

The Role of Computed Tomography in Blunt Abdominal Trauma

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دور الأشعة المقطعية (التفريسي المقطعي المحوسب) في الكشف عن إصابات البطن الكليّة

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المخلص: الهدف: تحديد استعمالات الأشعة المقطعية (التفريسي المقطعي المحوسب) في كشف إصابات البطن الكليّة ومقارنتها بنتائج ما بعد التداخلات الجراحية والفحوص السريرية. **الطريقة:** في هذه الدراسة الاستيعادية التحليلية تم مقارنة نتائج 245 مريضاً تعرضوا لإصابات البطن الكليّة خلال فترة خمس سنوات (من 1999 إلى 2004). أما نوع الإصابات ونسبتها المئوية فقد تمّ حديدها اعتماداً على نتائج الأشعة المقطعية. وتم تسجيل المعلومات الأخرى مثل العمر والجنس ونوع الإصابة. قارنا النتائج التي حصلنا عليها من الأشعة المقطعية مع تلك التي شوهدت في العمليات الجراحية. أو الملاحظات السريرية في زيارات المتابعة للحالات التي عولجت حفظياً. **النتائج:** من مجموع 245 مريضاً تمّ معالجة 113 جراحياً (46%). بينما كانت معالجة الباقيين (132 - 54%) حفظياً. . كان هناك 12 حالة وفاة. تم الكشف عن نزف جوفي عند 170 مريضاً. حيث تم تقسيمهم إلى ثلاث مجموعات من حيث كمية النزف الجوفي (خفيف، متوسط وشديد). حيث كانت الإصابات خفيفة في 52 مريضاً، وتمّ معالجتهم حفظياً، بينما كانت الإصابات شديدة في 22 مريضاً وتمّ معالجتهم جراحياً. كانت الإصابات من حيث العضو المصاب كما يلي: 95 إصابة طحال، 63 إصابة كلى، 48 إصابة كبدي، 13 إصابة بنكرياس، 21 إصابة معوية و خمس إصابات وعائية جوفية. كانت الإصابة في أكثر من عضو في 23 مريضاً. **الخلاصة:** بالمقارنة مع نتائج الفحوصات السريرية ونتائج التداخلات الجراحية تبين أن نتائج الأشعة المقطعية كانت موثوقة بها في الكشف عن إصابات الأعضاء الداخلية الجوفية بحساسية وصلت إلى 97% ودقة نوعية وصلت إلى 95%. أما القيمة التنبؤية الموجبة فكانت 82% والقيمة التنبؤية السلبية 100%.

مفتاح الكلمات: الأشعة المقطعية إصابات البطن.

ABSTRACT Objective: To determine the utility of the computed tomography (CT) scan in blunt abdominal trauma and to compare it with operative findings or clinical outcomes. **Methods:** A retrospective analysis based on existing, diagnostic CT scan reports taken during a 5 year period from 245 consecutive patients with blunt abdominal trauma. Percentages and types of trauma identified were based on CT scan findings. Recorded data included age, sex, type of injuries and scan results. The CT findings were compared and correlated with the operative findings, or clinical follow-up in conservatively managed cases. **Results:** Of the total of 245 patients, 113 (46%) underwent surgery. One hundred and thirty two (54%) patients were conservatively managed. There were 12 (4.9%) deaths. Hemoperitoneum were detected in 170 patients. All 52 patients with small hemoperitoneum on CT scan were conservatively managed and all 22 patients with large hemoperitoneum required surgical exploration. There were 95 splenic, 63 renal, 48 hepatic and 13 pancreatic injuries. Twenty one patients had bowel injuries. Five patients had vascular injuries. Twenty three patients had multi-organ injuries. Organ injuries were graded using the OIS (Organ Injury Scale) guidelines. **Conclusion:** In conjunction with close clinical monitoring, CT was reliable in the evaluation of blunt abdominal trauma in a selected group of patients, with overall sensitivity of 97% and specificity of about 95%. Positive predictive value 82% and negative predictive value 100%.

Key words: Blunt abdominal trauma, CT scan.

