External validation of a pediatric decision rule for blunt abdominal trauma

Adam P. Sigal MD1 | Traci Deaner MSN1 | Sam Woods DO1
Elizabeth Mannarelli DO1 | Alison L. Muller MS2 | Anthony Martin RN2
Alexis Schoener BS3 | McKenna Brower BS4 | Adrian Ong MD2 | Thomas Geng DO2
Felipe Guillen MS5 | Brian Lahmann MD1 | Tom Wasser PhD1 | Christopher Valente MD1

1 Department of Emergency Medicine, Reading Hospital, West Reading, Pennsylvania, USA
2 Department of Surgery, Section of Trauma and Critical Care, Reading Hospital, West Reading, Pennsylvania, USA
3 Penn State Berks, Reading, Pennsylvania, USA
4 Syracuse University, Syracuse, New York, USA
5 Drexel University College of Medicine, Philadelphia, Pennsylvania, USA

Correspondence
Adam P. Sigal, MD, Department of Emergency Medicine, Reading Hospital, 420 S. Fifth Avenue, Reading PA 19611, USA.
Email: adam.sigal@towerhealth.org

Funding and support: By JACEP Open policy, all authors are required to disclose any and all commercial, financial, and other relationships in any way related to the subject of this article as per ICMJE conflict of interest guidelines (see www.icmje.org). The authors have stated that no such relationships exist.

Abstract

Introduction: Blunt traumatic injuries are a leading cause of morbidity and mortality in the pediatric population. Contrast-enhanced multidetector computed tomography is the best imaging tool for screening patients at risk of blunt abdominal injury. The Pediatric Emergency Care Applied Research Network (PECARN) abdominal rule was derived to identify patients at low risk for significant abdominal injury who do not require imaging.

Methods: We conducted a retrospective review of pediatric patients with blunt trauma to validate the PECARN rule in a non-pediatric specialized hospital from February 3, 2013, through December 31, 2019. We excluded those with penetrating or mild isolated head injury. The PECARN decision rule was retrospectively applied for the presence of a therapeutic intervention, defined as a laparotomy, angiographic embolization, blood transfusion, or administration of intravenous fluids for pancreatic or gastrointestinal injury. Sensitivity and specificity analysis were conducted along with the negative and positive predictive values.

Results: A total of 794 patients were included in the final analysis; 23 patients met the primary outcome for an acute intervention. The PECARN clinical decision rule (CDR) had a sensitivity of 91.3%, a negative predictive value of 99.5, and a negative likelihood ration of 0.16.

Conclusion: In a non-pediatric specialty hospital, the PECARN blunt abdominal CDR performed with comparable sensitivity and negative predictive value to the derivation and external validation study performed at specialized children’s hospitals.

KEYWORDS
blunt abdominal injury, clinical decision rule, intervention, low risk, pediatric, trauma
1 | INTRODUCTION

1.1 | Background

Traumatic injuries are the number 1 cause of death from ages 1–18 years.¹ In 2015, >140,000 patients aged <19 years were injured, resulting in 3400 deaths. More than 73% of these injuries occurred by blunt mechanisms, with most being falls or motor vehicle accidents. Abdominal injuries were documented in almost 13% of these patients.² American College of Surgeons Committee on Trauma (ACS COT) notes that a contrast-enhanced, multidetector computed tomography (CT) scan is the best imaging tool for screening the patient with blunt abdominal trauma, especially for identifying active hemorrhage and hepatobiliary, splenic, pancreatic, and genitourinary injuries.³ The use of CT imaging in evaluating pediatric traumas has resulted in a shift to non-operative management. A normal CT after blunt abdominal trauma has a high negative predictive value (NPV) for intra-abdominal injuries (IAIs) requiring intervention (IAIs-I).⁴,⁵

1.2 | Importance

Unfortunately, the use of CT scans in children, especially when the cumulative dose becomes greater than 50 mGy, increases the risk of cancer development.⁶ This observation has led the ACS-COT to recommend minimizing unnecessary imaging in pediatric patients.³ The Pediatric Emergency Care Applied Research Network (PECARN) was established to translate research results into clinical practice. In 2013, the network derived a clinical decision rule (CDR) to identify children at very low risk for IAIs that would require intervention, obviating the need for CT scans of the abdomen and pelvis (Table 1).⁷,⁸

1.3 | Goals

The initial CDR was derived using specialized trauma centers with pediatric trauma expertise.⁸ It has undergone external validation also at a pediatric emergency department (ED) in an academic tertiary care children’s hospital with an ACS level 1 trauma designation.⁹ Our objective was to determine the sensitivity of the PECARN CDR in a non-pediatric specialty care hospital.

