Evaluation of triphasic abdominal computed tomography in the management of pediatric blunt abdominal trauma

Mohamed Hassan M., Wael A. Ghanem, Mohamed H. Soliman, Nader N. Guirguis, Mohamed El Debeiky

Department of Pediatric Surgery, Faculty of Medicine, Ain Shams University, Cairo, Egypt

Correspondence to Mohamed Hassan Mohamed, MSc, Pediatric surgery assistant lecturer, Ain Shams University, Cairo, Egypt. Tel: +201122194533; e-mail: mohamedhamh@gmail.com

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Introduction
Despite improvement in the management of pediatric trauma, it remains the most common cause of morbidity and mortality. Missed abdominal injuries pose a greater risk in children than in adults. Abdominal trauma assessment is challenging in the pediatric age group. Computed tomography (CT) is currently the gold standard in the identification of intraabdominal injury in blunt abdominal trauma. Being more sensitive to radiation, pediatric centers have adopted protocols with the goals of reducing radiation exposure. This study aims to evaluate the use of triphasic abdominal CT as a diagnostic tool in the management of pediatric blunt abdominal trauma.

Patients and methods
Patients under 14 years of age with blunt abdominal trauma treated in a tertiary care center over a period of 10 months were included in a prospective observational study. Rate of triphasic abdominal CT was calculated and compared with the rate of CT in clinical effectiveness guidelines according to Leeper and colleagues.

Results
Of the 107 pediatric patients presented during the study period, 96 patients were hemodynamically stable and fulfilled complete abdominal triphasic CT criteria and were included in the study. In all, 60 cases underwent CT, while 36 cases were managed without CT due to the lack of criteria needed for the decision of CT in clinical presentation, laboratory results, and FAST. Triphasic CT of the abdomen was crucial for the diagnosis and intervention for seven (11.5%) cases; three cases underwent exploration while four cases were managed by interventional radiology, whereas the rest of cases were managed nonoperatively. The number of male and female participants was 62 and 34, respectively (64.5 and 35.4%). Their ages ranged from 6 months to 13.5 years with a median age of 5 years. The mechanism of injury included falls from height (45%), automobile versus pedestrian accident (31%), and crush injury to the torso (13%). The rate of CT use in this study was compared with that of use in case of implementing clinical effectiveness guidelines were 62.5 and 72.9%, respectively.

Conclusion
Triphasic abdominal CT in properly selected patients is effective in the management of pediatric trauma without overuse.

Keywords:
blunt abdominal trauma, imaging, pediatrics, triphasic CT of abdomen

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Introduction

Despite improvements in the management of pediatric trauma, it remains the most common cause of morbidity and mortality [1,2]. Missed abdominal injuries pose a higher risk in children than in adults [3]. Death is the most serious adverse effect after blunt abdominal trauma [3]. Motor vehicle accidents and falls from height are the most common mechanism [4–6].

Children have increased risk than adults as regards intraabdominal injuries (IAI) for several reasons such as low body weight, dissipation of force received over a small area and reduced protection to their internal organs attributed to their weak muscles, less fat, and malleable ribs [7].

Computed tomography (CT) is currently the gold standard in the identification of IAI [8–10]. CT of the abdomen can accurately detect such injuries and is relatively noninvasive as long as the patient is vitally stable; nonetheless, it is relatively costly and requires exposure to radiation, contrast injection, and patient transport [11]. Children are more sensitive to radiation in comparison to adults that may lead to increase the risk of developing cancer. As a result, alternative ways to identify abdominal injuries in children have been considered. Sensitive and specific clinical practice guidelines have been developed based on physical examination findings, symptoms, laboratory testing, and other factors that predict solid organ injury [12–17].

Most centers have adopted protocols aimed at reducing radiation exposure [18]. With regard to the current study, it aims to evaluate using triphasic abdominal CT as a diagnostic tool in the management of blunt abdominal injuries.

Patients and methods

Patients younger than 14 years old with blunt abdominal trauma treated in a tertiary care center over a 10-month period were included in a prospective observational study. This research was performed at the Department of Pediatric Surgery, Ain Shams University Hospitals. Ethical Committee approval and written, informed consent were obtained from all participants.