THE CARE OF THE TRAUMA PATIENT IS demanding and requires speed and efficiency. Evaluating patients who have sustained blunt abdominal trauma (BAT) remains one of the most challenging and resource-intensive aspects of acute trauma care. Missed intra-abdominal injuries continue to cause preventable deaths. Physical examination findings are notoriously unreliable for several reasons; a few examples are the presence of distracting injuries, an altered mental state, and drug and alcohol intoxication in the patient. Coordinating trauma resuscitation demands a thorough understanding of the pathophysiology of trauma and shock, excellent clinical and diagnostic acumen, skill with complex procedures, compassion and the ability to think rationally in a chaotic milieu. BAT usually results from motor vehicle collisions, assaults, recreational accidents, or falls. Men tend to be affected slightly more often than women. The most commonly injured organs are the spleen, liver, retroperitoneum, small bowel, kidneys, bladder, colorectum, diaphragm, and pancreas.

The CT scan remains the criterion standard for the detection of solid organ injuries.¹ In addition, a CT scan of the abdomen can reveal other associated injuries, notably vertebral and pelvic fractures and injuries in the thoracic cavity.

CT scans, unlike direct peritoneal lavage (DPL) or Focused Assessment with Sonography for Trauma (FAST) examinations, have the capability to determine the source of haemorrhage. In addition, many retroperitoneal injuries go unnoticed with DPL and FAST examinations.

CT scans provide excellent imaging of the pancreas, duodenum and genitourinary system. The images can help quantitate the amount of blood in the abdomen and can reveal individual organs with precision. The limitations of CT scans include marginal sensitiv-

ity for diagnosing diaphragmatic, pancreatic and hollow viscus injuries. Also, they are relatively expensive and time consuming and require oral or intravenous contrast, which may cause adverse reactions.^{2,3}

METHODS

In this retrospective study, over a period of 5 years (from May 1999 to March 2004), we used abdomen CT scan reports available within the clinical charts of 245 patients with BAT, who were stable enough to undergo radiological investigation in Prince Hashem Hospital in Zarqa, Jordan. The patients included 171 (70%) males and 74 (30%) females. The age range was 14 - 72 years.

Diagnostic peritoneal tapping was not performed in any of them. Patients with a normal CT scan and patients who either did not require admission, or who were discharged after a short, uneventful (max. 3 day) observation period without any further investigation, were excluded from the study.

All CT scans were obtained with a Hi Speed Dual Helical CT scanner from General Electric. A single breath-hold helical scan from the top of the T12 vertebral body to the pubic symphysis was obtained by using 5-mm beam collimation and 8 mm/sec table speed (pitch, 1.6; 120 kVp; 240-270 mAs). Routine oral (or through nasogastric tube) contrast agents in the form of 1-2% diluted ionic iodinated contrast were given 30-40 minutes before the study. Oral contrast was not given to 23 patients with repeated vomiting or when limited information was required before proceeding for prompt laparotomy. All patients received intravenous bolus of iodinated contrast agents. Following completion of the examination, the CT images were immediately reviewed by two specialist radiologists. They were in agreement on all the findings.

Delayed CT scans were also incorporated whenever



Figures 1-3: Patient with multi organ injury: Grade V renal injury and shattered spleen.
 Note: The 3D reformat of CT-angio with complete loss of renal vascularisation (left)

er there was suspicion of kidney or urinary tract injury. Follow up CT scans were obtained for 14 patients, as dictated by the clinical course of the patient, but they did not contribute any further information.

Hemoperitoneum on CT was graded as described by Federle and Jeffrey et al.⁴ [Table 1]. Individual organ injuries were graded according to the OIS (Organ Injury Scale) system.^{5,15} The OIS classification scheme is fundamentally an anatomic description, scaled from 1 to 5, representing the least to the most severe injury, ie. from simple organic contusion to avascularisation of one organ. CT findings were compared with operative findings in 113 patients, and with the clinical outcome and follow-up in 132 conservatively managed patients. The results were analysed with respect to hemoperitoneum quantification and OIS grades. The overall imaging findings were analysed for their role in guiding the therapeutic options, whether conservative or surgical.

RESULTS

Of the 245 patients with blunt trauma, road traffic accident was the commonest mode of injury and it was the cause of abdominal trauma in 186 patients. In 40 patients, the injury was caused by fall from height. Nineteen patients had blunt injuries from other miscellaneous causes.

