

ANALYTICAL REVISIT TO BASICS HELPS REDUCE UNNECESSARY CT SCAN IN CHILDREN WITH ABDOMINAL TRAUMA: A SINGLE INSTITUTION EXPERIENCE

© R.A. Khan, M. Hazique, S. Wahab

JNMCH, AMU, Aligarh, India

Received: 29.01.2018

Accepted: 05.04.2018

Introduction. CT scan is regarded as the investigation choice for accurate depiction of blunt abdominal injuries in children and is considered as an inevitable tool in the armamentarium of the clinician before deciding for conservative management of these children. However over dependence on CT scan puts the patient to many disadvantages.

The **aim** of this study to devise stratification criteria for the children with blunt abdominal injury and advise CT scan to the children only who really require it.

Material and methods. All the children with blunt abdominal injury were studied prospectively over a period of two years. These children underwent clinical, biochemical and ultrasonographic assessment at presentation followed by CT abdomen. Efficacy of predefined clinical, biochemical and ultrasonographic parameters was compared with CT scan to triage the children with intra abdominal injury.

Results. A total of 84 children were registered in the study based on final diagnosis of presence or absence of intra abdominal injury the children were divided in two groups. These groups were then compared for various clinical, laboratory and ultrasonographic parameters to predict intra abdominal injury. The children having isolated abdominal injury, tenderness, raised AST, ALT and amylase and free fluid on ultrasonography were found to have more chances of intrabdominal injury ($p < 0.001$). These parameters were the most sensitive parameters to predict intra abdominal injury and the cumulative sensitivity of these parameters was 99.7%. The CT abdomen was negative in 74.7% of the patients.

Conclusion. Due to high negative rate of CT abdomen in children with abdominal trauma, its use as first line imaging investigation is questionable in all the children with abdominal trauma. We suggest that by utilizing clinical, biochemical and ultrasonographic parameters, the children at risk of intra abdominal injuries can identified with almost 100% accuracy mandating the use of CT scan only in these children.

Keywords: children; blunt abdominal trauma; CT scan.

РЕГУЛЯРНЫЕ КЛИНИЧЕСКИЕ ОСМОТРЫ ПОЗВОЛЯЮТ СНИЗИТЬ КОЛИЧЕСТВО НЕОПРАВДАНЫХ КОМПЬЮТЕРНЫХ ТОМОГРАФИЙ СРЕДИ ДЕТЕЙ С ТУПОЙ ТРАВМОЙ ЖИВОТА: ОПЫТ ОДНОГО УЧРЕЖДЕНИЯ

© Р.А. Хан, М. Хазикьюе, Ш. Вахаб

Джавахарлал Неру медицинский колледж, Алигархский мусульманский университет, Алигарх, Индия

Статья поступила в редакцию: 29.01.2018

Статья принята к печати: 05.04.2018

Введение. Компьютерная томография (КТ) считается методом выбора в диагностике тупых травм живота у детей и рассматривается как процедура, необходимая для определения стратегии консервативного лечения. Однако такая чрезмерная зависимость от КТ создает ряд проблем для пациента. Целью данного исследования явилась разработка критериев стратификации детей с тупой травмой живота для последующего направления на КТ только тех пациентов, кому это действительно необходимо.

Материалы и методы. Мы провели проспективное исследование всех случаев тупой травмы живота у детей, поступивших в наш стационар в течение двух лет. Все участники исследования прошли клиническое, биохимическое и ультразвуковое обследование, а также КТ-сканирование органов брюшной полости. Оценивали эффективность нескольких клинических, биохимических и ультразвуковых показателей в диагностике внутрибрюшной травмы по сравнению с КТ.

