



## Usefulness of free intraperitoneal air detected by CT scan in diagnosing bowel perforation in blunt trauma: Experience from a community-based hospital



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### ABSTRACT

**Introduction:** Computed tomography (CT) scan has increasingly become the diagnostic modality of choice for the evaluation of patients with blunt abdominal trauma. CT scan is highly sensitive in the detection of small amounts of free intraperitoneal air (FIA). We aimed to evaluate the usefulness of FIA detected by CT scan in diagnosing bowel perforation in blunt trauma patients.

**Patients and methods:** All abdominal CT scans of blunt trauma patients who were treated at Al Rahba Hospital during the period from October 2010 till December 2013 were retrospectively reviewed. The results of abdominal CT scan were compared with the clinical follow up and operative findings to evaluate the sensitivity, specificity, predictive values, and usefulness index of CT-detected FIA in diagnosing bowel perforation.

**Results:** Abdominal CT scans were performed for 419 trauma patients. 21 (5%) patients were found to have FIA, two of them were true positive (10%), six (29%) needed mechanical ventilation, and eleven (52%) had a pneumothorax. 15/21 (71%) patients had multiple FIA pockets; the median (range) was 3 (2–10) air pockets. Two patients with multiple air pockets of 10 mm-thick cuts or more had small bowel perforation. Six (29%) patients had a single air pocket of less than 10 mm and none had bowel perforation. 398 patients had negative CT scan for FIA; two of them were false negative. CT-detected FIA scan had a sensitivity of 50% (95% CI: 6.8%–93.2%), specificity of 95.4% (95% CI: 92.9%–97.2%), a positive predictive value of 9.5% (95% CI: 1.2%–30.4%) and a negative predictive value of 99.5% (95% CI: 98.2%–99.9%) for detecting bowel perforation. The usefulness index for abdominal CT scan FIA for detecting bowel perforation was 0.23 (not useful).

**Conclusions:** Our study which stemmed from a community-based hospital showed that free intraperitoneal air found on abdominal CT scan of blunt trauma patients was an unreliable radiological finding for bowel perforation. The decision for laparotomy should be based on combined clinical and radiological findings. Conservative management with active observation may avoid unnecessary laparotomy.

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### Introduction

Computed tomography (CT) scan has increasingly become the diagnostic modality of choice for the evaluation of patients with

blunt abdominal trauma [1]. Free intraperitoneal air (FIA) following blunt abdominal trauma is a significant radiological finding. It is usually attributed to bowel perforation that needs immediate laparotomy [2]. CT scan is highly sensitive in the detection of small amounts of FIA [1].

Recently, we have noticed abdominal trauma CT scans with pockets of FIA without finding any bowel perforations after laparotomy. It is a dilemma for surgeons to decide whether the CT scan detected FIA is due to a hollow viscus perforation or it is a

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benign finding without bowel perforation [3]. We aimed to evaluate the usefulness of FIA detected by CT scan in diagnosing bowel perforation in blunt trauma patients.

## Patients and methods

Al Rahba Hospital is a Secondary Hospital with a capacity of 190 beds. The hospital is located on the main highway connecting Dubai and Abu Dhabi and has a very busy Emergency Department. The Hospital is administrated under the oversight of representatives on site of the Johns Hopkins University on behalf of the Health Authority of Abu Dhabi.

All abdominal CT scans of blunt trauma patients who were treated at Al Rahba Hospital during the period from October 2010 till December 2013 were retrospectively studied. The results of abdominal CT scan were compared with the clinical follow up and operative findings. Data were collected from Al Rahba Hospital Trauma Registry and the operative notes. This included demography, mechanism of injury, the need for endotracheal intubation and mechanical ventilation, Injury Severity Score (ISS), hospital stay, results of laparotomy, and mortality.

CT scans were performed using a General Electric 64 Slice Light Speed Volume (GE 64 slice Light speed VCT). Images were analyzed at 2.5 mm thick axial cuts in lung, bone and soft tissue windows. Abdominal CT scans with free pockets of air were further analyzed in coronal and sagittal planes. Care was taken to be sure that the lower slices of the lungs were not mistaken for free intraperitoneal air.

Abdominal CT scans were independently reviewed by two radiologists. They disagreed on three CT scans and decided to exclude them from the study because the findings were none conclusive. A third consultant radiologist from another institution reviewed all positive CT scans for free intraperitoneal air and agreed on the presence of the FIA. A rough estimate of the volume of free air was made. A small volume was considered if air was less than 10 mm-thick cuts (seen in four slices or less). Large volume of air was considered if air was 10 mm or more (if air was seen in five slices or more) [4,5].

