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Original Contribution

External validation of a clinical prediction rule for very low risk pediatric blunt abdominal trauma☆

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ABSTRACT

Background: Computed tomography (CT) is frequently used to identify intra-abdominal injuries in children with blunt abdominal trauma (BAT). The Pediatric Emergency Care Applied Research Network (PECARN) proposed a prediction rule to identify children with BAT who are at very low risk for clinically-important intra-abdominal injuries (CIIAI) in whom CT can be avoided.
Objective: To determine the sensitivity of this prediction rule in identifying patients at very low risk for CIIAI in our pediatric trauma registry.
Methods: Retrospective review of our institutional trauma registry to identify patients with CIIAI. CIIAI included cases resulting in death, therapeutic intervention at laparotomy, angiographic embolization of intra-abdominal arterial bleeding, blood transfusion for intra-abdominal hemorrhage, and administration of intravenous fluids for two or more nights for pancreatic or gastrointestinal injuries. Patients were identified using ICD diagnosis and procedure codes. Kappa was calculated to evaluate inter-reviewer agreement.
Results: Of 5743 patients, 133 (2.3%) had CIIAI. 60% were male and the mean age was 8 (SD 4.4) years. One patient with CIIAI met the proposed very low risk criteria, resulting in a prediction rule sensitivity of 99%, 95% CI [96–100%]. This patient also had extra-abdominal arterial bleeding requiring revascularization, offering an alternative reason for transfusion. Kappa was 0.85, 95% CI [0.82, 0.89], indicating strong inter-rater agreement.
Conclusions: One out of 133 patients with CIIAI met very low risk criteria based on the PECARN prediction rule. This study supports the PECARN clinical prediction rule in decreasing CT use in pediatric patients at very low risk for CIIAI.

1. Introduction

Unintentional injury is the leading cause of death in pediatric patients, causing approximately 6000 deaths annually in children between 1 and 19 years old [1]. Injuries in children younger than 15 years of age account for over 7 million emergency department visits per year, with the majority of these visits for unintentional falls, bicycle, and motor vehicle collisions (MVCs), which are frequently associated with blunt abdominal trauma (BAT) [2,3]. Computed tomography (CT) is the criterion standard for identifying intra-abdominal injury in patients with BAT, and is thus frequently used in the evaluation of both adult and pediatric trauma patients [4,5].

Compared to adults, children have a higher predicted rate of developing radiation-induced fatal cancer, with an estimated lifetime attributable risk of death from cancer up to 0.14% per abdominal CT scan [6,7]. Although pediatric institutions have lower rates of CT utilization in children, most pediatric patients are initially evaluated in general emergency departments [8-11]. Additionally, young children with mild to moderate injuries undergo more abdominal CTs than their severity-matched adult counterparts [12]. The benefit of identifying clinically important intra-abdominal injury (CIIAI) must be balanced with the risk of radiation-induced malignancy from abdominal CT. Several prediction rules have been proposed to risk-stratify these patients and to identify low-risk children in whom abdominal CT can be avoided [13-20].

In 2013, Holmes et al. published a prospective study through the Pediatric Emergency Care Applied Research Network (PECARN), which offered a clinical prediction rule to identify a cohort of children with BAT who are at very low-risk of CIIAI [21]. The rule uses seven readily available clinical variables based on history and physical exam: evidence of abdominal wall trauma or seatbelt sign, Glasgow coma score, abdominal tenderness, thoracic wall trauma, abdominal pain, breath sounds, and

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vomiting. 12,044 patients were enrolled from 20 participating pediatric emergency departments (PEDs). The prediction rule is 97% sensitive (95% CI [93.7, 98.9]) in identifying patients at very low-risk of having CIIAI [21]. In that study, only 0.1% of patients who fulfilled the very low-risk criteria were found to have an intra-abdominal injury requiring acute intervention, resulting in a less favorable risk-benefit ratio in relation to radiation-induced malignancy. Our objective was to determine the sensitivity of the PECARN prediction rule by determining the proportion of patients with CIIAI who failed the proposed very low-risk criteria and to identify patients who would not have been identified using the prediction rule.

