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ORIGINAL CONTRIBUTION

Occult Pneumothoraces in Children With Blunt Torso Trauma

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Abstract

Objectives: Plain chest x-ray (CXR) is often the initial screening test to identify pneumothoraces in trauma patients. Computed tomography (CT) scans can identify pneumothoraces not seen on CXR ("occult pneumothoraces"), but the clinical importance of these radiographically occult pneumothoraces in children is not well understood. The objectives of this study were to determine the proportion of occult pneumothoraces in injured children and the rate of treatment with tube thoracostomy among these children.

Methods: This was a planned substudy from a large prospective multicenter observational cohort study of children younger than 18 years old evaluated in emergency departments (EDs) in the Pediatric Emergency Care Applied Research Network (PECARN) for blunt torso trauma from May 2007 to January 2010. Children with CXRs as part of their trauma evaluations were included for analysis. The faculty radiologist interpretations of the CXRs and any subsequent imaging studies, including CT scans, were reviewed for the absence or presence of pneumothoraces. An "occult pneumothorax" was defined as a pneumothorax that was not identified on CXR, but was subsequently demonstrated on cervical, chest, or abdominal CT scan. Rates of pneumothoraces and placement of tube thoracostomies and rate differences with 95% confidence intervals (CIs) were calculated.

Results: Of 12,044 enrolled in the parent study, 8,020 (67%) children (median age = 11.3 years, interquartile range [IQR] = 5.3 to 15.2 years) underwent CXRs in the ED, and these children make up the study population. Among these children, 4,276 had abdominal CT scans performed within 24 hours. A total of 372 of 8,020 children (4.6%; 95% CI = 4.2% to 5.1%) had pneumothoraces identified by CXR and/or CT. The CXRs visualized pneumothoraces in 148 patients (1.8%; 95% CI = 1.6% to 2.2%), including one false-positive pneumothorax, which was identified on CXR, but was not demonstrated on CT. Occult pneumothoraces were present in 224 of 372 (60.2%; 95% CI = 55.0% to 65.2%) children with pneumothoraces. Tube thoracostomies were performed in 85 of 148 (57.4%; 95% CI = 49.0% to 65.5%)

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children with pneumothoraces on CXR and in 35 of 224 (15.6%; 95% CI = 11.1% to 21.1%) children with occult pneumothoraces (rate difference = –41.8%; 95% CI = –50.8 to –32.3%).

Conclusions: In pediatric patients with blunt torso trauma, pneumothoraces are uncommon, and most are not identified on the ED CXR. Nearly half of pneumothoraces, and most occult pneumothoraces, are managed without tube thoracostomy. Observation, including in children requiring endotracheal intubation, should be strongly considered during the initial management of children with occult pneumothoraces.

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Among children in the United States, unintentional injuries are the leading cause of mortality and morbidity, with most of these injuries resulting from blunt trauma.[1] The most common intrathoracic injuries resulting from blunt chest trauma are rib fractures, pulmonary contusions, and pneumothoraces.[2–4] Complications of traumatic pneumothoraces include respiratory compromise with the potential to evolve into life-threatening tension pneumothoraces and cardiovascular collapse. A pneumothorax that initially causes minimal or no respiratory symptoms may lead to complications in patients with diminished cardiopulmonary reserve or who require positive-pressure mechanical ventilation. Timely identification of pneumothoraces, and potential treatment with thoracostomy tube placement, is necessary to prevent increased risks of morbidity or mortality.[2]

Chest radiography (CXR) is the initial diagnostic screening test for children with blunt torso trauma.[5] Although CXR identifies many thoracic injuries, when compared to computed tomography (CT) as a reference standard, it fails to identify some thoracic injuries, including some rib fractures, pulmonary contusions, and pneumothoraces.[2,6–8] With the increasing use of CT in the evaluation of injured patients,[9–12] thoracic injuries not previously identified are now being diagnosed, including radiographically occult pneumothoraces not visualized on the initial emergency department (ED) CXR.[2,7,13–15] Although recent recommendations regarding the diagnosis and treatment of occult pneumothoraces in adults are available,[16] data on the clinical importance and the appropriate management of occult pneumothoraces in children are limited. The objectives of this study were to determine the proportion of occult pneumothoraces in injured children after blunt torso trauma and the rate of treatment with tube thoracostomies. We hypothesized that more than 50% of all pneumothoraces would be occult and fewer than 10% of the occult pneumothoraces would be managed with tube thoracostomies.