The definitions used in our study were as follows. A true positive result (TP) was FIA detected by CT scan associated with bowel perforation as confirmed by laparotomy. A false positive (FP) result was FIA detected by CT scan not associated with bowel perforation as confirmed by laparotomy or clinical follow up.

A false negative (FN) finding was absence of FIA by CT scan and presence of bowel perforation confirmed by laparotomy. A true negative (TN) result was absence of FIA by CT scan and absence of bowel perforation confirmed by clinical follow up. The derived variables were calculated according to the following formulas: sensitivity = TP/(TP + FN); specificity = TN/(TN + FP); positive predictive value = TP/(TP + FP); negative predictive value = TN/(TN + FN); and usefulness index = sensitivity × [sensitivity + (1 – specificity)]. A test is regarded as useful if the usefulness index is 0.35 or more [6,7]. The Exact 95% confidence interval (95% CI) of binomial proportions was calculated using the Diagnostic Test Evaluation Calculator of the free access Interactive Statistical Pages website [8]. Al Rahba Hospital Research Ethics Committee has approved this research project (ARH/rec-015).

## Results

During the study period, 19,626 trauma patients were treated in the Emergency Department. Out of them, 2263 (11.5%) patients were admitted to the hospital.

Abdominal CT scans were performed for 419 trauma patients. Four patients had bowel perforation (1%). There were two true positive results, 19 false positive results, 396 true negative results, and two false negative results. FIA detected by CT scan had a sensitivity of 50% (95% CI: 6.8%–93.2%), specificity of 95.4% (95% CI: 92.9%–97.2%), a positive predictive value of 9.5% (95% CI: 1.2%–30.4%) and a negative predictive value of 99.5% (95% CI: 98.2%–99.9%) for detecting bowel perforation. The usefulness index for abdominal CT scan FIA for detecting bowel perforation was 0.23 (not useful).

The 21 patients who had FIA were studied in detail so as to explain the reason for their high false positive results (Table 1). 18 patients were males (86%). The median (range) age was 24 (5–45) years. The mean (range) ISS was 18.8 (4–45). Intubation and mechanical ventilation was needed in six (29%) patients, four of them were intubated before the abdominal CT scan.

Eleven (52%) patients had pneumothorax: three had occult pneumothorax (was not evident on the plain radiograph and was identified on CT scan), four had small pneumothorax (occupies less than 15% of the hemi-thorax), and four had clinically significant pneumothorax. Five of the patients who had pneumothorax (45%) needed a chest tube insertion. Only one of them had the chest tube

**Table 1**  
Blunt trauma patients who had free intraperitoneal air detected by CT scan (n=21).

	Age (year)	Gender	Bowel perforation	Free intraperitoneal fluid	Pneumothorax	Suspected peritonitis	Abdominal injuries	Mechanical ventilation	ISS	Laparotomy
Case 1	24	M	Yes	Yes	No	Yes	Small bowel	No	9	Yes
Case 2	34	M	Yes	Yes	No	Yes	Small bowel	No	9	Yes
Case 3	45	M	No	No	Yes	No	Right kidney	No	29	No
Case 4	5	M	No	Yes	No	No	Liver	No	13	No
Case 5	24	M	No	Yes	No	Yes	Mesentery	No	4	Yes
Case 6	27	M	No	No	Yes	No	No	Yes	14	No
Case 7	38	M	No	No	No	No	No	Yes	45	No
Case 8	20	M	No	No	No	No	No	Yes	14	No
Case 9	27	F	No	No	Yes	No	No	No	17	No
Case 10	20	M	No	Yes	Yes	No	Spleen	Yes	41	No
Case 11	26	M	No	No	Yes	No	No	Yes	29	No
Case 12	21	M	No	No	No	No	No	No	29	No
Case 13	11	F	No	Yes	Yes	No	Liver	No	17	No
Case 14	35	M	No	Yes	Yes	No	Liver	No	13	No
Case 15	23	M	No	Yes	Yes	No	Liver	No	13	No
Case 16	31	M	No	Yes	No	No	Right kidney	No	18	No
Case 17	22	M	No	Yes	Yes	No	No	Yes	36	No
Case 18	28	M	No	No	Yes	No	Liver	No	14	No
Case 19	32	M	No	No	Yes	No	No	No	17	No
Case 20	15	M	No	No	No	No	No	No	5	No
Case 21	20	F	No	Yes	No	No	Liver	No	9	Yes

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