related to the hospital where the data from the study were collected. The hospital is a tertiary hospital with a regional emergency center, and there was no dedicated trauma specialist. The initial evaluation of multiple trauma patients was performed in the Department of Emergency Medicine by an on-call emergency medical doctor called according to the injury site. Furthermore, there was no specialized trauma protocol or surgical process for trauma patients, and the main treatment process was carried out entirely according to the subjective decision of the on-call staff. Therefore, the treatment process of trauma patients was not homogeneous, which served as another limitation of this study. Moreover, since not all official readings of the CT scan were performed prior to surgery, retrospective data research was insufficient to accurately determine how the CT scan was interpreted at the time of the visit. However, since the aim of this study was to identify the diagnostic capacity of CT taken at the time of admission, it would be meaningful to compare the CT readings with the HVI examination results in the operating room. Lastly, the adequacy of nonoperative management based on CT findings was impossible to assess because this study only investigated patients who underwent a laparotomy. The importance of CT in determining the implementation of nonoperative management and informing subsequent patient management should be considered. In addition, further research

on how to avoid a negative laparotomy is needed as an HVI is not the only indication for a laparotomy.

In conclusion, CT findings alone form an insufficient basis for the diagnosis of HVI in urgent situations. CT scans should be interpreted based on clinical situations and should not be used as a single diagnostic test. Therefore, the diagnosis of HVI in urgent situations should be determined carefully, based on a combination of clinical and radiological findings.

Author Contributions

Conceptualization: THH, HWK. Formal analysis: THH, HWK. Methodology: THH, HWK. Project administration: THH. Visualization: THH, HWK. Writing - original draft: THH, HWK. Writing - review and editing: THH, HWK, BRP.

Conflicts of Interest

No potential conflicts of interest relevant to this article was reported.

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Ethical Statement

The ethics committees of the Hallym University Institutional Review Board approved this study (approval no. HALLYM 2019-08-001), and the requirement for informed consent was waived due to the retrospective design.

Data Availability

All relevant data are included in this manuscript.

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