
Is Hospital Admission and Observation Required after a Normal Abdominal Computed Tomography Scan in Children with Blunt Abdominal Trauma?

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Abstract

Objectives: The objective was to determine if hospital admission of children with blunt abdominal trauma for observation of possible intraabdominal injury (IAI) is necessary after a normal abdominal computed tomography (CT) scan in the emergency department (ED).

Methods: The authors conducted a prospective observational cohort study of children less than 18 years of age with blunt abdominal trauma who underwent an abdominal CT scan in the ED. Abdominal CT scans were obtained with intravenous contrast but no oral contrast. The decision to hospitalize the patient was made by the attending emergency physician (EP) with the trauma or pediatric surgery teams. An abnormal abdominal CT scan was defined by the presence of any visualized IAI or findings suggestive of possible IAI (e.g., intraperitoneal fluid without solid organ injury). Patients were followed to determine if IAI was later diagnosed and the need for acute therapeutic intervention if IAI was present.

Results: A total of 1,295 patients underwent abdominal CT, and 1,085 (84%) patients had normal abdominal CT scans in the ED and make up the study population. Seven-hundred thirty-seven (68%) were hospitalized, and 348 were discharged to home. None of the 348 patients discharged home and 2 of the 737 hospitalized patients were identified with an IAI after a normal initial abdominal CT. The IAIs in patients with normal initial CT scans included a 10-year-old with a mesenteric hematoma and serosal tear at laparotomy and a 10-year-old with a perinephric hematoma on repeat CT. Neither underwent specific therapy. The negative predictive value (NPV) of a normal abdominal CT scan for IAI was 99.8% (95% confidence interval [CI] = 99.3% to 100%).

Conclusions: Children with blunt abdominal trauma and a normal abdominal CT scan in the ED are at very low risk of having a subsequently diagnosed IAI and are very unlikely to require a therapeutic intervention. Hospitalization of children for evaluation of possible undiagnosed IAI after a normal abdominal CT scan has a low yield and is generally unnecessary.

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Intraabdominal injury (IAI) after blunt abdominal trauma in children may be serious, and identification is often difficult. Prior evidence indicates that abdominal computed tomography (CT) scan is useful in evaluating children with blunt abdominal trauma for possible IAI.¹⁻³ In fact, abdominal CT scanning has

become the preferred modality for identifying IAI in hemodynamically stable children with blunt trauma due to its high sensitivity, lack of invasiveness, and ability to determine the extent, type, and grade of injury. The use of abdominal CT for evaluation of children with blunt abdominal trauma allows for increased nonoperative

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management of those with IAI and leads to improved patient outcomes.⁴

Older-generation CT scanners, however, were limited by their inability to detect gastrointestinal and pancreatic injuries.⁵⁻⁸ Therefore, historically, many children were hospitalized for serial abdominal examinations and laboratory measurements to observe for possible IAI, despite a normal initial abdominal CT scan.^{9,10} Newer-generation helical CT scanners, however, have significantly improved the sensitivity for identifying gastrointestinal injuries in both adult and pediatric patients after blunt abdominal trauma.¹¹⁻¹⁴ Furthermore, a prospective, multi-institutional study concluded that adult trauma patients with normal abdominal CT scans can be safely discharged from the emergency department (ED), because they do not benefit from hospital admission.¹⁰ There are limited data in the pediatric population, however, regarding the utility of the practice of hospital observation after a normal abdominal CT scan. Current practice in many trauma centers is to admit pediatric patients for observation despite normal abdominal CT scans.^{15,16}

The objective of this study was to determine the utility of hospital admission of pediatric patients with blunt abdominal trauma after a normal abdominal CT scan obtained in the ED to detect undiagnosed IAI. We hypothesize that after a normal abdominal CT scan in the ED, admission for ongoing observation and laboratory measurements to identify initially undiagnosed IAI is not necessary.

METHODS

Study Design

We conducted a prospective observational cohort study of children with blunt abdominal trauma from March 2001 to May 2004. The study was approved by the study site's institutional review board.

Study Setting and Population

The study was conducted at an urban Level 1 trauma center. The center admits approximately 3,800 trauma patients annually and serves as the only pediatric trauma center in the region.

Patients younger than 18 years of age undergoing initial abdominal CT scanning in the ED after blunt abdominal trauma were eligible for enrollment. Patients were excluded if they were transferred to the facility with an abdominal CT scan previously performed or if they underwent abdominal CT scanning for penetrating trauma or for nontraumatic indications.