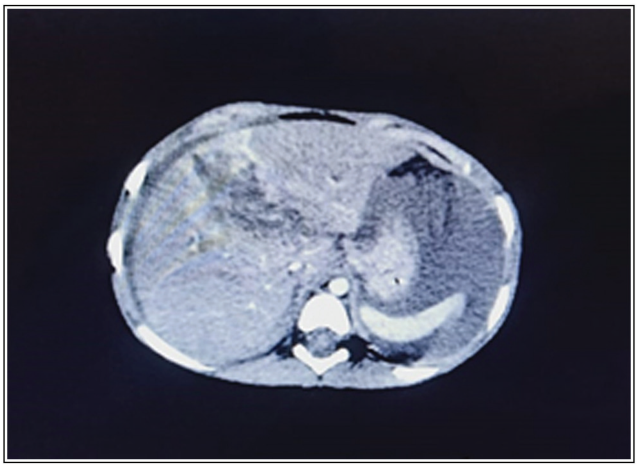
Upon the patient's arrival in the emergency department (ER), the ER physician starts the initial survey and the care continued by the pediatric surgery specialist. If the patient is hemodynamically stable, a secondary and tertiary survey is performed. The patient is admitted to the ward or ICU. Decision of triphasic CT abdomen is made for hemodynamically stable patients with suspected abdominal injury. Decision of CT abdomen depends on the mechanism of injury, its severity, clinical signs such as abdominal pain and tenderness, evidence of abdominal wall trauma, laboratory abnormalities such as aspartate aminotransferase (AST) and alanine aminotransferase (ALT) more than 200, amylase more than 100, hemoglobin drop by 1 g or more in 6 h range and FAST findings as mild, moderate, and marked collection. The rate of triphasic abdominal CT was calculated in polytrauma patients and compared with the rate of triphasic abdominal CT if clinical effectiveness guidelines according to Leeper and colleagues were applied in this setting.

Results

Of the 107 pediatric patients presented during the study period, 96 patients were hemodynamically stable and fulfilled the criteria for imaging by triphasic CT of the abdomen while 11 cases were excluded due to hemodynamic instability. The excluded cases included three mortalities, eight cases underwent urgent intervention out of which three underwent craniotomies; four gastrointestinal tract injuries were explored and there was one case of splenectomy. The number of males and females was 62 and 34, respectively (64.5 and 35.4%). The age range was 6 months to 13 years with a median age of 5 years. The mechanism of injury included falling from height (45%), automobile versus pedestrian accidents (31%), and crush injury in the torso (13%), motor vehicle accident (7%), others as physical assault to the abdomen and sexual assault (4%). The rate of CT use in this study compared with its use in case of implementing clinical effectiveness guidelines was 62.5 and 72.9%, respectively.

The number of patients who underwent CT was 60 cases, while 36 cases were managed without CT due to the lack of criteria needed for CT decision in clinical presentation, laboratory results, and FAST. Triphasic CT of the abdomen was crucial for the diagnosis and intervention for seven (11.5%) cases out of 60 by either exploration or interventional radiology. Three (5%) cases were operated, whereas four (6.6%) cases were managed by intervention radiology. The three operated cases were: duodenal perforation (posterior wall of the third part), bladder intraperitoneal rupture, and renal injury grade 4 (ureteric avulsion from pelvis) underwent nephrectomy after trials of repair. While the four cases of interventional radiology were: one case of grade 3 liver injury with moderate ascites and subhepatic collection in which external drainage was done percutaneously, one case with renal injury grade 5 with progressive hematoma underwent selective embolization, two cases of renal injury grade 4 with perinephric urinoma underwent external drainage and cystoscopic double J insertion in the ureter. Figures 1 and 2 show CT cuts for liver injury and duodenal perforation, respectively. The rate of CT use in this study compared with its use

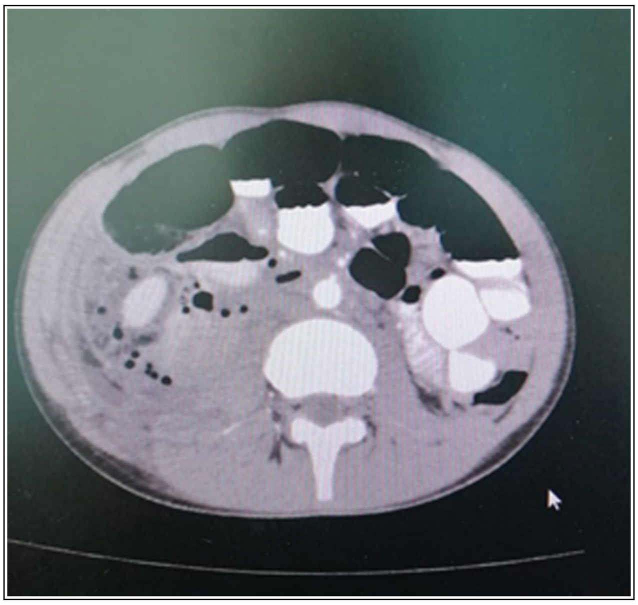
Figure 1



Grade 5 liver and grade 3 spleen managed nonoperatively.