2. Methods

2.1. Study design

We performed a retrospective review of pediatric patients evaluated and treated in a pediatric emergency department in an academic, tertiary care children's hospital and American College of Surgeons (ACS) level 1 trauma center from January 2011 to August 2016. The pediatric trauma service maintains a registry of all patients treated for traumatic injuries, excluding minor extremity trauma. Patients are identified by International Classification of Diseases (ICD) diagnosis and procedure codes, and trauma team members manually abstract data from the charts. This includes, but is not limited to, date of injury, trauma level, initial vital signs, transfusions required, length of hospital stay, and disposition. We used this registry to identify patients with CIIAI requiring acute intervention (defined below) and reviewed these charts for the presence of very low-risk criteria. This study was approved by the institutional review board (Protocol #161912) prior to commencement.

2.2. Study setting and population

All pediatric trauma patients <16 years of age are evaluated and treated in the children's hospital, as are those from 16 to 18 years of age who do not meet adult level one or two trauma activation criteria. The institutional trauma registry includes pediatric trauma patients treated in and admitted to the pediatric hospital, as defined by ICD codes in Appendix A. During the study period, the institution transitioned from ICD-9 to ICD-10 coding.

2.3. Study protocol and measurements

We initially sought to identify any patient within the trauma registry who sustained any intra-abdominal, spinal or pelvic injury after sustaining blunt abdominal trauma. To accomplish this, we narrowed our list to all patients in the registry with ICD codes in Appendix B. We then sought to specifically identify those patients who sustained CIIAI as defined below. To achieve this, we further narrowed our patient list to only those with applicable ICD procedure codes, administration of blood products, hospitalization for two or more nights in the hospital, or death were included (Appendix C). Each of these remaining charts was reviewed and abstracted.

PECARN proposed a prediction rule to identify children with BAT who are at very low risk for CIIAI in whom CT can be avoided. In this study, intra-abdominal injury and acute intervention were defined using criteria from the original PECARN study [21]. Intra-abdominal injury included any radiographically- or surgically-apparent injury to the following structures: spleen, liver, urinary tract (from the kidney to the urinary bladder), gastrointestinal tract (including the bowel and associated mesentery from the stomach to the sigmoid colon), pancreas, gallbladder, adrenal gland, intra-abdominal vascular structure, or traumatic fascial defect (traumatic abdominal wall hernia). Acute intervention was defined by an intra-abdominal injury associated with any of the following: death caused by the intra-abdominal injury, a therapeutic intervention at laparotomy, angiographic embolization to treat bleeding from the intra-abdominal injury, blood transfusion for anemia as a result of hemorrhage from the intra-abdominal injury, or administration of intravenous (IV) fluids for two or more nights in patients with pancreatic or gastrointestinal injuries. Therapeutic laparotomy was defined as any surgical intervention to treat an intra-abdominal injury. Thus, for this research we defined CIIAI as (1) Intra-abdominal injury that required (2) Acute intervention, both defined in accordance with the PECARN study.

Spinal and pelvic injuries were not included in the PECARN cohort. Our study group elected to include both spinal and pelvic injuries in addition to intra-abdominal injuries, to determine if any patients with these injuries required transfusion and met very low-risk criteria. Specifically, the authors were interested in patients with pelvic fractures and associated shear injuries causing sufficient hemorrhage to require blood transfusion. For these patients, orthopedic surgical intervention for these fractures was not considered an acute intervention.

Patients with penetrating trauma, injuries occurring over 24 h prior to presentation, known pregnancy, and pre-existing neurologic disorders precluding reliable examination were excluded from the PECARN cohort. We had two notable differences in exclusion criteria from the original study. First, to increase our sensitivity in identifying patients with CIIAI, patients with injuries occurring >24 h from time of presentation, or with an unknown injury time or mechanism, were included. Second, children transferred from a referring facility with a previous abdominal CT or diagnostic peritoneal lavage were included. It is the standard practice of our institution to have all referring facility trauma CTs reinterpreted by our institution's radiologists. The CT reinterpretation was referenced for the presence and grading of all intra-abdominal injuries. If a reinterpretation report was not available, the referring facility radiology report was used.

