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Diagnostic Accuracy of CT Scan for Detecting Ongoing Internal Bleeding Following Torso Injury Keeping per Operative Findings as Gold Standard

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ABSTRACT

Objective: To determine the diagnostic accuracy of a CT scan for detecting ongoing internal bleeding following torso injury, keeping operative findings as the gold standard.

Study Design: Cross-sectional validation study.

Place and Duration of Study: Radiology Department, Pakistan Institute of Medical Sciences, Islamabad Pakistan, from Jul 2021 to Oct 2021.

Methodology: Contrast-enhanced CT was carried out for 100 patients with torso injury to detect the incidence of extravasated contrast material, an outcome that signifies any active haemorrhages present. The findings were then compared with the per-operative findings of the patient.

Results: We detected active haemorrhages in 48 out of 100 patients on Computed Tomography. A total of 83 injury sites were recorded. Active haemorrhages were mostly visible through the spill of contrast agents in a jet stream in 61(73.4%) out of 83 injury sites. Immediate surgical intervention was performed on all the patients who were detected with active haemorrhages on CT, which confirmed the findings. In 3 patients out of 100, CT did not detect active haemorrhage, but surgical intervention showed active haemorrhage on intra-peritoneal sites. Computed Tomography had a high diagnostic accuracy for torso injuries (97.0 %) with a sensitivity of 94. 11 % and a specificity of 100 %.

Conclusion: Instantaneous surgical intervention is obligatory whenever contrast extravasation is identified on Computed Tomography (CT).

Keywords: Abdominal injury, Active bleeding, Computed tomography scan, Contrast extravasation; Torso injury.

How to Cite This Article: *Zafar I, Majeed AI, Bhutta MR, Khan A, Khan MNN, Siddiqui AS. Diagnostic Accuracy of CT Scan for Detecting Ongoing Internal Bleeding Following Torso Injury Keeping per Operative Findings as Gold Standard. Pak Armed Forces Med J 2023; 73(6): 1624-1627. DOI: https://doi.org/10.51253/pafmj.v73i6.7549*

INTRODUCTION

The identification of torso injuries due to blunt injury is challenging because the damages might not visibly themselves on clinic examination during the early evaluation and since the presence of other more evident injuries may sidetrack the consideration of the initial evaluator from the potentially life-threatening underlying bleeding.[1] A major progress in the care of patients with abdominal injury has been the rapid and precise diagnosis now delivered by CT.[2] CT has been ascertained to be an outstanding technique for detecting injury in the abdomen.[3] Many researchers have reported their fruitful experience in the detection of active abdominal bleeds in torso injury patients with the help of contrast-enhanced CT imaging.[4,5]

Researchers have mentioned that it is rare to see a spill of contrast material in the torso injury patients when imaged on the conventional Computed Tomography.[6-8] When multidetector helical CT scans the patients with torso injury, it was seen that active bleeds were detected more frequently, especially if there were hepatic or direct splenic injuries.[9,10]

For the past 15 years, Computed Tomography has been used for the study of patients with torso injury. In accordance with the previous studies, we suggest that a high number of active bleeds are detected in patients with torso injury. Our understanding of CT in the radiology department suggests that many active bleeds are perceived in these patients.The objective of this research was to determine the diagnostic accuracy and efficiency of CT scans for detecting ongoing internal bleeding following torso injury while keeping the per-operative findings as the gold standard to confirm the results.

METHODOLOGY

The cross-sectional validation study was conducted at the Radiology Department of Pakistan Institute of Medical Sciences Islamabad Pakistan from July to October 2021 after approval from the IERB.Using the WHO sample size calculator, the sample size was calculated.

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Received: 21 Oct 2021; revision received: 28 Dec 2021; accepted: 31 Dec

Inclusion Criteria: Patients of either gender, aged ≥18 years presenting with acute injuries resulting from torso injury were included.

Exclusion Criteria: Patients with prior injury related surgeries; patients with unstable haemodynamically were excluded.

One hundred patients were included in the study through consecutive non-probability sampling technique. Systematic procedures of restoration allowing the approaches of ATLS of the ACS (American College of Surgeons) were employed.[11] Original hemodynamic permanence was attained with careful IV fluid restoration with 2 litres or less of liquid, which qualified the person to go through an abdomen CT. Contrast-enhanced CT was executed on the patients in the Computed Tomography suite. All patients, before undergoing CT evaluation, were haemodynamically stable.

All Computed Tomography examinations were accomplished on an OPTIMA CT scanner mounted in a Computed Tomography suite in the Radiology department. All the scans were completed through IV administration of 100 millilitres of Iohexol (Omnipaque Injection 350 mg/ml) with a NEMOTO jet injector at a stream rate of 3 ml/sec.