in case of implementing clinical effectiveness guidelines was 62.5 and 72.9%, respectively, with a *P* value of 0.185. Distribution of different organ injury solid organ injury (SOI) and non-SOI according to the degree of injury, type of intervention, and triphasic abdominal CT is shown in Tables 1 and 2.

Figure 2



Duodenal perforation as shown in triphasic CT of the abdomen with subhepatic and perinephric collection with air foci. CT, computed tomography.

Discussion

In general, evaluation of trauma patients involved history taking, clinical examination, laboratory results, and FAST and then whether to proceed to tripahsic CT of abdomen or not. The American College of Surgeons in the Advanced Trauma Life Support recognizes FAST as an adjunct diagnostic option for the evaluation of abdominal trauma in pediatric patients [19]. Abdominal ultrasound offers several advantages in blunt abdominal trauma. First, ultrasound leads to an immediate assessment of the injured child with easy application. Second, in the case of hemodynamically unstable child, presence of free intraabdominal fluid on ultrasound guides for urgent intervention, that is, rapid blood transfusion and/or emergent laparotomy. In a prospective observational study testing the accuracy of FAST in correlation to clinically significant free fluid in moderate or greater amount of intraperitoneal free fluid on CT or injury requiring surgery, showed FAST to have a sensitivity of 52% and a specificity of 96% [20]. In the same vein, the results of the current study showed a specificity of 94%, but a higher sensitivity of 90%. In an attempt to increase its utility as a screening tool to detect solid-organ injuries, studies have been conducted combining FAST findings with other factors. The combination of FAST with elevated liver transaminases (ALT or AST >100 IU/l) was studied and showed an improvement in sensitivity to (88%) free intraperitoneal fluid or IAI in pediatric patients

Table 1 Distribution of SOI (isolated and combined) according to the degree of injury, type of intervention, and triphasic abdominal computed tomography

POC (isolated and combined injuries)	Spleen 24 cases		Liver 36 cases		Renal 13 cases		
Grade of injury	Mild grade	High grade	Mild grade	High grade	Mild grade	High grade	Pancreas 3 cases
Number of cases	14 cases	10 cases	31 cases	5 cases	4 cases	9 cases	
Triphasic CT abdomen							
Excluded		1					
Y	10	9	20	4	4	9	3
N	4		11	1			
Intervention							
NOM	14	9	30	4	4	4	3
Minimal			1			3	
Operative		1		1		1	

CT, computed tomography.

Table 2 Distribution of non-SOI+adrenals according to the number of cases, type of intervention, and triphasic abdominal computed tomography

	Intestine	Adrenal	Urethra	Bladder	Perineal injury	Free
Number of cases	6 cases	2 cases	1 case	2 cases	4 cases	24 cases
NOM	1	2				21
Operative	5		1	2	4	5
Triphasic CT of abdomen						
Excluded	4					3
Y	2	2		1		8
N			1	1	4	13

CT, computed tomography.

with blunt abdominal trauma [21]. In the present study, this combination elevated sensitivity (95%) with same specificity percentage.

However, stable children with solid organ injury and unconscious patients with suspected abdominal injury would still require an abdominal triphasic CT scan for the diagnosis and staging of the injury. Patients who remain hemodynamically unstable with signs and symptoms of peritonitis require immediate operation and no time should be wasted in obtaining a CT scan [22]. The CT diagnosis of abdominal injury also guides nonoperative decisions such as the duration of hospitalization, intensity of care, length of activity restriction, and follow-up [23,24]. It has been evident that high doses of radiation associated with CT scanning increased the lifetime risk of radiation-induced malignancy for children. Therefore, several prediction rules have been formed to stratify patients after blunt abdominal trauma into low risk and high risk for acute intervention. Patients with a low risk for IAI after blunt trauma can avoid abdominal CT scanning. Furthermore, clinical effective guidelines were formulated by expert consensus in certain trauma centers based on the best available literature from several studies and prediction rules. The guidelines identified certain parameters from clinical examination, laboratory abnormalities, and findings in FAST upon which the frequency of abdominal CT can be reduced.