Three independent reviewers abstracted information from provider documentation, radiology reports, trauma nursing flowsheets, lab results, scanned referring facility records, and discharge summaries. Prior to the start of data collection, two sets of 10 charts were co-reviewed to ensure agreement in the method of data abstraction and to modify the data collection instrument as needed. A data source hierarchy was created to improve inter-rater agreement when the chart contained conflicting information. Patient demographics and details of injury mechanism and mode of arrival were obtained from a trauma flowsheet, a standard form filled out for all patient encounters with a trauma designation. Emergency physician documentation was used for subjective and physical examination findings, supplemented by the trauma surgeon's documentation when data elements were not present. Laboratory data were obtained from the electronic medical record, and surgical interventions from the operative note. A random number generator was used to select 10% of charts for co-review in order to assess inter-rater reliability. Co-reviewers determined the presence or absence of all low-risk criteria and a qualifying acute intervention. While reviewers were not blinded to the objectives of the study, they were blinded to the data abstracted from co-reviewed charts.

2.4. Data analysis

Descriptive statistics were calculated to report patient demographics, injury patterns, and interventions required for intra-abdominal injuries. The PECARN blunt abdominal trauma prediction rule, as well as other validated and widely implemented clinical prediction rules, have high sensitivity to identify patients at very low risk of injuries requiring intervention [22]. We followed this rationale and calculated sensitivity as the proportion of patients with CIIAI who failed one or more very low risk criteria. Sensitivity of the prediction rule and Cohen's kappa statistic to determine inter-rater agreement were generated using Stata Version 14.1 (StataCorp, College Station, TX).

3. Results

Of 5743 total patients in the registry, 671 (11%) had ICD codes indicating possible intra-abdominal injuries (Fig. 1). 148 (2.6%) of these patients did not require acute intervention and were therefore excluded. The remaining 523 charts (9.1%) were reviewed and abstracted. 81 patients (1.4%) had penetrating trauma and were not included in the final data set. The Cohen's kappa values for inter-rater agreement comparing very-low risk criteria fulfillment and acute intervention requirement were 0.81, 95% CI [0.76, 0.86] and 0.92, 95% CI [0.86, 0.97], respectively. The composite kappa for both observations was 0.85, 95% CI [0.82, 0.89], indicating strong inter-rater agreement [23].

133 patients (2.3%) were identified with CIIAI requiring acute intervention (Table 1). 39 patients (29%) were transferred to our PED from referring hospitals. 80 patients (60%) were male, with an average age of 8 (SD 4.4) years. Children 3 years of age or less comprised 18.8% of the total study sample (n = 25). The most commonly injured organs were bowel or mesentery, liver (median grade 3 [IQR 3,4]), and spleen (median grade 3 [IQR 2,4]). Motor vehicle collisions were the most frequent mechanism of injury. For six patients (4.5%), non-accidental trauma was ultimately determined to be the mechanism of injury. The most common intervention was blood transfusion, followed by two or more nights of IV fluids, and therapeutic intervention at laparotomy. No patients required angiographic embolization, and one patient died.

Four patients with CIIAI met low-risk criteria during initial chart abstraction and triggered further review (Table 2). Three of these patients were excluded, as noted in Table 2, resulting in only one case (patient 1) in which a patient with CIIAI would have been identified as very-low risk by the PECARN prediction rule. This resulted in a clinical prediction rule sensitivity of 99%, 95% CI [95.9, 100]. A sensitivity analysis was performed in which patients transferred from referring hospitals were not included in our estimate, resulting in a sensitivity of 99%, 95% CI [94.2, 100].

An additional three patients met very low risk criteria with pelvic or spinal injuries requiring acute intervention, excluding operative fixation of their fractures. These patients had no additional intra-abdominal injuries. A 13-year-old female in a rollover all-terrain vehicle (ATV) incident with neurologic deficits on exam was found to have an L2 fracture-dislocation that required operative fixation and intra-operative blood transfusion. However, her associated spinal cord injury prevented reliable abdominal examination, excluding her from the low-risk group. Following an ATV collision, a 4-year-old male required a blood transfusion after sustaining a fracture of the anterior superior iliac spine, in addition to a large groin laceration which required operative laceration repair and repair of the femoral artery by vascular surgery. A 4-week-old female with somnolence and possible seizure activity was found to have skull fractures, subdural and subarachnoid hemorrhages, and parenchymal contusions on head CT. A skeletal survey additionally noted pelvic fractures and abdominal ultrasound showed no intra-abdominal injury or hemoperitoneum. She required blood transfusion for her injuries. These two latter patients required blood transfusion but had significant alternate sources of blood loss, and neither had hemoperitoneum suggestive of pelvic shear injury.