Результаты. В исследование были включены 84 ребенка, которые были разделены на две группы в зависимости от наличия или отсутствия внутрибрюшной травмы в соответствии с окончательным диагнозом. Далее эти группы сравнивали по различным клиническим, лабораторным и ультразвуковым показателям для выявления внутрибрюшной травмы. Было установлено, что вероятность внутрибрюшной травмы выше у детей с изолированной травмой живота, демонстрирующих болезненность при пальпации, повышенные уровни сывороточной амилазы, АЛТ и АСТ, а также признаки свободной жидкости при ультразвуковом обследовании ($p < 0,001$). Эти параметры были наиболее чувствительны в отношении внутрибрюшной травмы; их совокупная чувствительность составила 99,7 %. При КТ внутрибрюшная травма не подтвердилась у 74,4 % пациентов.

Заключение. Использование КТ брюшной полости в качестве первого способа визуализации у детей с тупыми травмами живота весьма сомнительно вследствие значительного количества отрицательных результатов. Мы полагаем, что, используя клинические, биохимические и ультразвуковые параметры, можно с почти 100 % точностью идентифицировать детей с высоким риском травм органов брюшной полости, которым действительно требуется КТ.

Ключевые слова: дети; тупая травма живота; КТ-скан.

Introduction

In this speedily moving world, trauma has emerged as the major cause of mortality and morbidity in children [1]. Blunt abdominal injury is more common and difficult to diagnose in this age group [2]. If the child remains hemodynamically stable, the currently accepted management protocol states nonoperative management preceded by a computed tomography of abdomen [2, 3]. However only 15% of children following blunt abdominal injury have intra abdominal injury and most of them do not require surgical intervention [3, 4]. Abundant use and over reliance on CT scan for non operative management of these children put them at risk of radiation related malignancy with additional disadvantage of delay in patient care and over treatment of minor injuries [5–7]. Several authors had expressed the need of justified application of radiation emitting imaging techniques in children [9–14]. We proposed this study to help identify the clinical, biochemical and ultrasonographic parameters that would best differentiate the children who need CT abdomen following blunt abdominal injury.

The **aim** of this study to devise stratification criteria for the children with blunt abdominal injury and advise CT scan to the children only who really require it.

Material and methods

This was a prospective study conducted on children <14 years of age with history of blunt abdominal trauma admitted to our hospital over a period of two years at a tertiary care hospital. At presentation all the children were evaluated with

primary survey and simultaneous resuscitation. The vital signs (blood pressure and heart rate), detailed abdominal examination and presence of other significant injuries were recorded. Hematocrit (HCT), white blood cell count (WBC), AST, ALT and serum amylase and routine and microscopic urinalysis were performed. Plain radiography of chest and abdomen including the pelvis was also performed. This was followed by detailed abdominal sonographic examination, performed and interpreted in by a radiologist. Ultrasonography was performed with 3–5 MHz curvilinear and 7–12 MHz linear high frequency transducer using a 12-inch monochrome display monitor (TOSHIBA NEMIO XG, Japan). This was followed by abdominopelvic CT performed within 24 hours of admission. The CT scan (Siemens Somatom Emoticon 16 slice CT, Germany) was interpreted by the senior radiologist. The scanning was performed with intravenous contrast (iohexol) injected at rate of 1.5–2 ml/kg. Whenever clinically indicated oral contrast (1% iohexol) was given at the dose of 450 mL half an hour before scanning and an additional 250 mL immediately before scanning. Intravenous and oral contrast dose was also adjusted according to age and weight of child. CT was performed from the lung bases to the pelvis with 5-mm contiguous sections, and with a table speed of 6 mm/s (pitch — 1, 2).