Study Protocol

Patient historical and clinical findings at the time of initial ED evaluation were documented on a standardized data collection form. Patients then underwent abdominal CT scanning on a Lightspeed GE 16-slice CT scanner (General Electric Healthcare, Waukesha, WI). No oral contrast was used, but intravenous contrast (usually Omnipaque, GE Healthcare) was administered based on patient size (2.0 mL/kg). All abdominal CT scans were interpreted by board-certified/-eligible faculty radiologists. Abdominal

CT scans were considered to have findings suggestive of IAI if there was evidence of injury to the solid organs, pancreas, the gastrointestinal tract, the bladder, or any intraabdominal vascular structure. Findings suggestive of gastrointestinal injury included intraperitoneal fluid without solid organ injury, bowel wall edema or hematoma, intraperitoneal air, or mesenteric streaking/hematoma.¹¹⁻¹³

The decision to hospitalize the patient was made by the attending emergency physician (EP), in conjunction with the trauma or pediatric surgical teams. Hospitalized patients were observed for a minimum of 24 hours. Trauma admission policy at the study site dictates that each patient undergo serial abdominal examinations every 6 hours, complete blood cell counts every 6 hours, and a repeat amylase or lipase measurement on the day after admission. The white blood cell count was used to assess for hollow viscus injury, the hematocrit for occult hemorrhage, and the amylase/lipase for pancreatic injury. Hospitalized patients were eligible for hospital discharge if they did not require further hospitalization for other nonabdominal injuries, developed no intraabdominal complications, and were able to tolerate oral intake.

All patients in the study had their medical records reviewed at least 30 days after hospitalization to determine if they returned to the ED of the participating institution with an IAI or were transferred from an outside facility to the study institution with an IAI. Furthermore, hospital, trauma, and ED continuous quality improvement (CQI) committee records were reviewed to determine if patients discharged from the ED or hospital without a diagnosis of IAI were subsequently identified with an IAI at another facility (and referred back to the participating institution).

Outcome Measures

The study's outcome measures were the presence of IAI and the presence of IAI requiring acute therapeutic intervention. IAI was considered present if an injury to the spleen, liver, gallbladder, pancreas, kidneys, ureters, urinary bladder, gastrointestinal tract, or an intraabdominal vascular structure was identified during the ED or hospital course. An IAI requiring acute therapeutic intervention was defined as any of the following: blood transfusion for intraabdominal hemorrhage, surgical intervention at laparotomy, or angiographic embolization of an injured intraabdominal organ. For those subjects initially discharged from the ED, we reviewed the hospital and ED records, the trauma CQI reports, the trauma registry database, and the hospital electronic medical record (which captures information for both patient clinic visits and hospitalizations) to identify any patient who was subsequently diagnosed with an IAI.

Data Analysis

The study population is described with simple descriptive statistics, including the negative predictive value (NPV) of abdominal CT scan for subsequently diagnosed IAI of any type, or IAI in need of acute intervention. We calculated and report 95% confidence intervals (CIs) where appropriate.

RESULTS

A total of 1,295 children underwent abdominal CT scan for blunt abdominal trauma and were enrolled. Two-hundred ten (16.2%; 95% CI = 14.2% to 18.3%) had traumatic abnormalities consistent or suggestive of IAI. Therefore, 1,085 (83.8%; 95% CI = 81.7% to 85.8%) had normal initial ED abdominal CT scans and make up the study population. Of those with normal CT scans, 737 (68%) were admitted to the hospital and 348 (32%) were discharged to home from the ED. Table 1 describes the differences between the patients discharged to home from the ED and those admitted to the hospital. In general, patients admitted to the hospital were more likely to have a Glasgow Coma Scale (GCS) score of <14 and had more auto versus pedestrian-type mechanisms of injury.

The mean (\pm standard deviation [SD]) age of the study population was 9.6 (\pm 5.4) years and 645 (60%) were male. Of the 737 patients hospitalized, 318 (43%) were hospitalized for 1 day and 419 (57%) were hospitalized for 2 or more days. The 419 patients were hospitalized longer than 1 day due to the presence and ongoing treatment or observation of injuries outside of the abdomen. Of the 318 patients hospitalized for only 1 day, 2 patients died from severe head injuries. Of the remaining 316, 130 (41%) had abdominal tenderness, 54 (17%) had distracting injuries, 44 (14%) had initial GCS scores of <15, and 14 (4%) underwent nonabdominal surgery (orthopedic = 10, facial = 3, and complex laceration repair = 1).