4. Discussion

In this study, we sought to validate the sensitivity of the PECARN blunt abdominal trauma clinical prediction rule in a cohort of patients with CIIAI by identifying those who screened as very low risk for the outcome. Our results indicate that the PECARN blunt abdominal trauma clinical prediction rule has high sensitivity to identify patients at very low risk of CIIAI who are thus unlikely to benefit from CT imaging and should not be exposed to the radiation dose of this procedure.

Several other sets of low-risk criteria have been proposed to decrease unnecessary CT use in pediatric BAT. Hynick, et al. retrospectively reviewed data from a single trauma center and found that hematuria,

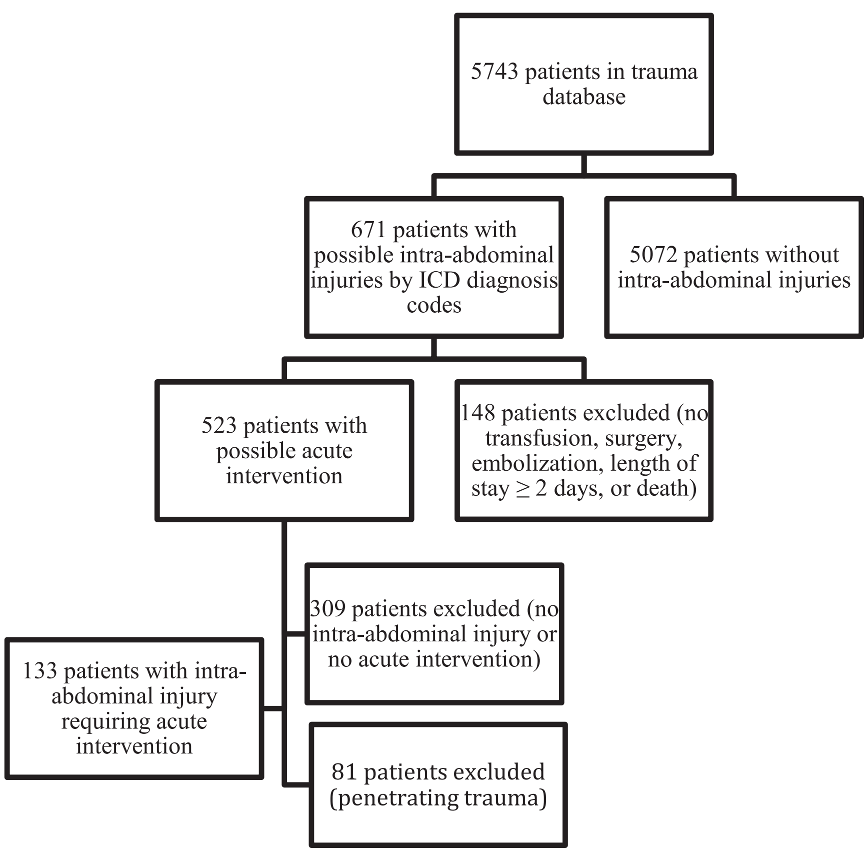

Fig. 1. Patient inclusion flow chart.

Table 1
Demographics, injury type and mechanism, and interventions for 133 patients with CIIAI evaluated for proposed low-risk criteria.