Abnormal values for clinical, biochemical, ultrasonographic and CT scan findings were defined. A systolic blood pressure was considered low if less than $(70 + 2 \text{ times the age})$ mm Hg for children up to 10 years and less than 90 for children between 11 years and 14 years. The tachycardia was defined >180 beats per minute for children

up to 1 year, >150 beats per minute for children between 1 year and 3 years >135 beats per minute for children between 4 years and 8 years, and >110 beats per minute for children between 9 years and 14 years. Clinical examination of abdomen was considered abnormal if abdominal wall contusion with tenderness, guarding or abdominal distension was documented. A hematocrit value of less than 30.0% was considered abnormal. ALT and AST level of more than 50 U/L was taken as abnormal. Hematuria was considered if more than five red bloods cell per high-power field were found. Serum amylase was considered as raised if it was >100 U/L. The WBC count of >11000/cu.mm was taken as abnormal. The detailed ultrasound examination included longitudinal and transverse images of all the quadrants of the abdomen and transverse and longitudinal views of all the solid organs including pancreas, kidneys and bladder for any laceration, hematoma. The lower quadrants were specifically examined for intraperitoneal and retroperitoneal fluid. CT was defined as positive if an intra-abdominal injury was found in the form of any contusion or laceration of an intraperitoneal or retroperitoneal organ and/or the presence of free intraperitoneal or retroperitoneal fluid. Solid organ injuries were graded according to American Association for the Surgery of Trauma. Data was entered and analyzed using SPSS version 20. Sensitivity, specificity, positive & negative predictive value for each of clinical, biochemical & USG parameters were calculated using online MedCalc software.

The association between clinical, biochemical & USG parameters with intra-abdominal injury was determined using Fisher exact test.

Results

There were 102 patients of blunt trauma abdomen during the period of study but only 84 were included in the final analysis. These 84 patients underwent all the clinical, biochemical, ultrasonography as well as CT abdomen. The patients who did not undergo the treatment as per the protocol (e.g. any biochemical test, USG or CT scan not done) were excluded from the study. The most common cause of injury was road traffic vehicle accidents (54%). The causes include pedestrian hit by a vehicle and fall from height.

Only 18 % patients were involved in a polytrauma while rest were of isolated abdominal injury. The mean age of the patients was 7.2 years (SD-2.43). Both the groups were comparable as regards to age and sex. In the final analysis, there were a total of 22 patients in whom there was a final diagnosis of some form of intrabdominal injury. This final diagnosis was either based on CT scan or laparotomy. Out of these, 21 (95%) cases were diagnosed based on CT scan and 1 case on exploratory laparotomy. The injured organs were liver ($n = 9$), spleen ($n = 7$), kidney ($n = 3$), pancreas ($n = 1$) and bowel ($n = 2$). One case of bowel injury was diagnosed on laparotomy which showed transverse tear in mesentery leading to bowel gangrene. The results in both the group of children (with and without intrabdominal injury) were compared (Table 1). The children having isolated abdominal injury and tenderness were found to have more chances of intrabdominal injury. This difference was statistically significant. If children sustained high impact injury and had tachycardia on examination then there are more chances of intrabdominal injury. This was not statistically significant but the difference was high enough to be ignored. The children with intrabdominal injury also had high percentages of body wall contusion, contusion and hypotension. Thus the clinical examination should be comprehensive and repetitive. On laboratory evaluation we found that children with abdominal injury had low hematocrit and raised ALT and this difference was statistically significant. In addition these children are more likely to have raised AST, leucocytosis and hematuria. The presence of free fluid and detection of specific organ injury on USG was also significantly different ($p < 0.001$) in both the groups (Table 1).

The analysis of abnormal clinical, biochemical and radiological parameters was also done on cumulative basis i.e. taking the parameters as abnormal even if one of the sub-parameter was present in the patients (Table 2). From table 2 it can be deduced that none of the clinical findings can be ignored. Similarly, ultrasonographic finding of either free fluid or for that matter specific organ injury is significant. The sensitivity and specificity of clinical, biochemical and radiological parameters for detection of injury is shown in Table 3. The most sensitive clinical parameter was tenderness (68.2%) (95% CI, 45.1–86.1%). It was also found

Table 1

Association of individual clinical, biochemical & USG parameters with intra-abdominal injury