Fenton *et al.* [25] in their retrospective review found that only 2% of all children with abdominal CT scan and 5% with an abnormal CT scan had surgical exploration. Similarly in our study, three (5%) cases out of 60 cases who performed triphasic abdominal CT underwent surgical intervention. Holmes *et al.* [26] in a prospective study validated a previously derived clinical prediction rule (CPR) for the identification of children at very low risk for IAI after blunt torso trauma; therefore, triphasic CT can be avoided. This rule had a sensitivity of 95% and a specificity of 37%. Subsequently, a multicenter study to derive a CPR applied the following variables limited to history and physical examination: no evidence of abdominal wall trauma or seat belt sign, Glasgow Coma Scale score greater than 13, no abdominal tenderness, no evidence of thoracic wall trauma, no complaints of abdominal pain, no decreased breath sounds, and no vomiting. The rule had a sensitivity of 97% and a specificity of 42.5%. Six patients requiring intervention would have been missed by the rule; the addition of imaging adjuncts as FAST and laboratories as AST, ALT, and urine analysis to the prediction rule would have captured these patients [14]. In a study by Leeper and colleagues, they created evidence-based solid-organ injury guidelines at Children's Hospital of Pittsburgh of UPMC, a high-volume academic pediatric trauma center. These clinical effective guidelines were determined by expert consensus based on several studies and prediction rules as previously mentioned [27]. They compared implementation of guidelines on the rate CT used before and after this protocol (17.5 vs. 8.7%, P=0.010), which led to a significant decrease in the rate of CT use [18]. We used these guidelines as a control to compare the rate of CT; our rate was 62.5% and if clinical effectiveness guidelines were followed in our setting, CT will be performed on 72.9% of the cases with no statistical difference .It means that the triphasic CT scan of the abdomen was not overused in the current study. A recent prospective observational study by Streck and colleagues yielded a CPR and another study for external validation of this CPR suggested that the CPR was a valid and generalizable tool that may be used to identify children with blunt abdominal trauma at very low risk for any IAI, and not just IAI receiving an acute intervention, in which abdominal CT can be safely avoided. These rules used these parameters: abdominal pain, abdominal wall trauma, tenderness or distention on physical examination, abnormal chest radiograph, abnormal pancreatic enzymes, and AST of more than 200 U/l elevated AST. This rule had a sensitivity of 97.5% for IAI and 100% for abdominal injury requiring intervention and the same result was found in our study [17]. In brief, the clinical effectiveness guidelines in Leeper and colleagues or the CPR by Streck and colleagues and the criteria used in this study were effective in identifying patients with a very low risk for any IAI. Consequently, triphasic abdominal CT can be avoided without missing any patient in need of an intervention.

Conclusion

Triphasic abdominal CT in properly selected patients is effective in the management of pediatric trauma without overuse.

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Conflicts of interest

No conflict of interest.

References

1 Prevention CfDCa. CDC childhood injury report; child safety and injury prevention; CDC injury center. Atlanta, GA: CDC; 2017.

2 World Health Organization. Global burden of disease. Available at: http://www.who.int/healthinfo/global_burden_disease/en/. [Accessed May 01, 2010].

3 Wegner S, Colletti JT, Van Wie D. Paediatric blunt abdominal trauma. Pediatr Clin N Am 2006; 53:243–256.

4 Brenner DJ. Estimating cancer risks from pediatric CT: going from the qualitative to the quantitative. Pediatr Radiol 2002; 32:228–231. [discussion 42–44].

5 Miglioretti DL, Johnson E, Williams A, Greenlee RT, Weinmann S, Solberg LI, *et al*. The use of computed tomography in pediatrics and the associated radiation exposure and estimated cancer risk. JAMA Pediatr 2013; 167:700–707.

6 Scaife ER, Rollins MD. Managing radiation risk in the evaluation of the pediatric trauma patient. Semin Pediatr Surg 2010; 19:252–256.

7 Lynch T, Kilgar J, Al Shibli A. Pediatric abdominal trauma. Curr Pediatr Rev 2018; 14:59–63.

8 Pearce MS, Salotti JA, Little MP, McHugh K, Lee C, Kim KP, *et al*. Radiation exposure from CT scans in childhood and subsequent risk of leukaemia and brain tumours: a retrospective cohort study. Lancet 2012; 380:499–505.