2 | METHODS

2.1 | Study design and setting

We conducted a retrospective review of all pediatric trauma patients (aged <19 years) from February 3, 2013, through December 31, 2019. The study took place at a large community ED with an annual census of 134,000 patients, 20% of which are pediatric patients, defined as age <19 years. The hospital is also a level 1 designated trauma center with 1500 trauma activations, of which 6.6% are pediatric patients, defined as age <15 years per ACS-COT. In February 2019, a separate pediatric ED section opened within the main ED, which is staffed by a combination of emergency physicians, pediatric emergency physician assistance and nurse practitioners. The Institutional Review Board reviewed and approved the study protocol.

2.2 | Data collection

A total of 2 researchers (SW, EM) reviewed all pediatric trauma patients evaluated in either the trauma bay, ED, or in the pediatric ED and removed all of those with penetrating injury or isolated head injury. Charts excluded represented patients with obvious isolated injury or a mechanism thought very unlikely to cause a blunt abdominal injury. A total of 3 abstractors (FG, MB, AS) then reviewed each chart and manually entered variables in Research Electronic Data Capture (REDCap). A total of 2 investigators (AS, TD) reviewed their first 10 charts for accuracy. Any charts with abstracting questions were reviewed by 2 of 4 reviewers (APS, TD, CV, AO), and a consensus was reached. Study data were collected and managed using REDCap electronic data capture tools hosted at Reading Hospital.¹⁰,¹¹ REDCap is a secure, web-based software platform designed to support data capture for research studies, providing (1) an intuitive interface for validated data capture, (2) audit trails for tracking data manipulation and export procedure, (3) automated export procedures for seamless data downloads to common statistical packages, and (4) procedures for data integration and interoperability with external sources.

2.3 | Analysis

Statistical analysis between categorical variables was performed with a chi-square test of fit association, and analysis between groups on continuous variables was performed using a group t test. Sensitivity and specificity analyses were conducted for the CDR variables indicating appropriateness of imaging and the need for an acute intervention.
Evidence of Limitations

RESULTS

Continuous data were reported as means (averages) and SDs. Tabular data were reported as counts and percentages within categories. Data were uploaded into SPSS format. Descriptive data involving discreet variables most likely to have missing documentation (Tables 2 and 4). In addition, we calculated the positive predictive value (PPV) and NPV for the CDR.

During the review, we included pediatric trauma patients with blunt mechanisms of injury, such as falls, bicycle accidents, pedestrian versus motor vehicle accidents, and motor vehicle crashes. We excluded patients with minor isolated head trauma, transfers from other hospitals, those with CT imaging before arrival, and non-blunt mechanisms of injury such as drowning. We also excluded charts with missing data.

Any \( P \) value <0.05 was considered significant for analysis. Because of the exploratory nature of this analysis, there were no corrections applied to the data for multiple comparisons. No missing value imputations were performed for any data variable, and missing subject data were deleted on a case-by-case, variable-by-variable basis.

All statistical analyses for this research were performed using SPSS version 25.0 (IBM Corp). Data were downloaded from an Excel file and uploaded into SPSS format. Descriptive data involving discreet variables were reported as counts and percentages within categories. Continuous data were reported as means (averages) and SDs.

3 | RESULTS

A total of 1953 pediatric patients with traumatic injuries or a traumatic mechanism of injury were reviewed during the study period. After exclusions, a total of 794 patients were included in the final analysis, and 23 met criteria for needing an acute intervention (Figure 1).

There was no significant difference between patients who received a CT scan and those who did not regarding sex or the use of the focused assessment with sonography for trauma (FAST) exam. Those patients who received a CT scan during the trauma evaluation were more likely to have experienced a motor vehicle accident or crash (40.8% vs 22.7%; \( P < 0.001 \)) and to be older (13.9 vs 9.2 years; \( P < 0.001 \); Table 2).

To identify patients with possible missed injuries, we reviewed the PECARN-negative charts without imaging for follow-up ED visits 1 week after the index visit. Of the 264 patients who were PECARN negative and did not have a CT scan performed, none returned within 7 days to the ED for a re-evaluation. Of the 157 patients who were PECARN negative who had a CT scan performed, 2 patients had blood transfusions. Patient 1 was a 17-year-old victim of a motor vehicle crash with a pelvic fracture that required a transfusion and orthopedic surgery. Patient 2 was a 15-year-old with a lower extremity penetrating injury near the inguinal region with active bleeding. The patient underwent operative control. Although a grade II liver laceration was identified, the blood loss anemia was thought secondary to the extremity injury. A review of the 129 patients who were PECARN positive without CT imaging did not identify any additional patients requiring intervention within the week after the index visit (Table 2).