Parameters	Intra-abdominal injury				Significance (Fisher exact test)
	Absent (n = 62)		Present (n = 22)		
	n	%	n	%	
Clinical examination					
High impact injury	8	12.9	11	50	0.001
Isolated abdominal injury	13	21	14	63.6	<0.001
Body wall contusion	4	6.5	7	31.8	0.006
Abdominal distension	1	1.6	4	18.2	0.016
Tenderness	5	8.1	15	68.2	<0.001
Peritonitis	1	1.6	3	13.6	0.053
Tachycardia	3	4.8	8	36.4	0.001
Hypotension	3	4.8	5	22.7	0.026
Lab examination					
Raised S. amylase	55	88.7	20	90.9	1.000
Raised AST	17	27.4	18	81.8	<0.001
Raised ALT	16	25.8	18	81.8	<0.001
Low Hct	18	29	16	72.7	0.001
Raised WBC	20	32.3	15	38.2	0.005
Hematuria	1	1.6	4	18.2	0.016
USG examination					
Free fluid	4	6.5	16	72.7	<0.001
Organ injury	0	0	13	59.1	<0.001

Table 2

Association of abnormal (on cumulative basis) clinical, biochemical & USG with intra-abdominal injury

Parameters	Intra-abdominal injury				Significance (Fisher exact test)
	Absent (n = 62)		Present (n = 22)		
	n	%	n	%	
Clinical examination (any one parameter positive)	28	45.2	21	95.5	<0.001
Lab examination (any one parameter positive)	60	96.8	22	100	1.000
USG examination (any one parameter positive)	4	6.5	20	90.9	<0.001

Table 3

Sensitivity, specificity, positive & negative predictive value for prediction of intra- abdominal injury

Parameters	Sensitivity (95% CI)	Specificity (95% CI)	Positive predictive value (95% CI)	Negative predictive value (95% CI)
Clinical examination				
High impact injury	50.0 (28.2–71.8)	87.1 (76.2–94.3)	57.9 (38.9–74.8)	83.1 (76.2–88.3)
Isolated abdominal injury	63.6 (40.7–82.8)	79.0 (66.8–88.3)	51.8 (37.7–65.7)	86.0 (77.6–91.5)
Body wall contusion	31.8 (13.9–54.9)	93.6 (84.3–98.2)	63.6 (36.2–84.4)	79.4 (74.3–83.2)
Abdominal distension	18.2 (5.2–40.3)	98.4 (91.4–100.0)	80.0 (32.1–97.1)	77.2 (73.5–80.5)
Tenderness	68.2 (45.1–86.1)	91.9 (82.2–97.3)	75.0 (55.3–87.9)	89.1 (81.5–93.8)
Peritonitis	13.6 (2.9–34.9)	98.4 (91.3–100)	75.0 (24.8–96.5)	76.2 (73.1–79.2)
Tachycardia	36.4 (17.2–59.3)	95.2 (86.55–99.0)	72.7 (43.7–90.2)	80.8 (75.4–85.3)
Hypotension	22.7 (7.8–45.4)	95.2 (86.5–99.0)	62.5 (30.3–86.5)	77.6 (77.3–81.4)
Lab examination				
Raised S. amylase	90.9 (70.8–98.9)	11.3 (4.7–21.9)	26.7 (23.7–29.9)	77.8 (44.0–94.0)
Raised AST	81.8 (59.7–94.8)	72.6 (59.8–83.2)	51.4 (40.3–62.4)	91.8 (82.1–96.5)
Raised ALT	81.8 (59.7–94.8)	74.2 (61.5–84.5)	52.9 (41.4–64.2)	92.0 (82.4–96.6)
Low Hct	72.73 (49.8–89.3)	71.0 (58.1–81.8)	47.1 (35.8–58.6)	88.0 (78.4–93.7)
Raised WBC	68.2 (45.1–86.1)	67.7 (54.7–79.1)	42.9 (32.1–54.3)	85.7 (76.1–91.9)
Hematuria	18.2 (5.2–40.3)	98.4 (91.3–99.7)	80.0 (32.1–97.1)	77.2 (73.5–80.5)
USG examination				
Free fluid	72.7 (49.8–89.3)	93.6 (84.3–98.2)	80.0 (60.0–91.4)	90.6 (83.0–95.1)
Organ injury	59.1 (36.4–79.3)	100.0 (94.2–100)	100.0	87.3 (80.6–91.9)