9 Kim PK, Zhu X, Houseknecht E, Nickolaus D, Mahboubi S, Nance ML. Effective radiation dose from radiologic studies in pediatric trauma patients. World J Surg. 2005; 29:1557–1562.

10 Brunetti MA, Mahesh M, Nabaweesi R, Locke P, Ziegfeld S, Brown R. Diagnostic radiation exposure in pediatric trauma patients. J Trauma 2011; 70:E24–E28.

11 Richards JR, Derlet RW. Computed tomography for blunt abdominal trauma in the ED: a prospective study. Am J Emerg Med 1998; 16:338–342.

12 Poletti PA, Mirvis SE, Shanmuganathan K, Takada T, Killeen KL, Perlmutter D, *et al*. Blunt abdominal trauma patients: can organ injury be excluded without performing computed tomography? J Trauma 2004; 57:1072–1081.

13 Streck CJ Jr., Jewett BM, Wahlquist AH, Gutierrez PS, Russell WS. Evaluation for intra-abdominal injury in children after blunt torso trauma: can we reduce unnecessary abdominal computed tomography by utilizing a clinical prediction model? J Trauma Acute Care Surg 2012; 73:371–376. [discussion 6].

14 Holmes JF, Lillis K, Monroe D, Borgialli D, Kerrey BT, Mahajan P, *et al*. Identifying children at very low risk of clinically important blunt abdominal injuries. Ann Emerg Med 2013; 62:107–116.e2.

15 Holmes JF, Mao A, Awasthi S, McGahan JP, Wisner DH, Kuppermann N. Validation of a prediction rule for the identification of children with intra-abdominal injuries after blunt torso trauma. Ann Emerg Med 2009; 54:528–533.

16 Taylor GA, Eichelberger MR, O'Donnell R, Bowman L. Indications for computed tomography in children with blunt abdominal trauma. Ann Surg 1991; 213:212–218.

17 Streck CJ, Vogel AM, Zhang J, Huang EY, Santore MT, Tsao K, *et al*. Identifying children at very low risk for blunt intra-abdominal injury in whom CT of the abdomen can be avoided safely. J Am Coll Surg 2017; 224:449–458.

18 Leeper CM, Nasr I, Koff A, McKenna C, Gaines BA. Implementation of clinical effectiveness guidelines for solid organ injury after trauma: 10-year experience At a level 1 pediatric trauma center. J Pediatr Surg 2017; 53:4.

19 American College of Surgeons Committee on Trauma. Pediatric trauma. In: American College of Surgeons, editors. Advanced trauma life support for doctors. 8th ed. Chicago, IL: American College of Surgeons; 2008. 1–492.

20 Fox JC, Boysen M, Gharahbaghian L, Cusick S, Ahmed SS, Anderson CL. Test characteristics of focused assessment of sonography for trauma for clinically significant abdominal free fluid in pediatric blunt abdominal trauma. Acad Emerg Med 2011; 18:477–482.

21 Sola JE, Cheung MC, Yang R, Koslow S, Lanuti E, Seaver C, *et al*. Pediatric FAST and elevated liver transaminases: an effective screening tool in blunt abdominal trauma. J Surg Res 2009; 157:103–107.

22 Holmes JF, Brant WE, Bond WF, Sokolove PE, Kuppermann N. Emergency department ultrasonography in the evaluation of hypotensive and normotensive children with blunt abdominal trauma. J Pediatr Surg 2001; 36:968–973.

23 Gaines BA. Intra-abdominal solid organ injury in children: diagnosis and treatment. J Trauma 2009; 67:S135–S139.

24 Sivit CJ. Abdominal trauma imaging: imaging choices and appropriateness. Pediatr Radiol 2009; 39:S158–S160.

25 Fenton SJ, Hansen KW, Meyers RL, Vargo DJ, White KS, Firth SD, *et al*. CT scan and the pediatric trauma patient – are we overdoing it? J Pediatr Surg 2004; 39:1877–1881.

26 Holmes JF, Mao A, Awasthi S, McGahan JP, Wisner DH, Kuppermann N. Validation of a prediction rule for the identification of children with intra-abdominal injuries after blunt torso trauma. Ann Emerg Med 2009; 54:528–533.

27 Streck CJ, Jewett BM, Wahlquist AH, Gutierrez PS, Russell WS. Evaluation for intra-abdominal injury in children after blunt torso trauma: Can we reduce unnecessary abdominal computed tomography by utilizing a clinical prediction model? J Trauma Acute Care Surg 2012; 73: 371–376.