Age (years, SD)	8.0, 4.4
Male n (%)	80 (60)
Total number of injuries	314
Injuries per patient (Median [IQR])	2 [1,3]
Injury types (n [%])	
Bowel or mesentery	74 (24%)
Liver	39 (12%)
Spleen	37 (12%)
Spinal fracture	32 (10%)
Pelvis fracture	30 (10%)
Pancreas	20 (6%)
Abdominal hematoma	19 (6%)
Kidney	16 (5%)
Adrenal gland	15 (5%)
Other	11 (4%)
Vascular	10 (3%)
Bladder or other urinary tract	6 (2%)
Traumatic fascial defect	5 (2%)
Gallbladder	0 (0%)
Trauma mechanism (n [%])	
Motor vehicle collision	69 (52%)
ATV or other non-street motorized vehicle	20 (15%)
Pedestrian vs. automobile	14 (11%)
Other	9 (7%)
Fall	7 (5%)
Bicycle, skateboard, or rollerblade	6 (5%)
Crush	5 (4%)
Horse-related	2 (2%)
Assault	1 (1%)
Total number of interventions	211
Interventions per patient (Median [IQR])	2 [1,3]
Interventions (n [%])	
Blood transfusion	83 (39%)
≥2 nights of IV fluids	65 (31%)
Therapeutic intervention at laparotomy	62 (29%)
Death	1 (0.5%)
Angiographic embolization	0 (0%)

elevated serum alanine aminotransferase (ALT), and clinically concerning abdominal exam findings were significant predictors of a clinically important intra-abdominal injury (IAI) [16]. Acker, et al. also proposed low-risk criteria comprised of GCS 15, normal pediatric age-adjusted shock index (heart rate/systolic blood pressure), and injury attributable to a single, non-motorized, blunt force to the abdomen [13]. The criteria included readily available information from history and vital signs, and thus did not depend on rapid laboratory availability or ultrasonography expertise. The authors reported that of 101 low-risk children, only one required blood transfusion (1%) and no child died or required laparotomy or discharge to a rehabilitation facility. However, the study included a relatively small sample size and the experience of only two trauma centers, limiting its external validity. Additionally, the study excluded injuries from motorized vehicles, which comprise the majority of pediatric BAT injuries.

Holmes, et al. prospectively identified 6 findings associated with IAI: low systolic blood pressure, abdominal tenderness, femur fracture, aspartate aminotransferase (AST) > 200 U/L or ALT > 125 U/L, urinalysis with >5 red blood cells per high-powered field, and initial hematocrit <30% [17]. The criteria are 98% sensitive and 49% specific. However, patients were enrolled at a single center, limiting generalizability. Karam et al. proposed the BATiC score, which is calculated using abnormal abdominal Doppler ultrasound, abdominal pain, peritoneal irritation, hemodynamic instability, AST > 60 IU/L, ALT > 25 IU/L, white blood cell count > 9.5 g/L, LDH > 330, lipase > 30 IU/L, and creatinine > 50 μg/L [20]. A BATiC score ≤ 7 is 91% sensitive and 84% specific to identify children with IAI. However, the study was small, with only 31 patients with IAI identified during the study period.

Streck et al. prospectively derived a prediction rule including readily available history and physical exam findings, in addition to lab and chest x-ray data. Patients were enrolled at fourteen trauma centers, improving generalizability from single center studies. The resulting prediction rule is 98.4% and 100% sensitive for identifying IAI and IAI requiring intervention, respectively [14]. However, the rule is less specific (38% and 34.7%) than the PECARN study, and depends on the availability of rapid laboratory results, which may not be available at all facilities.

There are some notable differences between this study and the initial PECARN study. Patients transferred from referring institutions with prior abdominal CT or diagnostic peritoneal lavage were excluded from the initial prospective study. To increase the sample size, the authors elected to include these patients in this study, despite the introduction of provider bias. In the PECARN study, an emergency department faculty or fellow physician performed an assessment of clinical variables, including physical exam findings. Given the retrospective study design, the authors chose to include both medical and surgical physician documentation to increase the likelihood of documentation of low-risk variables.

While four patients meeting very low-risk criteria with possible CIIAI were initially identified, on further chart review three patients met one or more exclusion criteria from the original PECARN study. This resulted in a prediction rule sensitivity of 99%.

The remaining patient had significant poly-trauma, including femoral arterial bleeding requiring emergent operative repair, in addition to liver and adrenal lacerations. As this patient had a clear source of extra-abdominal large-volume blood loss, it is difficult to definitively attribute his anemia and transfusion requirement to his intra-abdominal injuries. Exclusion of this patient would have resulted in 100% sensitivity; however, this patient was included to provide a most-conservative estimate of sensitivity.