to be very specific as well (specificity of 91.9%) (95% CI, 82.2%–97.3%). The isolated abdominal injury was also quite sensitive (63.6%). Besides peritonitis, the presence of abdominal distension, tachycardia, hypotension, body wall contusion and tenderness were the most specific indicators in that order. Thus all the clinical parameters were having specificity of 79 % and above. This further

emphasizes the role clinical examination. Among the biochemical parameters raised serum amylase was the most sensitive test. We found that raised ALT was more sensitive than raised AST while the most specific test was hematuria (specificity of 98%) (95% CI, 91.3%–99.7%). The finding of free fluid has a positive predictive value and negative predictive value of 80% and 90.6% respectively.

Table 4

Cumulative sensitivity of the most sensitive parameters

Combination of Variables	Sensitivity
Clinical examination (tenderness & isolated abdominal injury)	88.4
Clinical examination (tenderness & isolated abdominal injury) & lab examination (s. amylase)	99.0
Clinical examination (tenderness & isolated abdominal injury) & USG examination (free fluid combined with organ injury)	98.7
Clinical examination (tenderness & isolated abdominal injury), lab examination (s. amylase) & USG examination (free fluid combined with organ injury)	99.7

Since sensitivity of a test or examination indicates its ability to detect the true positives we tried to find out the cumulative sensitivity of sub-parameters which demonstrated maximum sensitivity among clinical, biochemical and radiological parameters (Table 4). From table 4 we can deduce that if we combine the most sensitive sub-parameters then it becomes even more sensitive for example if we combine the clinical examination (tenderness & isolated abdominal injury), lab examination (s. amylase) & USG examination (free fluid combined with organ injury) then the sensitivity becomes 99.7% i.e. this combination of sensitive parameters is able to detect all the patients correctly having some form of intra-abdominal injury.

There were a total of 83 abdominal CT were done to find out 21 intra-abdominal injuries (one patient was diagnosed on laparotomy). Thus, close to three-fourth (74.7%) of abdominal CT scans were normal. Among these 83 children only one underwent laparotomy based on the finding of free air on CT scan i.e. 1.2 % while the rest were managed conservatively. Out of 21 injuries identified by CT scan, thirteen were also identified by USG (six hepatic injuries, five splenic injuries and two renal injuries).

Discussion

Abdominal trauma in children leading to blunt and veiled intrabdominal injuries poses an exigent test to the attending clinician [1–3]. In such a patient scenario, as the child is often irritable and uncooperative leading to high probability of variable and erroneous clinical examination, computed tomography (CT) of abdomen takes the centre stage. CT scan is credited with the success of nonoperative management in children with blunt

abdominal trauma [4, 5]. And since CT abdomen allows precise anatomical location of injury and triage of injured solid viscera and identification and quantification of intraperitoneal and extraperitoneal fluid plus the assessment of bony boundaries of the abdomen (ribs, spine, and pelvis), it has become the most important tool in the current protocol for the initial workup of the children with intrabdominal injuries [7].