Of the total of 245 patients, 113 (46%) underwent surgery and 132 (54%) patients were conservatively managed without any complications. There were 12 deaths, three of which were related to postoperative complications. The other nine patients died of associ-

ated head injuries within 24 hours. No autopsy results were available.

Hemoperitoneum was detected in (69.4%) patients and they were divided into three groups according to the Federle and Jeffrey system⁴ [Table 1]. There were 52 'small' patients, 96 'moderate' patients and 22 'large' patients [Table 2]. All 52 patients with small fluid hemoperitoneum on CT were conservatively managed and all 22 patients with large hemoperitoneum required surgical exploration. In the moderate fluid group, 50 patients were managed conservatively and the other 46 patients that were either unstable haemodynamically and/or had unexplained abdominal rigidity and/or packed-cell volume (PCV) drop were surgically explored. Thus the rate of therapeutic laparotomy in patients with moderate hemoperitoneum shown on the CT scan was 52%.

Among the solid organ injuries, the spleen was the commonest organ involved. There were 95 (38.8%) splenic, 63 (25.7%) renal, 48 (19.6%) hepatic and 13 (5.3%) pancreatic injuries. Twenty one (8.6%) patients had bowel injuries. Five (2%) patients had vascular injuries. Twenty three patients had multi-organ injuries [Figs. 1, 2 & 3]. Organ injuries were graded using the OIS guidelines.⁵ Among the 95 splenic injuries, 52 had mild injuries (grade II), 37 had grade III [Fig. 4] and IV [Fig. 7] injuries [Fig. 1] and 6 had grade V injuries. Nineteen of the 43 patients with moderate to severe (grade III, IV and V) injuries required surgery.

Sixty three patients had kidney injuries, 51 were unilateral and 12 bilateral. Of these 39 patients had grade III, 20 patients had grade IV and four patients



Figure 4: Grade III splenic injury

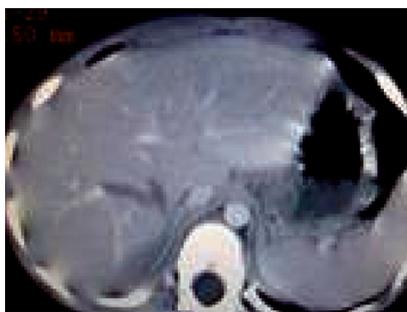


Figure 5: Grade II liver tear



Figure 6: Retroperitoneal, (right) Paraspinal Haematoma.
Note: the associated fracture involving the transverse process of L4 vertebra; it represents an anatomical entity at the level of aortic bifurcation

Table 1: CT quantification of hemoperitoneum (Federle et al.)⁴

Description	Estimates	Approximate amount
Fluid in only one space	Small	100-200 ml
Fluid in two or more spaces	Moderate	250-500 ml
Fluid in all spaces or pelvic fluid anterior/ superior to urinary bladder	Large	>500 ml

Location of hemoperitoneum:
 1. Perisplenic space 2. Perihepatic space 3. Morrison's pouch 4. Left paracolic gutter 5. Cul-de-sac in pelvis.

had grade V [Fig.2] injuries. Only fourteen of the 63 patients with renal injury up to grade IV required surgery. All patients with grade V injury were operated upon as expected.

Forty eight patients had liver injuries. Twenty nine had grade II and III [Fig. 5], 15 had grade IV and 4 patients had grade V injuries. All grade V and 11 out of 15 grade IV liver injuries required surgery. The rest of the injuries were managed conservatively. Similarly, 13 patients had grade II and III pancreatic injuries. All these patients were managed conservatively.

Of the total 245 patients in our study, 219 (89.4%) patients had solid organ injuries (liver, spleen, pancreas or kidneys). CT OIS grading in these patients showed that all 62 patients with grade II injuries were conservatively managed, while 14 patients with grade V injuries were operated. However, the majority, i.e. 143 of these 219 patients, had either grade III or grade IV injuries and these were either managed conservatively or operated on depending on their assessment on an individual basis [Table 3]. Hence, in the overall analysis of solid organ injuries, OIS grading in isola-



Figure 4: post operative finding, note grade IV splenic rupture

tion did not appear to predict the management protocols in a small proportion of them. After calculations, the sensitivity and specificity were 97% and 95%, respectively.