METHODS

Study Design

This was a planned substudy conducted as part of a larger multicenter prospective observational cohort study to derive an abdominal CT prediction rule to identify children at very low risk of intra-abdominal injuries after blunt torso trauma.[17] The institutional review boards of all participating institutions approved the study. Details of the methods for the parent study have been previously published.[17] The study methods pertinent to this substudy are presented below.

Study Setting and Population

This study was conducted at 20 participating EDs in the Pediatric Emergency Care Applied Research Network (PECARN) from May 2007 to January 2010.[18,19] Among these institutions, 17 (85%) were Level I trauma centers, and 10 (50%) were free-standing children's hospitals. Patient eligibility for the parent study included those younger than 18 years old, presenting within 24 hours of blunt torso trauma. Patients were excluded for any of the following: trauma occurring more than 24 hours prior to ED evaluation, penetrating injury mechanism, presence of preexisting neurologic disease precluding adequate clinical assessment, known pregnancy, previous enrollment into the study within 30 days, or having been transferred from an outside facility with an abdominal CT performed at the referring institution prior to arrival to the study facility. Eligibility for this substudy included plain CXR obtained during the patient's ED evaluation. Children with pneumothoraces diagnosed by plain cervical spine radiograph or solely by clinical means were excluded from this study.

Study Protocol

The treating clinician documented the patient history and physical examination on a structured data collection form prior to knowledge of any imaging studies, if performed. Imaging, including radiography and CT, of the abdomen and/or chest were performed at the discretion of the treating clinicians. Data collected included patient demographics, injury mechanism, symptoms (including respiratory complaints), and physical examination findings (including thoracic examination). A severe mechanism of injury was defined as any of the following: motor vehicle collisions with ejection, rollover, or death in same collision; motor vehicle collisions with speed greater than 20 mph and patient unrestrained; falls greater than 10 feet; pedestrians/bicyclists struck by vehicles moving greater than 20 mph; and bicycle collision with handlebars striking the abdomen. For study purposes, children were classified as having either normal or abnormal physical examinations. To be classified as having a normal physical examination, all of the following had to be documented: Glasgow Coma Scale (GCS) score of 14 or 15, normal age-adjusted blood pressures and respiratory rates, no evidence of posterior or anterior thoracic wall trauma, no thoracic tenderness to palpation, and normal breath sounds on auscultation. We used the following age-adjusted

parameters to define a low initial ED systolic blood pressure (sBP): 1) age 0 to 1 month, sBP less than 70 mm Hg; 2) 1 month to 5 years, sBP less than 80 mm Hg; and 3) 5 to 18 years, sBP less than 90 mm Hg.[20] The initial ED respiratory rates were considered elevated if they were more than two standard deviations (SDs) above the age-adjusted mean.[21]

Admission to the hospital was at the discretion of the treating clinicians. We performed medical record reviews to determine patient clinical outcomes and recorded the data onto structured data collection forms. For children discharged from the ED, trained research coordinators conducted follow-up telephone calls 1 week to 3 months after the index ED visits to determine if the patients had any complications after the index ED visits. Follow-up calls were conducted to specifically determine if any abdominal or thoracic imaging was performed or additional injuries were identified after the initial ED visits. When a missed injury or hospitalization was identified at follow-up, the medical records, including imaging results, were obtained and reviewed, and clinical outcomes were recorded. In the event that telephone follow-up was not available, we mailed a follow-up survey to the family. Those who were not hospitalized or had no telephone or mail follow-up accounted for 10% (n = 767) of the study cohort. For these patients, we reviewed the medical records, quality improvement reports, trauma registries, and morgue reports at the respective sites to identify any missed injuries.[17]

Outcome Measures

The primary outcome measures were: 1) the proportion of pneumothoraces among enrolled children (all of whom who were evaluated with CXRs), 2) the proportion of occult pneumothoraces in those evaluated with CXR and CT, and 3) the frequency of tube thoracostomy in children with nonoccult and occult pneumothoraces. A pneumothorax was defined as a collection of air between the visceral pleura and chest wall.[15] Pneumomediastinum and subcutaneous air were not considered pneumothoraces. An occult pneumothorax was defined as a pneumothorax not visualized on CXR in the ED, but identified on a cervical, chest, or abdominal CT scan.[2,3,14,15]