However, CT has its own limitations, and its findings can be variable in children having blunt injuries of bowel and mesentery [8]. It is expensive, time taking, requires trained personnel, needs unmonitored transport of the injured child to a specialized suite, may possibly require sedation and has the risk of contrast-induced nephropathy. Furthermore the biggest concern is the radiation exposure to the children who have increased radiosensitivity of certain tissues [4, 5]. The estimated risk of a fatal cancer from radiation is 1 per 1000 pediatric CT scans. There are various proposed practices to minimize the risks of radiation in children, like the implementation of ALARA (as low as reasonably achievable) concept and adjustment of CT technique [6]. But the most important practice is the sensible use of CT scan i.e. to decide whether the CT scan is really required in a particular child or not.

We found that out of 83 CT scans done for the children who sustained blunt abdominal injuries, only 21 CT scans were positive (a negative rate of 74.7%) and only one patient underwent laparotomy based on CT scan (i.e. 1.2%). For such low yield rate do we really need to perform CT abdomen that liberally?

We studied different clinical, laboratory and ultrasonographic data with the aim to identify

parameters that may help reduce the need for CT scan in children following blunt abdominal trauma. In the clinical examination we evaluated eight parameters and found that isolated abdominal injury and tenderness were significantly different in children with and with intra abdominal injury (Table 1) and these were the two most sensitive parameters for indicating intra abdominal injury also (Table 3). The abnormal clinical examination was significantly different in the two groups even if we take any one of the parameters to be positive (table 2). Thus if abnormal abdominal examination is properly defined then clinical examination can be reliable in predicting the presence of intra abdominal injuries in children with blunt abdominal trauma. In the laboratory evaluation we studied six variables and on statistical analysis we found that raised AST and raised ALT were significantly different in two groups. We found that raised serum amylase, raised AST and raised ALT were the most sensitive parameters to suggest intra abdominal injury. Serum transaminases are widely produced in different solid organs of the body (liver, pancreas, kidney, muscles and heart). Therefore a blunt force on these organs may lead to their increased serum levels. Both the enzymes are significant markers of intra abdominal injury. Takishima et al demonstrated that the serum amylase level if done within 3 hours of blunt abdominal injury then it is not diagnostically significant [15]. In addition, a low hematocrit was also found to be a sensitive indicator of (sensitivity of 72%) of intra-abdominal injury in the current study. A significantly lower hematocrit would predict more severe injury [12].

In the current study, we did not performed FAST rather a detailed ultrasonographic examination of children presenting with blunt abdominal trauma was done. The FAST would invariably detect the most common nonspecific finding of unexplained intraperitoneal fluid without any aim to identifying intra abdominal injury [16–18]. This often compels to the clinician to advise further radiological confirmation with abdominal CT scan. When we performed USG with the aim of finding both the free fluid and organ injury we were able to sort out those cases where on USG only the non specific finding of only free fluid is present. In our study the ultrasound demonstrated as sensitivity of 72% for detecting intra abdominal injury. Since in our

study, we have included only those patients who had undergone both CT scan as well as USG we were able to find that ultrasound has a negative predictive value of 87.3%. When used alone USG examination may miss a small percentage of patients with free fluid and/or organ injury. Since the management is usually nonoperative in hemodynamically stable children the significance of these small numbers of missed cases is unknown [17, 18].

Besides hemodynamic status, clear cut anatomical delineation of injury to vital intrabdominal organs like the spleen, liver, kidney, pancreas, adrenals, and retroperitoneum is imperative for the successful nonoperative management in these children [2, 5].

Since CT scan gives prompt and accurate assessment of intra abdominal injuries, we do not want take out the advantage that it offers in the planning of non operative management of these children. Thus selective CT imaging is an essential consideration in decreasing the radiation exposure to children.