The PECARN (CDR) performed with a sensitivity of 91.3% (95% confidence interval [CI], 72.0–98.9) and a NPV of 99.5 (95% CI, 98.2–99.9; Table 2). A total of 2 patients identified as PECARN negative had an intervention. Both patients required a blood transfusion and the interventions described previously. The specificity was 54.4% (95% CI, 50.8–57.9), and the PPV was 5.63 (95% CI, 4.9–6.5; Table 3).

Of the charts reviewed, 21% were not included as a result of missing data. Compared with those included in the analysis who were PECARN positive and negative, patients with missing data were younger (mean age, 9.9 years vs 13.94 and 12.46, respectively), less likely to have a FAST performed (39.2% vs 62.4% and 63.6%, respectively), and more likely to have a fall as the mechanism of injury (52.8% vs 35.6% and 40.3%, respectively). Children aged \( \leq 5 \) years represented 61% of the charts with not enough data for abstraction. Glasgow Coma Score, the presence of abdominal pain, and abdominal tenderness were the variables most likely to have missing documentation (Tables 2 and 4).

3.1 | Limitations

This study has several limitations. The study is from a single institution and is a retrospective review. Inherent in retrospective reviews are missing data, and in our review 212 patients had missing data. In addition, because it was a single-site review, the prevalence of disease was low, with only 23 patients requiring an intervention. However, the utility of the CDR is in identifying low-risk patients without disease. Our results using data external to the original cohort and occurring at a non-pediatric hospital are similar to prior studies.

As part of the retrospective review, we excluded patients from analysis whose charts described isolated head injury or penetrating injury in whom abdominal injury was not considered. There is the risk that the treating clinicians mentally reviewed PECARN variables and incorporated them into the medical decision making without documenting their medical decision making. We also did not review these charts for subsequent return visits for missed IAIs or IAIs-I. This review setting was done at a regional trauma center and not a specialized pediatric
tertiary trauma center. Emergency medicine service units may preferentially defer higher acuity patients to pediatric specialty centers in our region.

4 | DISCUSSION

We retrospectively applied the PECARN abdominal CDR in a non-pediatric community hospital. We obtained sensitivity slightly lower but a NPV comparable with the derivation and externally validated study. The small negative likelihood ratio of 0.16 in our study suggests that the PECARN rule can safely identify pediatric patients at low risk of an IAI-I, thus obviating the need for CT imaging and the subsequent risks of ionizing radiation exposure. Our sensitivity and NPV results closely mirror those of Ozcan et al in their retrospective application of 3 CDRs for pediatric blunt abdominal trauma (BAT). That study was also conducted at a tertiary pediatric hospital. We estimate that following the PECARN rule would have resulted in a 37% reduction in CT scan use if applied appropriately. The utility of the PECARN CDR is in avoiding unnecessary ionizing radiation exposure in patients with low risk of having an injury requiring intervention.

Physicians should be cognizant that even if a patient meets some or all PECARN CDR criteria, imaging is not mandated. Although obtaining a CT image would have been justified in an almost equal number of pediatric patients based on a positive PECARN rule, the low positive likelihood ratio of the PECARN rule coupled with a low disease prevalence of 2.9% (Table 2) suggest that CT scanning in every patient who is PECARN positive may not be necessary. It is difficult to abstract from the medical records how physician gestalt regarding the presence of a significant blunt abdominal injury influenced the decision not to image this cohort of patients who were PECARN positive. However, clinicians appear to use other factors when caring for younger patients and those with lower energy mechanisms of injury, as these patients were less likely to receive CT scanning compared with other patients. The poor reliability of the history from younger patients coupled with a difficult exam may explain the lack of documentation for these categories.