Table 2
Patients with CIIAI who met very low-risk criteria on initial chart abstraction.

Patient	Age	Intra-abdominal injury (IAI)	Mechanism	Qualifying intervention for IAI	Additional injuries	Criteria for exclusion from low-risk cohort	Notes
1	15 years	Adrenal laceration, grade 3 liver laceration	Rollover ATV incident	Blood transfusion	Femur fracture, superficial femoral artery damage	None	Arterial injury required immediate operative revascularization
2	26 months	Grade 5 liver laceration	Presumed non-accidental trauma	Blood transfusion		Unknown injury time, possible abdominal tenderness, faint abdominal bruising noted by consulting child abuse physician	No specific traumatic injury ever reported by caregivers
3	13 months	Rectal laceration	Fall onto bathtub stopper	Operative laceration repair, IV fluids		Penetrating trauma, injury to rectum not classified as intra-abdominal by PECARN study	
4	13 years		Rollover ATV incident	Blood transfusion	Spinal and scapular fractures, thoracic spine epidural hematoma, large-volume hemopneumothorax (HPTX)	Patient insensate below umbilicus in trauma bay secondary to thoracic spine hematoma, precluding reliable exam	HPTX required chest tube placement and blood transfusion in trauma bay

While the prediction rule proposed by the PECARN study was developed to identify patients with solely intra-abdominal injuries, we elected to also include pelvic and spinal fractures to determine if any patients with associated shear injuries required transfusion and met very low-risk criteria. No such patient was identified. Two patients with pelvic fractures without hemoperitoneum suggestive of pelvic shear injury required blood transfusion, but both had significant alternate sources of blood loss. Thus, providers should be cautious in applying these criteria to rule out pelvic and/or spinal injuries, as the prediction rule was not derived to identify these injuries and they may be present despite fulfillment of the proposed very low-risk criteria.

5. Limitations

This study is a retrospective chart review at a single institution and thus has several inherent limitations. Blunt abdominal injuries in pediatric patients infrequently require procedural intervention, making adequate study samples difficult to achieve in single trauma centers [19,24]. In this study, while similar to the findings of the PECARN study, only 19% of patients with ICD codes suggestive of intra-abdominal injury were found to require acute intervention, producing a sample of just 130 patients in over 5 years.

Ascertainment of low risk criteria was based on initial treating physician documentation, which occasionally was incomplete. Physical exam findings often conflicted both between medical and surgical teams and between trainee and attending physicians. Additionally, patients are identified for inclusion in the trauma registry by ICD codes indicating known injuries. Because patients evaluated for BAT but without identified injuries would not be included in the registry, the authors were unable to calculate specificity and further test characteristics. Furthermore, the registry is generated by manual data entry and thus data entry errors may have occurred.

There were a number of differences in patient inclusion from the initial PECARN study. Patients transferred with previous abdominal CT were included in this study, which introduces bias toward documentation of such elements as abdominal pain and tenderness on examination. However, time of documentation was not compared to time of availability of imaging results for non-transferred patients, and thus providers who complete documentation following the patient encounter are theoretically subject to the same bias. Finally, poly-trauma requiring blood transfusion accounted for a large number of the total patients, and the etiology of blood loss is difficult to definitively attribute in these patients.

Lastly, we used a very specific definition of CIIAI. This effort at consistency with the original PECARN study does not address all potential abdominal injuries sustained via blunt abdominal trauma, including those that, while not defined as clinically-important, might still be impactful to both the treating team, patient and family.

6. Conclusions

This study supports the use of the PECARN clinical prediction rule to decrease abdominal CT use in pediatric patients at very low-risk for CIIAI. Only one of 130 total patients with intra-abdominal injury requiring acute intervention met very low-risk criteria, and this patient had extra-abdominal arterial bleeding, offering an alternate etiology of blood loss requiring transfusion. No patients with pelvic or spinal fractures with associated shear injuries met the proposed criteria. A prospective, multicenter study is necessary to evaluate additional test characteristics of this clinical prediction rule and ensure a large enough patient volume for the outcome of interest.

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Meetings

Poster presentation at Pediatric Academic Societies annual meeting, Toronto, Canada, May 2018.