To further stratify the children with blunt abdominal trauma and find those children who really needed CT scan, we assessed the cumulative sensitivity of the most sensitive parameters that we found in clinical, laboratory and ultrasonographic evaluation (Table 4). The table 4 clearly demonstrates that by combining the most sensitive variables we can easily identify the true positives (i.e. the children having intrabdominal injury) among the children presenting with blunt abdominal trauma up to the tune of 99.7%. Thus, CT scan was unnecessary in 74% of the children with blunt trauma. Some of the previous studies recommended various approaches for sifting children with blunt abdominal trauma though with number of limitations like retrospective nature of the study, use of FAST instead of detailed USG, deficient statistical analysis due to inadequate CT scan in the study group. In the current study we evaluated an overall of sixteen parameters that could suggest intra abdominal injury in a prospective study design. Considering the fact that in study group we included only those children who had undergone all the selected criteria, our results more reflect more closely the association between intra abdominal injury and screening parameters. Thus, our results suggest that the children sustaining blunt abdominal trauma should be subjected to CT abdomen only when they have a combination of isolated abdominal injury & tenderness on clinical

examination, raised serum amylase (or raised serum AST and ALT) on biochemical assessment and presence of free fluid with some organ injury on USG examination. Our recommendation are intended to help reduce unnecessary radiation by reducing negative abdominal CT scans in children with abdominal trauma and use it where it is an absolute necessity. In children where definitive CT imaging is not obtained, serial clinical examination takes the centre stage in the nonoperative management.

There are many limitations in our study viz. fewer patients and single institution study. There are large multi-institutional studies available on the topic. But none of the studies followed a strict study protocol where all the previously decided parameters were done in every single patient. Moreover, we performed a detailed USG rather than FAST and CT scan was performed in every patient.

Conclusion

CT scan has established itself as the most precise imaging modality for diagnosis of intra abdominal injury in children with blunt trauma. But it is not 100% sensitive (blunt bowel and mesenteric injuries) and carries the risk of radiation exposure which can be prevented. Almost 3/4th of the children with abdominal trauma undergo unnecessary CT scan. Therefore, for further evaluation and for objective precision of intrabdominal injuries, abdominal CT scan should be done only in those children where preliminary clinical, biochemical and ultrasonographic features are suggestive of intrabdominal injury as outlined in our study. In resource crunch areas, this will make the patient care more cost-effective as well.

Funding and conflict of interest

There is no source of funding.

The authors declare the absence of obvious and potential conflicts of interest related to the publication of this article.

References

1. Holmes JF, Lillis K, Monroe D, et al. Identifying children at very low risk of clinically important blunt abdominal injuries. *Ann Emerg Med.* 2013;62(2):107-116. doi: 10.1016/j.annemergmed.2012.11.009.
2. Farach SM, Danielson PD, Amankwah EK, Chandler NM. Repeat computed tomography scans after pediatric trauma: results of an institutional effort to minimize radiation exposure. *Pediatr Surg Int.* 2015;31(11):1027-1033. doi: 10.1007/s00383-015-3757-1.
3. Gaines BA. Intra-abdominal solid organ injury in children: diagnosis and treatment. *J Trauma.* 2009;67(2 Suppl):S135-139. doi: 10.1097/TA.0b013e3181adc17a.
4. Hom J. The risk of intra-abdominal injuries in pediatric patients with stable blunt abdominal trauma and negative abdominal computed tomography. *Acad Emerg Med.* 2010;17(5):469-475. doi: 10.1111/j.1553-2712.2010.00737.x.
5. Brenner D, Elliston C, Hall E, Berdon W. Estimated risks of radiation-induced fatal cancer from pediatric CT. *AJR Am J Roentgenol.* 2001;176(2):289-296. doi: 10.2214/ajr.176.2.1760289.
6. Frush DP, Donnelly LF, Rosen NS. Computed tomography and radiation risks: what pediatric health care providers should know. *Pediatrics.* 2003;112(4):951-957. doi: 10.1542/peds.112.4.951.
7. Gaines BA, Ford HR. Abdominal and pelvic trauma in children. *Crit Care Med.* 2002;30(11 Suppl):S416-423. doi: 10.1097/00003246-200211001-00006.
8. Peters E, LoSasso B, Foley J, et al. Blunt bowel and mesenteric injuries in children: Do nonspecific computed tomography findings reliably identify these injuries? *Pediatr Crit Care Med.* 2006;7(6):551-556. doi: 10.1097/01.PCC.0000244428.31624.AB.
9. Cotton BA, Beckert BW, Smith MK, Burd RS. The utility of clinical and laboratory data for predicting intraabdominal injury among children. *J Trauma.* 2004;56(5):1068-1074; discussion 1074-1065. doi: 10.1097/01.TA.0000082153.38386.20.
10. Karam O, Sanchez O, Chardot C, La Scala G. Blunt abdominal trauma in children: a score to predict the absence of organ injury. *J Pediatr.* 2009;154(6):912-917. doi: 10.1016/j.jpeds.2009.01.001.
11. Streck CJ, Jr., Jewett BM, Wahlquist AH, et al. 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(2):371-376; discussion 376. doi: 10.1097/TA.0b013e31825840ab.
12. Poletti PA, Mirvis SE, Shanmuganathan K, et al. Blunt abdominal trauma patients: can organ injury be excluded without performing computed tomography? *J Trauma.* 2004;57(5):1072-1081. doi: 10.1097/01.TA.0000092680.73274.E1.
13. Allen CJ, Tashiro J, Sola JE. Role of FAST or Abdominal Ultrasound to Limit CT Imaging in Evaluation of the Pediatric Abdominal Trauma Patient. *Curr Surg Rep.* 2014;2(6). doi: 10.1007/s40137-014-0056-z.
14. Sola JE, Cheung MC, Yang R, et al. Pediatric FAST and elevated liver transaminases: An effective screening tool in blunt abdominal trauma. *J Surg Res.* 2009;157(1):103-107. doi: 10.1016/j.jss.2009.03.058.