In conjunction with close clinical monitoring, CT was reliable in the evaluation of blunt abdominal trauma in a selected group of patients, with overall sensitivity of 97% and specificity of about 95%. Positive predictive value was 82% and negative predictive value 100 %. Although sensitivity and specificity were calculated regarding intra abdominal injury in our group of patients, showing an overall sensitivity of about 97% and specificity of about 95%, it should be mentioned that these results were less in cases of bowel, mesenteric or vascular injuries. For solid organ injuries the results were higher for specificity and the same for sensitivity.

DISCUSSION

Several studies have highlighted the inaccuracies of the physical examination in BAT,⁶ however, CT requires a cooperative, haemodynamically stable patient

The accuracy of CT in haemodynamically stable blunt trauma patients has been well established. Sensitivity between 92% and 97.6% and specificity as high as 98.7% has been reported in patients subjected to emergency CT,^{7, 8} which is in the range of our study. Most authors recommend admission and observation following a negative CT scan.^{9, 10} In a recent study of 2,774 patients, the authors concluded that the negative predictive value (99.63%) of CT was sufficiently high to permit safe discharge of BAT patients following a negative CT scan.¹¹

We found good correlation between the CT quantification of the hemoperitoneum with the management approach. All 52 patients with small fluid were conservatively managed and similarly all 22 patients with large fluid required surgical exploration. Approximately half of the patients with moderate fluid were explored. Taylor et al. also reported a similar experience.¹²

CT is notoriously inadequate for the diagnosis of mesenteric injuries and may also miss hollow visceral injuries. In patients at risk for mesenteric or hollow visceral injury, DPL is generally felt to be a more appropriate test.^{7, 13} A negative CT scan in such a patient cannot reliably exclude intra-abdominal injuries. CT has the unique ability to detect clinically unsuspected

Table 2: CT quantification and management in 170 patients with Hemoperitoneum on CT examination

CT quantification of hemoperitoneum	Total number of patients	Number of conservatively managed patients	Number of operated patients
Small	52	52	0
Moderate	96	50	46
Large	22	0	22

injuries.

In a series of 444 patients, in whom CT was performed to evaluate renal injuries, 525 concomitant abdominal and/or retroperitoneal injuries were diagnosed. Another advantage of CT scanning over other diagnostic modalities is its ability to evaluate the retroperitoneal structures⁸ [Fig 6]. Kane performed CT in 44 haemodynamically stable blunt trauma patients following DPL. In 16 patients, CT revealed significant intra-abdominal or retroperitoneal injuries not diagnosed by DPL. Moreover, the findings from CT resulted in a modification to the original treatment plan in 58% of the patients.¹⁴

The OIS^{5, 15} (Organ Injury Scale) system is a relatively new system that is gaining recent acceptance in literature. Though its sole purpose is to establish uniformity in different studies and thereby facilitate easy comparison, we found that splenic injury upto grade III infrequently required surgery. Only 5 out of 25 in this category required splenectomy as a part of surgery for multi-organ injury. On the contrary, grade IV or higher grade splenic injuries required surgery more often (11 out of 18 patients).

We found no correlation between the grade of kidney injury with the management outcome. Although two cases of grade III kidney injuries required nephrectomies because of persistent hematuria and associated multi-organ injuries respectively, it is quite possible that, in the absence of significant hematuria or multi-organ injuries, isolated renal injury up to and including grade IV can be conservatively managed.

The overall likelihood of surgical management increases with higher OIS grading of solid organ injury, however OIS grading in isolation appears inadequate for predicting management protocol in the relatively small number of patients in our study.

Table 3: CT-OIS grading and management in 219 patients with solid organ injuries.

OIS grade	Total number of patients	Number of conservatively managed patients	Number of operated patients
II	62	62	0
III	96	85	11
IV	47	27	20
V	14	0	14

*Grade of the maximally injured organ in cases of multiorgan injuries.

CONCLUSION

We conclude that the CT scan is accurate, safe and has all the attributes to make it an initial investigation of choice in haemodynamically stable patients with BAT. The rate of negative laparotomy is reduced by avoiding surgical intervention in cases that can be managed conservatively.

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