None (0%; 95% CI = 0.0 to 0.9%) of the 348 patients discharged home after normal CT scans, and 2 (0.3%; 95% CI = 0.0 to 1.0%) of the 737 patients hospitalized after normal abdominal CT scans were subsequently diagnosed with IAI. The NPV of the abdominal CT scan for IAI, therefore, was 1,083/1,085 (99.8%; 95% CI = 99.3% to 100%).

There were two patients diagnosed with an IAI after normal initial abdominal CT scans. One was a 10-year-old girl who was a restrained passenger in a motor vehicle crash (MVC). At the time of initial ED evaluation, she was documented to have an abdominal

seat belt sign (abrasion and ecchymoses over the lower abdomen) but no abdominal tenderness. During the initial 24 hours of hospitalization, the patient developed abdominal tenderness, tachycardia, and a drop in hematocrit from 37% to 31%. At laparotomy, the patient was found to have several small bowel and colonic mesenteric hematomas and a serosal tear encompassing 75% of the circumference of the transverse colon. There was no evidence of bowel perforation or compromise of the bowel's circulation. None of these injuries were repaired during laparotomy. The second patient subsequently diagnosed with an IAI was a 10-year-old girl who was struck by an automobile traveling 35 mph. She was admitted to the hospital for traumatic brain injury and multiple pelvic fractures, and her initial abdominal CT was negative for IAI. She underwent a repeat abdominal CT scan 3 days after hospital admission for a declining hematocrit, which demonstrated a small perinephric hematoma. The patient's injury was observed and did not require an acute intervention.

Although one of the above-mentioned patients underwent an exploratory laparotomy, none of the 1,085 patients in this study underwent an acute therapeutic intervention for an IAI. Thus, the NPV of a normal abdominal CT scan for IAI requiring acute intervention was 100% (95% CI = 99.7% to 100%).

DISCUSSION

This study demonstrates that children with blunt abdominal trauma and normal abdominal CT scans in the ED are unlikely to have an IAI and are even less likely to have an IAI requiring acute intervention. Therefore, hospital admission for serial abdominal examinations and laboratory measurements after a normal abdominal CT scan in children has a very low utility. This suggests that unnecessary hospitalizations, with their associated costs and iatrogenic complications, can be avoided, and limited hospital resources can be better allocated.

A similar multicenter study of adult patients demonstrated that those patients with a normal abdominal CT

Table 1
Comparison of Patients Admitted versus Those Discharged from the ED

	Admission (<i>n</i> = 737)	Discharge from the ED (<i>n</i> = 348)
Age, years (mean \pm SD)	9.9 (\pm 5.3)	8.8 (\pm 5.6)
Mechanism of injury		
MVC	299 (41%)	146 (42%)
Auto vs. pedestrian	177 (24%)	42 (12%)
Fall	93 (12%)	66 (19%)
Auto vs. bicycle	56 (8%)	24 (7%)
Assault	22 (3%)	20 (6%)
Other	90 (12%)	50 (14%)
GCS score \geq 14	625/737 (85%)	335/348 (96%)
Initial chest tenderness in ED*	118/625 (19%)	79/335 (24%)
Initial abdominal tenderness in ED*	242/625 (39%)	153/335 (46%)

Auto = automobile; ED = emergency department; GCS = Glasgow Coma Scale; MVC = motor vehicle crash; SD = standard deviation.
*Variables assessed only in population with a GCS score \geq 14.

scan after blunt abdominal trauma do not benefit from hospital admission and observation.¹⁰ That study of nearly 2,300 patients utilized helical CT scanners, and a normal CT had a NPV of 99.6% for IAI. There were, however, six patients in that study who underwent laparotomies after initially normal abdominal CT scans, including patients with gastrointestinal, diaphragmatic, renal, and urinary bladder injuries who all underwent repair of their injuries at the time of laparotomy.

Conversely, one retrospective study of 88 pediatric blunt trauma patients demonstrated that a normal abdominal CT scan failed to identify a substantial number of patients with IAI requiring intervention (abdominal CT sensitivity = 67% for IAI requiring intervention). In that study, however, no patient with a normal abdominal CT scan and a normal abdominal examination had an IAI.¹⁷ That study was limited by its retrospective nature, the relatively small number of patients, and the use of an older generation nonhelical CT scanner. The study concluded that a patient's clinical abdominal examination should not be ignored despite a normal abdominal CT scan.