A dual-phase CT scan was performed, with the first phase being the late arterial phase commencing almost 30-40 seconds after the administration of the contrast agent and the other one being the port venous phase commencing at almost 70-80 seconds. The cylinder current was 180 mA/sec, and the voltage was 120 kV for all patients experiencing Computed Tomography assessment.

When dynamic extravasation of a contrast agent was eminent, classification rendering to the morphologic presence on Computed Tomography images was performed based on the characteristics: Category-I: Presence of high-intensity areas of spilt contrast enclosed by the hematoma, Category-II: Presence of high-intensity areas enclosed by the hematoma, Category-III: Detection of contrast agent as a jet stream.

We located the original area of haemorrhage, along with the assessment and grading of associated organ injuries. According to the American Association for the Surgery of Injury, the severity of organ injuries (Liver, Kidney and Spleen) was scored.[11,12] The clinical outcome of every patient was established. For patients undergoing surgery after CT, the surgery findings were compared with the CT results.

Statistical Package for Social Sciences (SPSS) version 23.0 was used for the data analysis. Quantitative variables were expressed as mean±SD and qualitative variables were expressed as frequency and percentages. Diagnostic parameters were calculated using a 2x2 contingency table. Sensitivity, specificity, positive predictive value, negative predictive value and diagnostic accuracy were determined by using the standard formulae.

RESULTS

One hundred patients were included in the study. The mean age of patients was 30.05±8.39 years. Out of 100 patients, 60(60%) were men and 40 (40%) were women. Contrast-enhanced A total of 83 injuries to parenchymal or visceral hollow organs (34 splenic injuries, 22 liver injuries, 21 injuries in the kidney, six adrenal gland injuries, and no gastric rupture) were detected in the total 48(48%) out of 100 patients. We located the original area of haemorrhage, along with the assessment and grading of associated organ injuries (Table-I).

Table-I: Frequency and grading of visceral Injury on Contrast-Enhanced Multi-detector CT of Patients with Torso Injury (n=100)

Grades	Liver	Spleen	Kidney
I	6(27.2%)	10(29.4%)	6(28.5%)
II	4(18.1%)	9(26.4%)	5(23.8%)
III	6(27.2%)	7(20.5%)	4(19%)
IV	3(13.6%)	6(17.6%)	4(19%)
V	3(13.6%)	2(5.88%)	2(9%)

More commonly, active haemorrhages were visible through the spill of contrast agents in a jet stream (Figure-1).

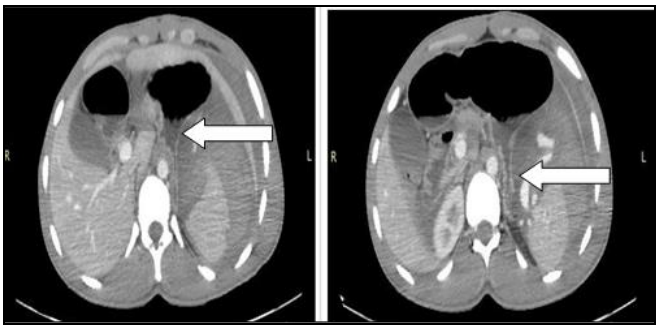

Figure-1: Evidence of Active Bleeding in a case of splenic injury (White arrow showed Active Contrast Extravasations as a Jet Stream)

Seen in 61(73.4%) out of 83 injury sites. Diffused or focal extravasation was less frequently seen in the bleeding sites. Some patients showed two active

haemorrhages, due to which 61 bleeding sites were recorded in just 48 patients. Information regarding the localisation of active haemorrhages is demonstrated in Table-II.

Table-II: Localization of sites of Active Bleeding (n=61)

Localization of Active Hemorrhage site	
Liver	8(13.1%)
Kidney	13(21.3%)
Spleen	11(18%)
Lumber Arteries	11(18%)
Rectus Muscle	9(14.7%)
Stomach (intraluminal)	4(6.5%)
Adrenal Gland	3(4%)
Gluteus Muscle	2(3.2%)

Immediate surgical intervention was performed on all 48 patients who were detected with active haemorrhages on CT. The surgical procedure established the bleeding source as demonstrated by multi-detector Computed Tomography in all the 48(100%) cases detected by CT. 52(52%) out of 100 patients showed no active bleeding on CT. 5(9.6%) out of these 52 patients developed hemodynamic instability and had to undergo multiple blood transfusions. Surgical intervention was performed on these five patients, which showed the presence of active intraperitoneal bleeding in 3 patients in which active contrast extravasation was not detected on the CT scan (Figure-2).