Data Analysis

We described and compared the characteristics of children with occult pneumothoraces to those with nonoccult pneumothoraces and those with no pneumothoraces, with frequencies and 95% confidence intervals (CIs) or medians and interquartile ranges (IQRs). We reported the rates of specific abnormal physical examination findings and tube thoracostomies for children with occult pneumothoraces, nonoccult pneumothoraces, and no pneumothoraces. We compared associated CXR findings in children with occult and nonoccult pneumothoraces with rate differences and 95% CIs. In addition, we compared the abnormal physical examination findings for children with occult pneumothoraces, nonoccult pneumothoraces, and no pneumothoraces, with rate differences and 95% CIs. As missing data were minimal, we did not perform multiple imputation. We calculated exact and asymptotic 95% CIs for rate differences by inverting a two-sided test for the difference in proportions incorporated in Cytel Studio software version 9.0.0 (Cytel, Cambridge, MA).[22] Categorical data were compared with chi-square tests of homogeneity and count data were compared with Wilcoxon rank-Sum tests using SAS software version 9.3 (SAS Institute, Cary, NC).

RESULTS

A total of 12,044 patients with blunt torso trauma were enrolled in the main study. Of these children, 8,020 (67%) had plain CXRs performed in the ED and were included in the study population (Figure 1). The median age for the children in this study was 11.3 years (IQR = 5.3 to 15.2 years). A total of 372 (4.6%; 95% CI = 4.2% to 5.1%) children were ultimately diagnosed with pneumothoraces. The ED CXRs demonstrated pneumothoraces in 148 of the 8,020 children (1.8%; 95% CI = 1.6% to 2.2%). Occult pneumothoraces were present in 224 (60.2%; 95% CI = 55.0% to 65.2%) of all children with pneumothoraces. One patient with a pneumothorax identified on initial plain CXR subsequently underwent chest CT scan that failed to demonstrate a pneumothorax. This patient was included in the ED CXR pneumothorax group for purposes of analysis, as this finding influenced the clinical care of this patient.

Of the 224 occult pneumothoraces diagnosed by CT, three were visualized on cervical CT, 21 on chest CT, and 200 on abdominal CT. The overall proportion of occult pneumothoraces among children imaged with CXRs was 2.8% (95% CI = 2.4% to 3.2%). Among the 4,276 children with both CXR and abdominal CT scans performed within 24 hours of ED triage, 200 children had occult pneumothoraces (4.7%; 95% CI = 4.1% to 5.4%).

Demographic characteristics of the children with occult and nonoccult pneumothoraces and those with no pneumothoraces are presented in Table 1. Six

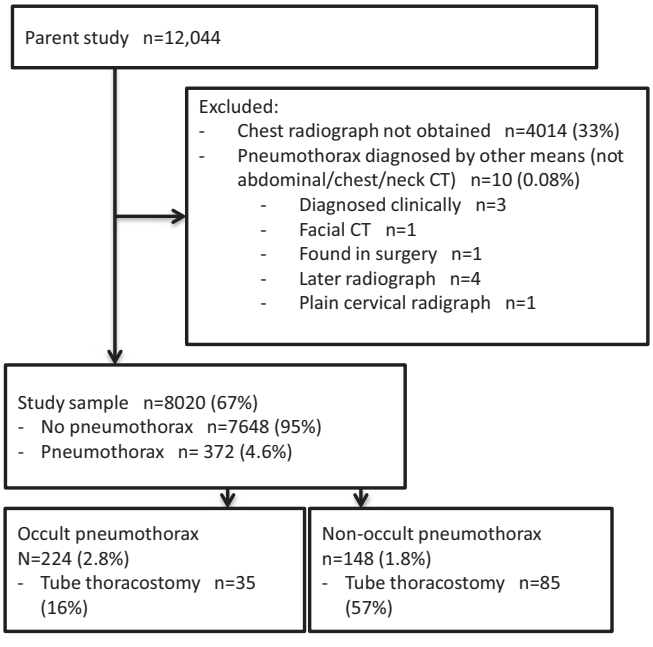

Figure 1. Derivation of study sample.

children (2.7%; 95% CI = 1.0% to 5.7%) with occult pneumothoraces were discharged home from the ED, and none were subsequently admitted to the hospital or died within 30 days of discharge. Children with occult pneumothoraces were similar to children with nonoccult pneumothoraces in regard to age, sex, proportion of high-risk injury mechanism, and GCS scores. Associated abnormal CXR findings in children with occult and nonoccult pneumothoraces, including pulmonary contusions and rib fractures, are described in Table 2. Children with occult pneumothoraces were less likely to have hemothoraces or rib fractures compared to those with pneumothoraces on CXR.