We did not evaluate the utility of various laboratory screening tests or point-of-care ultrasound and their ability to identify trauma patients at low risk for clinically significant abdominal injury. Streck et al retrospectively evaluated a prediction rule for clinically significant injuries using the following 6 high-risk variables: hypotension for age, abnormal exam, elevated aspartate aminotransferase (AST), decreased...
TABLE 2  Comparison of CT image use and PECARN criteria

| Variable  | Category         | PECARN negative CT performed | PECARN negative CT not performed | P value | PECARN positive CT performed | PECARN positive CT not performed | P value |
|-----------|------------------|------------------------------|----------------------------------|---------|------------------------------|----------------------------------|---------|
|           |                  | Count (%)                    | Count (%)                        | P value | Count (%)                    | Count (%)                        | P value |
| Sex       | Female           | 55 (35)                      | 88 (33.3)                        | 0.722   | 82 (33.6)                    | 54 (41.9)                        | 0.115   |
|           | Male             | 102 (65)                     | 176 (66.7)                       |         | 162 (66.4)                   | 75 (58.1)                        |         |
| Etiology  | Fall             | 26 (16.6)                    | 94 (35.6)                        | <0.001  | 22 (9)                       | 52 (40.3)                        | <0.001  |
|           | MVA              | 64 (40.8)                    | 60 (22.7)                        |         | 104 (42.8)                   | 30 (23.3)                        |         |
|           | MCA              | 17 (10.8)                    | 10 (3.8)                         |         | 26 (10.7)                    | 7 (5.4)                          |         |
|           | Ped accident     | 33 (21)                      | 56 (21.2)                        |         | 36 (14.8)                    | 9 (7)                            |         |
|           | Other            | 17 (10.8)                    | 44 (16.7)                        |         | 56 (23)                      | 31 (24)                          |         |
| FAST      | No               | 59 (37.6)                    | 103 (39)                         | 0.77    | 90 (36.9)                    | 47 (36.4)                        | 0.931   |
|           | Yes              | 98 (62.4)                    | 161 (61)                         |         | 154 (63.1)                   | 82 (63.6)                        |         |
| FAST neg/pos | Positive | 0 (0)                       | 0 (0)                            | N/A     | 13 (8.4)                     | 0 (0)                            | 0.003*  |
|           | Negative         | 98 (100)                     | 161 (100)                        |         | 141 (91.6)                   | 82 (100)                         |         |
| Continuous | Age, years      | Mean (SD)                    | Mean (SD)                        | <0.001  | Mean (SD)                    | Mean (SD)                        | <0.001  |
|           |                  | 13.94 (3.67)                 | 9.16 (5.1)                       |         | 12.46 (4.36)                 | 7.5 (4.99)                       |         |

Abbreviations: CT, computed tomography; FAST, focused assessment with sonography for trauma; MCA, motor cycle accident, MVA, motor vehicle accident; N/A, not applicable; PECARN, Pediatric Emergency Care Applied Research Network; PED, pedestrian.

*Fisher’s exact test.

TABLE 3  PECARN performance in a non-pediatric specialty care hospital

| Variable  | Category         | Intervention Count (%) | No Intervention Count (%) | P value |
|-----------|------------------|-------------------------|---------------------------|---------|
|           |                  | Yes (91.3)              | 21 (91.3)                 | <0.001  |
|           |                  | No (8.7)                | 2 (8.7)                   |         |
| Statistic | % (95% CI)       | 91.3 (71.96–98.93)      |                           |         |
| Sensitivity|                 | 54.35 (50.75–57.9)      |                           |         |
| Specificity|                 | 2.173–2.32              |                           |         |
| Negative likelihood ratio | 0.16 (0.04–0.6 |         |                           |         |
| Disease prevalence | 2.9 (1.84–4.31) |         |                           |         |
| Positive predictive value | 5.63 (4.89–6.47) |         |                           |         |
| Negative predictive value | 99.52 (98.23–99.87) |         |                           |         |
| Accuracy |                 | 55.42 (51.88–58.91)     |                           |         |

Abbreviations: CI, confidence interval; PECARN, Pediatric Emergency Care Applied Research Network.

TABLE 4  Characteristics of patients excluded as a result of missing data

| Variable                  | All n = 212 | Age ≤5 years n = 129 |
|---------------------------|-------------|----------------------|
| PECARN variable (count/%) |             |                      |
| Seat belt sign or abdominal wall trauma | 11 (5)      | 7 (63)               |
| Glasgow Coma Score        | 80 (38)     | 45 (56)              |
| Abdominal tenderness      | 40 (19)     | 23 (57)              |
| Thoracic wall trauma      | 6 (3)       | 4 (66)               |
| Complaint of abdominal pain | 113 (53)  | 88 (78)              |
| Decreased breath sounds   | 6 (3)       | 2 (33)               |
| Vomiting                  | 92 (43)     | 51 (55)              |
| Age                       | 9.9 (6.7)*  |                      |
| Mechanism of Injury       |             |                      |
| Fall                      | 112 (52)    |                      |
| MVC                       | 64 (40.8)   |                      |
| Ped accident              | 17 (10.8)   |                      |
| Other                     | 17 (10.8)   |                      |
| FAST                      | Yes         | 83 (39)              |
| No                        | 129 (61)    |                      |

Abbreviations: FAST, focused assessment with sonography for trauma; MVC, motor vehicle crash; PECARN, Pediatric Emergency Care Applied Research Network; PED, pedestrian.