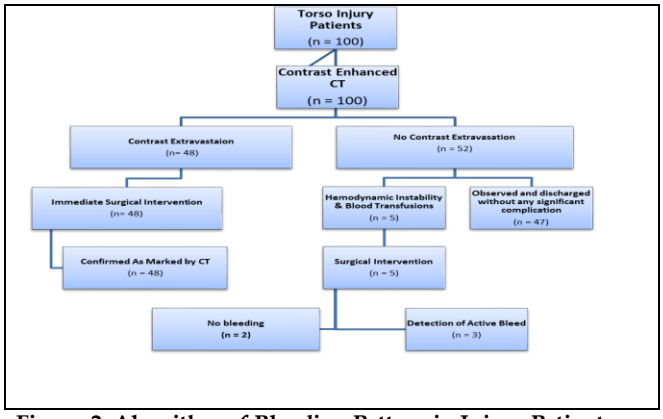

Figure-2: Algorithm of Bleeding Pattern in Injury Patients

Computed Tomography had a high diagnostic accuracy for torso injuries (97.0%). Instantaneous surgical intervention is obligatory whenever extravasation of contrast material is identified in Computed Tomography (CT). CT has a high diagnostic sensitivity for torso injuries (94.11%) and is proven to have a fairly significant role in detecting active haemorrhages in torso injuries with its high specificity (100%), as mentioned in Table-III.

Table-III: Diagnostic Parameters of Contrast Enhanced CT Scan in detecting Active Bleeding (n=100)

		Reference Standard (Per-operative findings)	
		Positive	Negative
Index Test (Contrast enhanced CT scan)	Positive	48(TP)	0(FP)
	Negative	3(FN)	49(TN)
Criteria		**Percentage**	
Sensitivity		94.11%	
Specificity		100 %	
Positive Predictive Value		100%	
Negative Predictive Value		94.23%	
Accuracy		97.0%	

DISCUSSION

We found that Computed Tomography had a high diagnostic accuracy for torso injuries (97.0%) with a sensitivity of 94.[11] % and a specificity of 100 %. These results were in harmony with the previous studies. In recent studies, it has been mentioned that CT is an excellent imaging modality in torso injury patients who are hemodynamically stable.[12] CT has been shown to decrease the average death and disease time due to its quick imaging and accurate diagnostic capability.[13]

We found that oral administration of contrast material was not beneficial in patients suffering from torso injury. This is because the enormous amount of extravasated contrast material will make detecting the active bleeding in the abdomen difficult.[14] In addition, introducing the contrast orally, even with the help of a gastric tube, is a time-consuming procedure which is not suitable for the critical situation of the patients admitted to the emergency department.[15]

A delay before the introduction of contrast is necessary to image the organs with and without contrast, as mentioned by Kanlerd *et al*. This also was in harmony with our study as after a steady time-lapse, all the scans were initiated with careful management of contrast intravenously (First phase at 25-40 seconds and second at 70-80 seconds).[14]

We classified extravasation rendering to the morphologic presence on Computed Tomography images based on the presence of high-intensity areas of spilt contrast, enclosure by the hematoma and detection of contrast agent as a jet stream was similar to the results seen in the study performed by Moussavi *et al*.[16] One study discovered that the frequency of reported active bleeds on CT scans can be variable.[17] Results of our study also correlated with their findings, as out of the 83 injuries detected, 34 were splenic, 22 were liver, 21 were in the kidney, and six were in the adrenal gland.

Results of our study were similar to the results of the study conducted by Willmann *et al*. as surgical intervention after detection of contrast extravasation established the bleeding source as demonstrated by multidetector Computed Tomography in all the forty-eight cases detected by CT.[18] Computed Tomography had a high diagnostic accuracy for torso injuries. CT has a high diagnostic sensitivity for torso injuries and is proven to have a fairly significant role in detecting active haemorrhages in torso injuries with its high specificity.

CONCLUSION

All the patients presenting with active haemorrhage on CT images underwent instantaneous surgical intervention. Computed Tomography had a high diagnostic accuracy for torso injuries (97.0%). Instantaneous surgical intervention is obligatory whenever extravasation of contrast material is identified in Computed Tomography (CT).

Conflict of Interest: None.

Authors Contribution

Following authors have made substantial contributions to the manuscript as under:

IZ & AIM: Study design, data interpretation, drafting the manuscript, critical review, approval of the final version to be published.

MRB & AK: Data acquisition, data analysis, critical review, approval of the final version to be published.

MNNK & ASS: Concept, data acquisition, drafting the manuscript, approval of the final version to be published.

Authors agree to be accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved.

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