Physical Examination Findings in Children With Pneumothoraces

Abnormal physical examination findings were less prevalent in children with occult versus nonoccult pneumothoraces (Table 3). A normal physical examination was present in 32 of 222 (14.4%; 95% CI = 10.1% to 19.7%) children with occult pneumothoraces and 14 of 147 (9.5%; 95% CI = 5.3% to 15.5%) children with nonoccult pneumothoraces (rate difference = 4.9%; 95% CI = –2.3% to 11.6%). Children with occult pneumothoraces, however, were more likely to have abnormal physical examination findings than those without pneumothoraces (Table 4).

Pneumothorax Treatment

Tube thoracostomy was performed in 85 of 148 (57.4%; 95% CI = 49.0% to 65.5%) children with nonoccult pneumothoraces and in 35 of 224 (15.6%; 95% CI = 11.1% to 21.1%) children with occult pneumothoraces (rate difference = –41.8%; 95% CI = –50.8% to –32.3%). The overall rate of tube thoracostomy for all identified pneumothoraces at individual study sites ranged from 0% to 49% (Table 5). Forty-five (20.2%) of the 223 children with occult pneumothoraces were endotracheally intubated (data missing on one child). Seventeen of these 45 (37.8%; 95% CI = 23.8% to 53.5%) had tube thoracostomies placed. Eighty of the 224 children with occult pneumothoraces (35.7%) underwent surgical procedures in the operating suite within 24 hours of ED presentation. Nineteen (23.8%; 95% CI = 15.0% to 34.6%) of these children had tube thoracostomies performed.

Table 1
Patient Characteristics

Characteristic	Occult Pneumothorax (n = 224)	Nonoccult Pneumothorax (n = 148)	No Pneumothorax (n = 7,648)
Age (yr), median (IQR)*	13.0 (7.8–16.3)	14.6 (8.9–16.5)	11.2 (5.2–15.2)
Male sex	142 (63)	103 (70)	4,772 (62)
High-risk mechanism of injury*	73 (33)	50 (34)	1,943 (25)
GCS score*			
14–15	162 (72)	103 (70)	6,838 (89)
≤ 13	62 (28)	45 (30)	807 (11)
Tube thoracostomy*†	35 (16)	85 (57)	13 (0)
ED disposition*†			
Discharged to home	6 (3)	6 (4)	3,054 (40)
Admitted to ward	103 (46)	61 (41)	3,239 (42)
Admitted to operating room	11 (5)	23 (16)	230 (3)
Admitted to ICU	102 (46)	56 (38)	1,094 (14)
Transferred to another hospital	1 (0)	2 (1)	20 (0)
Other	1 (0)	0 (0)	11 (0)

Data are reported as n (%) unless otherwise noted.
GCS = Glasgow Coma Scale; ICU = intensive care unit.
†CXR pneumothorax group statistically different ($p < 0.05$) from the occult pneumothorax group.
*No pneumothorax group statistically different ($p < 0.05$) from the occult pneumothorax group.

Table 2
Associated CXR Findings in Patients With Pneumothoraces

CXR Findings	Occult Pneumothorax (n = 224)	Nonoccult Pneumothorax (n = 148)	Rate Difference, % (95% CI)*
Any traumatic finding	76 (33.9)	67 (45.3)	–11.3 (–21.4 to –1.2)
Diaphragm injury	0 (0.0)	1 (0.7)	–0.7 (–4.1 to 1.0)
Hemothorax	2 (0.9)	11 (7.4)	–6.5 (–12.2 to –2.7)
Pneumomediastinum	6 (2.7)	10 (6.8)	–4.1 (–9.6 to 0.2)
Pneumopericardium	1 (0.4)	0 (0.0)	0.4 (–2.3 to 2.6)
Pulmonary contusion	59 (26.3)	37 (25.0)	1.3 (–8.2 to 10.3)
Rib fracture(s)	27 (12.1)	37 (25.0)	–13 (–21.5 to –5.0)