Data presented as n (% of all) unless otherwise indicated.

*Values are presented as mean (SD).
most utility in those cases in which the treating physician does not think laboratory testing is indicated. Other strategies to decrease the need for CT scans and ionizing radiation include monitoring children with hemodynamic stability and an initial benign physical exam. In 1 prospective study at a single center, the development of abdominal pain after a period of observation or the presence of abnormal selected laboratory studies would prompt imaging acquisition. Absence of concerning developments would result in family continuing to monitor the child at home with close follow-up phone calls from the ED. No complications were noted on children managed in the conservative pathway.

The PECARN CDR was designed to identify patients at sufficiently low risk for blunt IAIs-I in whom ionizing radiation diagnostic studies could be eliminated. As such, emphasis was placed on having a high sensitivity. It was not designed to identify patients at risk for IAIs-I. Other studies have evaluated the significance of mechanisms of injury, physical exam findings, laboratory abnormalities, and the role of FAST to predict the need for IAIs-I.

Implementing the CDR has proven to be difficult despite its validation. A pediatric referral center has noted a poor compliance with the PECARN head rule for identifying patients at low risk for significant traumatic brain injury. Both a level 1 trauma center and a pediatric trauma center did not find any improvement in the use of CT imaging after publication of both the PECARN head and abdominal rules. Further studies are needed on effective strategies to implement the CDR to decrease unnecessary ionizing radiation in children with blunt abdominal trauma.

This study supports the use of the PECARN CDR to identify patients at very low risk of IAIs-I. This study is the first to validate the rule in a non-pediatric specialty center. When applying the PECARN CDR in settings beyond that of the original derivation, clinicians must understand the rule limitations as well as how their individual experiences with pediatric trauma patients impact their clinical gestalt. A prospective application of the CDR in this similar setting is needed to for widespread adaption.

CONFLICT OF INTEREST
The authors declare no conflict of interest.

AUTHOR CONTRIBUTIONS
Adam P. Sigal, Traci Deane, Alison L. Muller, Anthony Martin, Adrian Ong, Thomas Geng, Tom Wasser, Brian Lahmann, and Christopher Valente developed the research project, analyzed the data, and wrote and edited manuscript and approved the final version. Sam Woods, Elizabeth Mannarelli, Alexis Schoener, McKenna Brower, and Felipe Guillen acquired and analyzed data and edited and approved the final manuscript. Adam P. Sigal, Traci Deane, Adrian Ong, and Christopher Valente also verified data abstraction.