Another older study of 1,112 children sustaining blunt abdominal trauma with normal abdominal CT scans examined the impact of abdominal CT findings on decision-making around operative management.¹⁸ Abdominal CT findings influenced the decision to operate in patients with hollow viscus injuries, but infrequently in those with solid organ injuries. The study also found a low false-negative rate of abdominal CT scans for the need for acute intervention, as only one (0.1%) patient with a normal abdominal CT scan underwent a subsequent laparotomy (NPV for IAI requiring acute intervention = 99.9%). The study concluded that normal abdominal CT findings strongly predicted the lack of subsequent deterioration requiring the need for operative intervention.

In our current study, no patients with normal abdominal CT scans who were discharged from the ED were subsequently diagnosed with an IAI. Furthermore, of the 737 patients with normal CT scans and admission to the hospital for observation, only 2 were found to have a falsely normal initial abdominal CT scan. The patient with the gastrointestinal injury had clinical findings (abdominal seat belt sign) highly suggestive of IAI. Although she did not have abdominal tenderness on initial evaluation, she developed abdominal tenderness over the subsequent hours. Previous research conducted by our group demonstrates that up to 30% of children with an abdominal seat belt sign will be diagnosed with an IAI, although the risk is substantially less in the absence of abdominal tenderness.¹⁹ The reliability of abdominal CT in the detection and grading of solid organ injury in pediatric blunt trauma patients is well documented. However, its accuracy in detecting bowel or mesenteric injuries is less clear, which has prompted the practice of frequent hospitalization of children after a normal abdominal CT scan in the presence of any ongoing abdominal tenderness.

As suggested by a prior study,¹⁷ the abdominal examination must be considered along with the abdominal CT findings in the evaluation of children with blunt abdominal trauma. Based on the current and other

studies,^{10,18} children with normal abdominal examinations and normal abdominal CT findings after blunt abdominal trauma are at such low risk for IAI that hospitalization for observation and detection of undiagnosed IAI should not be routine. There remains, however, a small but measurable risk of IAI in those patients with abnormal abdominal examination findings (abdominal tenderness, seat belt sign, abrasions, etc.) despite normal abdominal CT scans. Therefore, if children with abnormal abdominal examinations and normal abdominal CT findings are to be discharged to home, the patient and guardians must be carefully instructed about appropriate signs and symptoms to return to the ED and appropriate follow-up should be arranged. Hospitalization of those patients at highest risk for undiagnosed IAI (presence of abdominal seat belt sign, inability to tolerate oral intake, or moderate/severe abdominal tenderness on examination) may still be warranted, depending on the availability of clinical follow-up and reliability of the parents. In the current study, children were often hospitalized after normal abdominal CT scans, and nearly half of these were hospitalized for only 1 day. Many of these patients were hospitalized simply to "rule out" IAI with serial abdominal examinations and laboratory measurements. Based on the results of the current study, many of these children could be discharged home from the ED, with a resulting substantial decrease in resource utilization. As these patients are most likely to be evaluated and treated at Level 1 trauma centers that have substantial daily hospital charges, significant cost savings could be realized if this patient population was targeted for ED discharge.²⁰

LIMITATIONS

Our results are based on findings from a single, high-volume Level 1 trauma center that provides care for both pediatric and adult trauma patients. The prevalence of IAI and the use of CT at this center may be different from that of other trauma centers (i.e., either more or less frequently used). Either of these factors could result in a higher or lower reported NPV. Furthermore, the study used a helical CT scanner with results interpreted by radiologists experienced in the evaluation of pediatric trauma patients, possibly leading to more accurate interpretation of the abdominal CT scans. Therefore, the results may not be generalizable to all sites providing care to injured children.

Finally, some study patients were discharged from the ED to home after a normal abdominal CT scan. Some of these patients may have had IAIs that were not subsequently identified, as no in-person follow-up was performed for study purposes. However, no patient discharged from the ED in this study returned to the ED of the participating institution with an IAI was subsequently transferred from an outside facility to the study institution or was referred to the hospital, trauma, or ED CQI committees. Owing to the fact that the study institution is the only pediatric trauma center in the region, a pediatric patient identified with an IAI diagnosed at an outside facility would very likely be transferred to the study site for further care. Therefore,

it is highly unlikely that a patient discharged from the ED was subsequently identified with an IAI.

CONCLUSIONS

Children with normal abdominal CT scans after blunt abdominal trauma are unlikely to have an IAI and are extremely unlikely to have an IAI requiring acute intervention. The NPV of an abdominal CT scan in these patients is such that hospitalization for serial abdominal examinations and laboratory measurements is unwarranted for the great majority of patients. Altering practice to discharge children after a normal abdominal CT scan from the ED with appropriate follow-up care has the potential to limit iatrogenic problems of hospitalization and unnecessary costs and provide for more efficient utilization of limited hospital resources.

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