Data are reported as n (%)
*Exact 95% CI for the difference in rate.[22]

Table 3
Abnormal Physical Examination Findings in Patients With Pneumothoraces

Physical Examination Findings	Occult Pneumothorax (n = 224)*	Nonoccult Pneumothorax (n = 148)*	Rate Difference, % (95% CI)†
Abnormal thoracic examination	141 (64)	113 (77)	–13 (–22 to –4)
Evidence of thoracic wall trauma	102 (46)	80 (55)	–9 (–19 to 2)
Thoracic wall tenderness	70 (32)	69 (47)	–15 (–25 to –5)
Abnormal auscultation	31 (14)	34 (23)	–9 (–17 to –1)
Absent/decreased breath sounds	33 (15)	52 (35)	–20 (–30 to 11)
Hypotension (age-adjusted)	13 (6)	9 (6)	0 (–6 to 5)
GCS ≤ 13	62 (28)	45 (30)	–3 (–12 to 7)
Tachypnea (age-adjusted)			
Yes	62 (28)	56 (39)	–11 (–21 to –1)
Endotracheal intubation	45 (20)	29 (20)	0 (–9 to 8)

Data are reported as n (%).
GCS = Glasgow Coma Scale.
*Missing data are not included in percentages.
†Exact 95% CI for the difference in rate.[22]

Table 4
Abnormal Physical Examination Findings in Patients With Occult Pneumothoraces Compared to Those Without Pneumothoraces

Abnormal Physical Findings	Occult Pneumothorax (n = 224)*	No Pneumothorax (n = 7,648)*	Rate Difference, % (95% CI)†
Abnormal thoracic examination	141 (64)	2,423 (32)	32 (25–38)
Evidence of thoracic wall trauma	102 (46)	1,426 (19)	28 (21–34)
Thoracic wall tenderness	70 (32)	1,354 (18)	14 (8–20)
Abnormal auscultation	31 (14)	114 (2)	13 (9–18)
Absent/decreased breath sounds	33 (15)	156 (2)	13 (9–18)
Hypotension (age-adjusted)	13 (6)	134 (2)	4 (2–8)
GCS ≤ 13	62 (28)	807 (11)	17 (12–23)
Tachypnea (age-adjusted)			
Yes	62 (28)	1661 (22)	6 (1–12)
Endotracheal intubation	45 (20)	463 (6)	14 (9–20)

Data are reported as n (%).
GCS = Glasgow Coma Scale.
*Missing data are not included in percentages.
†Exact 95% CIs for the difference in rate.[22]

DISCUSSION

In this large prospective study of children with blunt torso trauma undergoing ED CXR, pneumothoraces were diagnosed in approximately 5% of patients. Over one-half of the pneumothoraces identified, however, were considered occult (identified on cervical, chest, or abdominal CT and not on ED CXR). Children with occult pneumothoraces were less likely to have abnormal physical examination findings compared to those with nonoccult pneumothoraces identified on CXR. They were also less likely to have tube thoracostomies placed than children with nonoccult pneumothoraces. Most children with occult pneumothoraces were managed without tube thoracostomies, even among those children undergoing positive pressure ventilation.

With the increasing use of CT in the evaluation of trauma patients,[9–12] the diagnosis of small pneumothoraces not visualized on initial CXR is becoming more frequent.[7,13,14,16,23] Upright CXR is more sensitive for detecting pneumothoraces, compared to supine CXR.[16] In the supine position, which is typical for the initial trauma evaluation, a pneumothorax is positioned in the least dependent spaces, including the anteromedial and cardiophrenic regions and the subpulmonic recess.[23,24] None of these areas are well visualized on CXR.[25] Obtaining upright posteroanterior CXRs on trauma patients, however, is not logistically feasible in those who must remain supine due to spinal precautions.[16,25] Therefore, clinicians should be aware of the potential presence of pneumothoraces despite normal ED CXRs. In addition to CXR, ED ultrasound is another imaging modality that may be useful for identifying pneumothoraces in the early resuscitation phase, as the extended focused assessment with sonography for trauma (eFAST) has demonstrated a sensitivity of 92% to 100% for detecting pneumothoraces among blunt trauma patients.[15]

The prevalence of occult pneumothoraces in adults with blunt torso trauma ranges from 1.8% to 12%, but this varies by the population sampled (i.e., all injured ED patients versus patients entered into a trauma