ORCID
Adam P. Sigal MD https://orcid.org/0000-0002-1610-7094

REFERENCES
1. National Center for Injury Control and Prevention, Center for Disease Control and Prevention. Leading causes of death, United States. https://www.cdc.gov/injury/wisqars. Accessed April 19, 2021.
2. Chang MC, Stewart RM, Rotondo MF, Nathens AB, National Trauma data bank 2016 pediatric annual report. facs.org/quality-programs/trauma/tqp CENTER Programs/ntdb/docpub. Accessed April 20, 2021.
3. American College of Surgeons TQIP Best Practices Guidelines in Imaging. https://www.facs.org/-/media/quality-programs/trauma/tqp/Imaging_guidelines.aspx. Accessed October 30, 2019.
4. Miele V, Picollo CL, Trinci M, Galluzza M, Ianniello S, Brunese L. Diagnostic imaging of blunt abdominal trauma in pediatric patients. Radiol Med. 2016;121:409-430.
5. Braungart S, Beatte T, Midgley P, Powis M. Implications of a negative abdominal CT in the management of pediatric blunt abdominal trauma. J Pediatr Surg. 2017;52:293-298.
6. Pearce MS, Salotti JA, Little MP, et al. Radiation exposure from CT scans in childhood and subsequent risk of leukemia and brain tumours: a retrospective cohort study. Lancet North Am Ed. 2012;380:499-505.
7. The Pediatric Emergency Care Applied Research Network. The Pediatric Emergency Care Applied Research Network (PECARN); rationale, development, and first steps. Acad Emerg Med. 2003;10(6):661-668. https://doi.org/10.1111/j.1553-2712.2003.tb00053.x.
8. 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.e2.
9. Springer E, Frazier SB, Arnold DH, Vukovic AA. External validation of a clinical prediction rule for very low risk pediatric blunt abdominal trauma. Am J Emerg Med. 2019.37:1643-1648.
10. Harris PA, Taylor R, Thielke R, Payne J, N G, JG C. Research Electronic Data Capture (REDCap) – a metadata-driven methodology and workflow process for providing translational research informatics support. J Biomed Inform. 2009;42(2):377-381.
11. Harris PA, Taylor R, Minor BL, et al. The REDCap Consortium: building an International community of software partners. J Biomed Inform. 2019.
12. Ozcan A, Ahn T, Akay B, Menoch M. Imaging for pediatric blunt abdominal trauma with different prediction rules: is the outcome the same [published online ahead of print 2021]? Pediatr Emerg Care. https://doi.org/10.1097/PEC.0000000000002346.
13. Streck CJ, Jewett BM, Wahquist AH, Gutierrez PS, Russell WS. Evaluation for intrabdominal injury in children following blunt torso trauma. Can we reduce unnecessary abdominal CT by utilizing a clinical prediction model? J Trauma Acute Care Surg. 2012;73(2):371-376.
14. Streck CJ, Vogel AM, Huang EY, 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;224:449-460.
15. Arbra CA, Vogel AM, Plumblee L, et al. External validation of a five-variable clinical prediction rule for identifying children at very low risk for intra-abdominal injury after blunt abdominal trauma. J Acute Care Surg. 2018;85(1):71-77.
16. Cousin I, Hardouin L, Linard C, et al. Professional practice assessment: establishment of an institutional procedure to treat blunt abdominal trauma in emergency pediatric department. Euro J Trauma Emerg Surg. 2021;47:105-112.
17. Dai LN, Chen CD, Lin XK, Wang YB, et al. Abdominal injuries involving bicycle handlebars in 219 children: results of 8-year follow-up. Euro J Trauma Emerg Surg. 2015;41:551-555.
18. Drucker NA, McDuffie L, Groh E, Hackworth J, Bell TM, Markel TA. Physical examination is the best predictor of the need for abdominal surgery in children following motor vehicle collision. J Emerg Med. 2018;54(1):1-7.
19. Flynn-O’Brien KT, Kuppermann N, Holmes JF. Costal margin tenderness and the risk for intraabdominal injuries in children with blunt abdominal trauma. Acad Emerg Med. 2018;25:776-784.

20. Hershkovitz Y, Navenh S, Kessel B, Shapira Z, Halevy A, Jeroukhimov I. Elevated white blood cell count, decreased hematocrit and presence of macrohematuria correlate with abdominal organ injury in pediatric blunt trauma patients: a retrospective study. World J Emerg Surg. 2015;10(41):1-6.

21. Zagory JA, Dossa A, Golden J, et al. Re-evaluation of liver transaminase cutoff for CT after pediatric blunt abdominal trauma. Pediatr Surg Int. 2017;33:311-316.

22. Calder BW, Vogel AM, Zhang J, et al. Focused assessment with sonography for trauma in children after blunt abdominal trauma: a multi-institutional analysis. J Trauma Acute Care Surg. 2016;83(2):218-224.

23. Pennell C, t Wilson, Bruce M, et al. Adherence to PECARN criteria in children transferred to a pediatric trauma center: an opportunity for improvement? Am J Emerg Med. 2020;38:1546.e1-1546.e4.

24. Gerber N, Sookraj K, Munnangi S, et al. Impact of the Pediatric Emergency Care Applied Research Network (PECARN) guidelines on emergency department use of head computed tomography at a level1 safety-net trauma center. Emerg Radiol. 2019;26:45-52.

25. Halaweish I, Reibe-Rodgers J, Randall A, Ehrlich P. Compliance with evidence-based guidelines for computed tomography of children with head and abdominal trauma. J Pediatr Surg. 2018;53:748-751.

AUTHOR BIOGRAPHY

Adam Sigal, MD, is a physician of emergency medicine at Reading Health System in Reading, Pennsylvania.

How to cite this article: Sigal AP, Deaner T, Woods S, et al. External validation of a pediatric decision rule for blunt abdominal trauma. JACEP Open. 2022;3:e12623. https://doi.org/10.1002/emp2.12623