Conflicts of interest

The authors have no conflicts of interest to disclose.

Author contributions

ES, AAV, and DHA conceived and designed the study; ES, SBF, and AAV performed data collection; ES and AV analyzed and interpreted the data; ES and AAV drafted the manuscript; all authors critically reviewed the manuscript; and DHA provided statistical expertise.

Appendix A. ICD-9 and ICD-10 codes used to generate institutional trauma registry

ICD-9	
800–959	Injury and Poisoning, EXCLUDING
	905–909: Late effects of injuries, poisoning, toxic effects, and other external causes 930–939: Effects of foreign body entering through body orifice 940–949: Burns without trauma Patients who are evaluated, resuscitated, treated, and released Patients who are treated and released from the ambulatory surgical center Patients who are obstetrics patients with no defined trauma injury Patients who are admitted whose injury is secondary to a primary medical diagnosis which caused the event Patients whose injuries were known to be sustained >48 h prior to admission
ICD-10	
S00–S99	Injuries to specific body parts – initial encounter (with 7th character modifiers of A, B, or C only) EXCLUDING:
	S00: superficial injuries of the head S10: superficial injuries of the neck S20: superficial injuries of the thorax S30: superficial injuries of the abdomen, pelvis, lower back and external genitals S40: superficial injuries of the shoulder and upper arm S50: superficial injuries of the elbow and forearm S60: superficial injuries of the wrist, hand, and fingers S70: superficial injuries of the hip and thigh S80: superficial injuries of the knee and lower leg S90: superficial injuries of the ankle, foot, and toes
T07	Unspecified multiple injuries
T14	Injury of unspecified body region
T79. A1–79. A9	Traumatic compartment syndrome – initial encounter (with 7th character modifier of A only)

Appendix B. ICD-9 and ICD-10 diagnosis codes used as initial screen for patient inclusion in study

ICD-9	
805.2–805.9	Fracture of vertebral column without mention of spinal cord injury (excluding cervical vertebra)
806.2–806.9	Fracture of vertebral column with spinal cord injury (excluding cervical vertebra)
808	Fracture of pelvis
809	Ill-defined fractures of bones of trunk
863	Injury to gastrointestinal tract
864	Injury to liver
865	Injury to spleen
866	Injury to kidney
867	Injury to pelvic organs
868	Injury to other intra-abdominal organs
869	Injury to other intra-abdominal organs
902	Injury to blood vessels of abdomen and pelvis
926	Crushing injury of trunk
929	Crushing injury of multiple and unspecified sites
959.12	Other injury of abdomen
ICD-10	
S31	Open wound of abdomen, lower back, pelvis and external genitals
S32	Fracture of lumbar spine and pelvis
S35	Injury of blood vessels at abdomen, lower back and pelvis level
S36	Injury of intra-abdominal organs
S37	Injury of urinary and pelvic organs
S38	Crushing injury and traumatic amputation of abdomen, lower back, pelvis and external genitals
S39	Other and unspecified injuries of abdomen, lower back, pelvis and external genitals
T07	Unspecified multiple injuries
T14	Injury of unspecified body region

Appendix C. ICD-9 and ICD-10 procedure codes used as secondary screen for patient inclusion in study

ICD-9	
00	Procedures And Interventions, Not Elsewhere Classified
17	Other Miscellaneous Procedures
34.8	Operations On Diaphragm
38	Incision, Excision, And Occlusion Of Vessels
39	Other Operations On Vessels
41	Operations On Bone Marrow And Spleen
42–54	Operations on the Digestive System
55–59	Operations On The Urinary System
83	Operations On Muscle, Tendon, Fascia, And Bursa, Except Hand
84	Other Procedures On Musculoskeletal System
99.0	Transfusion Of Blood And Blood Components
ICD-10	
04	Medical and surgical procedures of the lower arteries
06	Medical and surgical procedures of the lower veins
07-P	Medical and surgical procedures of the spleen
0D	Medical and surgical procedures of the gastrointestinal system
0F	Medical and surgical procedures of the hepatobiliary system and pancreas
0T	Medical and surgical procedures of the urinary system
0W	Medical and surgical procedures of anatomical regions, general

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