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Incidental sinusitis in a pediatric intensive care unit

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Abstract

Objective—Intubation is a risk factor for nosocomial sinusitis in adult intensive care patients. Sinusitis in intubated adults can be an occult cause of fever. In children nasal intubation may be associated with a greater risk of sinusitis. No pediatric study has determined the incidence of nosocomial sinusitis in the pediatric intensive care unit (PICU) setting. We hypothesized that within a subset of patients who had head CT imaging: (1) the incidence of sinusitis in PICU patients exceeds the incidence in non-PICU patients; (2) the incidence of sinusitis is greater in PICU patients with a tube (nasotracheal, nasogastric, orotracheal, or orogastric); and (3) nasal tubes confer an increased risk for sinusitis compared to oral tubes.

Design—Retrospective chart review

Setting—Independent not-for-profit pediatric healthcare system

Patients—PICU and non-PICU (inpatients hospitalized on medical-surgical wards) patients referred for head CT

Interventions—None

Measurements and Main Results—CT images were evaluated for the presence of a tube and sinusitis. Images were scored using the Lund-MacKay (LM) staging system. Sinusitis was defined as a LM score >3.5. 596 patients were studied; 395 (66.3%) PICU. 197 (50%) PICU versus 69 (34.3%) non-PICU patients had sinusitis ($p < 0.001$). 108/147 (73.5%) PICU patients with a tube present had sinusitis versus 88/248 (35.9%) of those without a tube present ($p < 0.001$). There was no significant difference in sinusitis based on tube location ($p = 0.218$). Younger age or the presence of a tube increased the probability of sinusitis ($p < 0.001$).

Conclusions—Almost 50% of our PICU patients imaged for reasons other than evaluation for sinus disease had evidence of sinusitis. This finding raises the concern that sinusitis in PICU patients is common and likely should be considered in the differential diagnosis of fever in PICU patients.

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Keywords

Sinusitis; PICU; Lund-Mackay; endotracheal tube; nasotracheal tube

INTRODUCTION

Endotracheal intubation is a risk factor for nosocomial sinusitis in adult intensive care patients (1–5). In adult patients, those with nasotracheal tubes have a higher incidence of this complication than those with oral tubes (6–10). Furthermore, sinusitis in intubated adult patients can be an occult cause of fever and evolve into secondary complications such as bacteremia, sepsis, or ventilator associated pneumonia (VAP) (11–15). As a consequence, the 2004 joint guidelines by the American Thoracic Society and the Infectious Disease Society of America for VAP explicitly recommend that nasotracheal tubes be avoided. Oral tubes (endotracheal and gastric), rather than nasal tubes, are recommended to reduce the frequency of nosocomial sinusitis and possibly VAP; although causality has not been firmly established (16).

Depending on the population studied and the method used the frequency of maxillary sinusitis in the adult critical care population ranges from 2% to 78% (3, 17). Sinus ultrasounds performed on surgical patients found that 36 of 46 with nasotracheal tubes had sinus abnormalities as early as five days after tube placement (17). Water's view portable radiography, demonstrated that 48% of patients intubated by the nasal route for greater than 48 hours develop evidence of maxillary sinusitis (8). Computed tomography (CT) evidence of paranasal sinusitis was discovered in 25% of nasally intubated head injury patients (6). Clinical criteria coupled to CT imaging and direct sinus aspirate resulted in 18% of nasally intubated patients receiving a diagnosis of maxillary sinusitis (15).

Although the adult literature is compelling, no population based pediatric study has been performed to determine either the incidence of nosocomial sinusitis or its complications in pediatric intensive care units (PICU). The most recent edition of Roger's textbook of pediatric intensive care provides an unreferenced word of caution: "In older children, nasal intubation may be associated with a greater risk of sinusitis or otitis media than is oral intubation" (18). One pediatric case report describes three intubated pediatric patients with sinusitis; demonstrating that this problem exists in younger critically ill patients (19). The incidence and implications of nosocomial sinusitis in pediatric intensive care are as of yet undefined.

Several studies have shown that sinus imaging in pediatric populations is complicated by a high rate of abnormalities in patients without sinusitis (20, 21). Because of this the American Academy of Otolaryngology recommends using the Lund-Mackay (LM) system to radiographically stage sinusitis on CT (22).

Using an adapted LM system, we sought to determine the incidence of nosocomial sinusitis in subset of PICU patients (23). We hypothesized that: (1) the incidence of sinusitis in PICU patients as demonstrated by head CT exceeds the incidence in non-PICU patients; (2) the incidence of sinusitis is greater in PICU patients with a tube present (nasotracheal, nasogastric, orotracheal, or orogastric); and (3) nasal tubes confer an increased risk for sinusitis compared to oral tubes.

MATERIALS AND METHODS

Subjects

All PICU and non-PICU patients (aged 1 week to 18 years) referred for head CTs from January 2006 through September 2008 were eligible for enrollment. Non-PICU patients were defined as inpatients hospitalized on the medical-surgical wards during the study period. Patients less than 1 week of age, NICU patients, patients with cystic fibrosis or a well defined immunodeficiency syndrome, and those with known injury to the facial bones or anterior cranial vault were excluded. This retrospective study was approved by the Institutional Review Board review at Children's Hospitals and Clinics of Minnesota. Informed consent was not required because the research presented no more than minimal risk.