Table 5
Hospital Practice Variability of Tube Thoracostomy Placement for Pneumothoraces

Hospital	Number Enrolled in Parent Study	Occult PTX	Nonoccult PTX	Total With Tube Thoracostomy, *n* (% of PTX)	Occult PTX and No Other Injuries, Tube Thoracostomy, *n/N* (%)	Occult PTX and other Injuries,* Tube Thoracostomy, *n/N* (%)	Nonoccult PTX and No Other Injuries, Tube Thoracostomy, *n/N* (%)	Nonoccult PTX and Other Injuries,* Tube Thoracostomy *n/N* (%)
1	1,215	23	20	21 (49)	0/1 (0)	6/22 (27)	0/0	15/20 (75)
2	424	27	17	17 (39)	0/3 (0)	5/24 (21)	0/2 (0)	12/15 (80)
3	310	24	16	16 (40)	0/1 (0)	3/23 (13)	0/0	13/16 (81)
4	840	12	14	11 (42)	0/0	1/12 (8)	1/2 (50)	9/12 (75)
5	724	20	17	11 (30)	0/0	1/20 (5)	2/4 (50)	8/13 (62)
6	354	16	10	11 (42)	0/0	3/16 (19)	0/2 (0)	8/8 (100)
7	615	14	4	6 (33)	0/1 (0)	4/13 (31)	0/1 (0)	2/3 (67)
8	613	19	9	4 (14)	0/0	3/19 (16)	0/5 (0)	1/4 (25)
9	484	8	6	4 (29)	0/1 (0)	2/7 (29)	0/1 (0)	2/5 (40)
10	217	9	6	4 (27)	0/1 (0)	2/8 (25)	0/1 (0)	2/5 (40)
11	183	6	4	4 (40)	0/1 (0)	1/5 (20)	0/0	3/4 (75)
12	368	4	5	3 (33)	0/0	1/4 (25)	0/2 (0)	2/3 (67)
13	254	20	4	2 (8)	0/1 (0)	2/19 (11)	0/1 (0)	0/3 (0)
14	142	2	3	2 (40)	0/0	0/2 (0)	0/0	2/3 (67)
15	219	13	3	1 (6)	0/0	1/13 (8)	0/0	0/3 (0)
16	113	3	1	1 (25)	0/0	0/3 (0)	0/0	1/1 (100)
17	75	0	4	1 (25)	0/0	0/0	1/3 (33)	0/1 (0)
18	39	2	1	1 (33)	0/1 (0)	0/1 (0)	0/0	1/1 (100)
19	732	1	4	0 (0)	0/0	0/1 (0)	0/0	0/4 (0)
20	99	1	0	0 (0)	0/1 (0)	0/0	0/0	0/0

GCS = Glasgow Coma Scale; PTX = pneumothorax.
*Includes the presence of any other significant injury, defined by the following: GCS score < 14, intra-abdominal injury, other thoracic injury in addition to pneumothorax, femur fracture and/or pelvic fracture.

registry).[2,3,15,26] In children, the prevalence of occult pneumothoraces is less well described, but appears to be similar to that identified in adults. A prospective observational study of injured children younger than 16 years old identified occult pneumothoraces in 3.7% of their 538 patients undergoing CXRs and abdominal CT scans.[6] The current study expands on the available published data regarding children with occult pneumothoraces, and the large sample in the current study provides narrow CIs around important point estimates. The proportion of occult pneumothoraces was 2.8% for the 8,020 patients undergoing initial ED CXR and 4.7% when considering only the 4,276 that underwent both CXR and abdominal CT.

Data on physical examination findings in children with occult pneumothoraces have previously been very limited. The current study provides clarifying information on the physical examination findings in patients with and without pneumothoraces. Not surprisingly, children with nonoccult pneumothoraces were more likely to have abnormal physical examination findings (e.g., tachypnea, thoracic wall tenderness, or abnormal chest auscultation) than children with occult pneumothoraces. Similarly, children with occult pneumothoraces were more likely to have abnormal physical examination findings compared to those children without pneumothoraces. Furthermore, this study demonstrates that 15% of children with occult pneumothoraces have "normal" physical examinations (GCS scores 14 or 15, normal respiratory rates and blood pressures, no thoracic tenderness or evidence of thoracic wall trauma, and normal chest auscultation). Although this rate may appear high, it is similar to the 9% previously reported in a small, prospective study.[6]

The current study also provides data on the additional traumatic injuries identified on the ED CXR in patients with occult pneumothoraces compared to those with nonoccult pneumothoraces. Additional injuries were identified in one-third of patients with occult pneumothoraces, which is higher than the 18% previously reported.[6] Also, we identified more additional injuries in patients with nonoccult pneumothoraces (rib fractures, hemothoraces) than patients with occult pneumothoraces.