15. Takishima T, Sugimoto K, Hirata M, et al. Serum amylase level on admission in the diagnosis of blunt injury to the pancreas: its significance and limitations. *Ann Surg.* 1997;226(1):70-76. doi: 10.1097/00000658-199707000-00010.
16. Retzlaff T, Hirsch W, Till H, Rolle U. Is sonography reliable for the diagnosis of pediatric blunt abdominal trauma? *J Pediatr Surg.* 2010;45(5):912-915. doi: 10.1016/j.jpedsurg.2010.02.020.
17. Scaife ER, Rollins MD, Barnhart DC, et al. The role of focused abdominal sonography for trauma (FAST) in pediatric trauma evaluation. *J Pediatr Surg.* 2013;48(6):1377-1383. doi: 10.1016/j.jpedsurg.2013.03.038.
18. Kessler DO. Abdominal Ultrasound for Pediatric Blunt Trauma. *JAMA.* 2017;317(22):2283. doi: 10.1001/jama.2017.6163.

Information about the authors

Rizwan Ahmad Khan — MS, MCh, Associate Professor, Department of Pediatric Surgery, JNMCH, AMU, Aligarh, India.

Mohd Hazique — MBBS Resident, Department of Radiodiagnosis, JNMCH, AMU, Aligarh, India.

Shagufta Wahab — MD, Associate Professor, Department of Radiodiagnosis, JNMCH, AMU, Aligarh, India. E-mail: drshaguftawahab@rediffmail.com.

Ризван Ахмад Хан — магистр наук, магистр хирургии, доцент, отделение детской хирургии, Джавахарлал Неру медицинский колледж, Алигархский мусульманский университет, Алигарх, Индия.

Мохд Хазикьюе — ординатор, отделение лучевой диагностики, Джавахарлал Неру медицинский колледж, Алигархский мусульманский университет, Алигарх, Индия.

Шагуфта Вахаб — врач, доцент, отделение лучевой диагностики, Джавахарлал Неру медицинский колледж, Алигархский мусульманский университет, Алигарх, Индия. E-mail: drshaguftawahab@rediffmail.com.