A traumatic pneumothorax may result in respiratory compromise or progress to a potentially life-threatening tension pneumothorax. Tube thoracostomy is the treatment of choice for a clinically important pneumothorax,[5] but there is no consensus or standards about the optimal management for occult pneumothoraces. Given the morbidity and complications associated with tube thoracostomies, the procedure should not be performed based on radiographic findings alone.[2,27] Tube thoracostomy is often recommended for patients with occult pneumothoraces undergoing positive pressure ventilation as a prophylactic measure against development of tension pneumothorax.[5] A systematic review of three adult randomized trials (tube thoracostomy vs. observation for patients with occult pneumothorax) found no statistically significant difference in the rate of pneumothorax progression between those treated and not treated with tube thoracostomy. The authors concluded that observation was at least as safe and effective as tube thoracostomy in these patients.[15] A retrospective study of adults with occult pneumothoraces also found that 51

of the 59 (86%) patients were managed successfully without tube thoracostomy, including 16 of the 20 (80%) exposed to positive-pressure ventilation.[28]

A recent prospective multicenter study identified risk factors for clinical deterioration and management strategies in 448 pediatric and adult trauma patients with occult pneumothoraces who were initially observed.[3] Twenty-seven patients (6%) ultimately underwent tube thoracostomies for progression of their pneumothoraces, respiratory distress, or hemothoraces, and the authors concluded that blunt trauma patients with occult pneumothoraces could be carefully monitored without initial tube thoracostomies.[3] This same study group also separately evaluated 51 pediatric trauma patients with occult pneumothoraces, of whom 49 were initially observed. Only two patients had progression of their occult pneumothoraces, and one underwent an undefined elective intervention. A third patient experienced a period of respiratory distress, but did not require a tube thoracostomy. Of nine children with occult pneumothoraces under positive-pressure ventilation, eight were successfully managed without tube thoracostomies. These authors concluded pediatric patients with occult pneumothoraces less than 16 mm may be safely observed.[29]

The current study included 224 children with occult pneumothoraces, of whom 35 (16%) underwent tube thoracostomies. The rate was slightly higher than anticipated, as a prior small study identified a rate tube thoracostomy of only 10%.[6] When considering the subgroup of the 45 children with occult pneumothoraces who were endotracheally intubated, only 17 (38%) underwent tube thoracostomy. Furthermore, children with occult pneumothoraces were less likely to have tube thoracostomies compared to children with nonoccult pneumothoraces. Considerable institutional variability, however, exists with tube thoracostomy placement. As variability is frequently a marker of inefficient care,[30] future efforts to better standardize indications for tube thoracostomy placement in children with occult pneumothoraces is warranted. The current study demonstrates that most children with occult pneumothoraces are safely managed without tube thoracostomies.

LIMITATIONS

We had limited data on the clinical indications for, and any complications associated with, tube thoracostomy in patients with occult and nonoccult pneumothoraces, including those patients who required positive-pressure ventilation. As a result, we are not able to make specific recommendations about the role of tube thoracostomies for children with occult pneumothoraces. This was an observational study; therefore, management decisions, including placement of a tube thoracostomy, were not dictated by study protocol, but represent current, real-world practice variation. Although all patients analyzed for this study underwent CXR, they did not uniformly have CT scans performed. Therefore, there may have been more children with occult pneumothoraces who were not identified. Despite these limitations, to our knowledge, this is the largest prospectively conducted study focused on children with occult pneumothoraces after blunt torso trauma.

CONCLUSIONS

Pneumothoraces occur in approximately 5% of children with blunt torso trauma, and most are not identified on initial chest radiography. Children with occult pneumothoraces are less likely to receive tube thoracostomies compared to those with nonoccult pneumothoraces. The clinical significance of occult pneumothoraces in children with blunt torso trauma remains uncertain, although observation for children with occult pneumothoraces, even in those requiring endotracheal intubation, should be strongly considered as an alternative to tube thoracostomy for initial management.

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