Procedures

Head CT images were reviewed in reverse chronological order. In addition to scoring the sinuses, the images were used to determine if a patient had an oral or nasal tube present, and to identify the indication for imaging. Chart review was used to determine if the observed tube was an endotracheal tube or gastric tube, and to document patient location, date of admission, gender, age, immune status, underlying medical problems, and number of days the endotracheal tube was in place. All images and charts were reviewed and scored by the primary investigator (24).

CT Scoring by Lund-MacKay Staging System

CT images were evaluated for sinus changes and scored using the LM staging system. The LM system quantifies radiographic findings on CT; allowing one to determine the degree of abnormality on a given patient's scan. The LM system scores a total of 6 factors on the left and 6 factors on the right (anterior ethmoid, posterior ethmoid, maxillary, frontal, and sphenoid sinuses, and osteomeatal complex) for a total of 12 factors. Sinuses are scored according to the following scale: 0, no opacification; 1, partial opacification; 2, complete opacification (22, 24).

Based on the work done by others, the diagnosis of sinusitis was defined by a LM score > 3.5 (25, 26). A previous study determined that the mean incidental LM score in a general pediatrics population, in the absence of sinusitis symptoms, was 2.8 (25). Another study found that by adopting a LM score of 5 for true disease, CT demonstrated a sensitivity and specificity of 86% and 85%, respectively. LM scores of ≤ 2 had an excellent negative predictive value, LM scores ≥ 5 had an excellent positive predictive value, and scores between 3 and 4 were equivocal (26). So as not to miss an equivocal score, we chose a cutoff of 3.5.

We did not include the osteomeatal complex because it is not possible to score this factor accurately with head CT images. The LM score was adjusted to range from 0 to 24 by scaling with the factor $12/n$, where n represents the number of scoreable (pneumatized) sinuses (24).

Sample size calculations

The total sample size was selected to detect an absolute difference of 10% at a power of 80% in the incidence of sinusitis between PICU and non-PICU patients. For sub-group comparisons utilizing Chi-square analysis, 100 patients in each group allowed detection of a difference in the incidence of sinusitis of 20% at a power 80% and an alpha of .05.

Statistical Analysis

Frequency distribution was used to describe categorical variables such as gender and location. Median (range) was used to describe continuous variables such as age and adjusted LM score. PICU and non-PICU patients were matched age, season, and gender. Matched patients were treated as paired data, so LM scores between PICU patients and matched non-PICU patients were compared using the non-parametric Wilcoxon Signed Ranks test. The incidence of sinusitis was compared between PICU patients with and without a tube present using Chi-square analysis. Additionally, LM scores for patients with oral versus nasal tubes were compared using the non-parametric Mann-Whitney Test. LM scores by age categories (i.e., 0–1 year, 2–5, 6–11, 12–18) and type of tube (oral, nasal, or both) were compared using the Kruskal-Wallis Test. A multivariate linear regression model was used to evaluate variables that predict LM scores. To assess the impact of individual factors on the incidence of sinusitis, a logistic regression model was fit to predict sinusitis in PICU patients. A two-sided p-value <0.05 was used for significance. All analyses were conducted with SPSS V15.0 (SPSS, Chicago, IL).

RESULTS

Study Population

600 images and charts were reviewed. Two patient's images were excluded because they had imaging performed twice on the same day. One patient was excluded due to facial trauma and another because the frontal sinuses were involved in a surgical procedure. 596 patients were included in the final analysis. 395 (66.3%) were PICU patients and 201 (33.7%) were non-PICU patients. There were 360 (60.4%) males and 236 females (39.6%). Median age was 3.3 years (range 0–17.9). Patients with tubes present were evenly distributed by season ($p=0.423$), however, fall and winter season influenced the rate of sinusitis ($p=0.014$), with high rates of sinusitis noted in the fall/winter. Overall, the primary indication for imaging was shunt malfunction 179 (30%).

Sinusitis. Matched PICU vs. non-PICU Patients

Table 1 compares the incidence of sinusitis and LM scores between the PICU and non-PICU populations. To determine the magnitude of the incidence of CT diagnosed sinusitis and to delineate differences between the PICU patients and non-PICU patients, patients were matched based on age, gender and season (Table 1). The most common indications for head CT for both populations were ventriculoperitoneal shunt malfunction, other, seizure, and trauma. There were more PICU patients with tubes present ($p<0.001$). The non-PICU patients with tubes all had gastric (either orogastric or nasogastric) tubes. There was a statistically significant difference between the incidence of sinusitis and median adjusted LM scores ($p=0.007$, $p=0.007$).

Nasal vs. Oral Tubes and Sinusitis in PICU Patients

Table 2 compares PICU patients with and without a tube present and differences based on the location of the tube. PICU patients with a tube present were more likely to have sinusitis when compared to patients without a tube ($p<0.001$). There was not a statistically significant difference in the incidence of sinusitis based on the location of the tube ($p=0.218$). This was also the case when oral tubes were compared to nasal tubes plus both (nasal+oral) ($p=0.193$). The median adjusted LM score in the PICU patients with a tube present was significantly higher than those without a tube ($p<0.001$). There was not a statistically significant difference in the median adjusted LM score based on the location of the tube when nasal, oral and both were looked at individually or when nasal and both (nasal+oral) were combined ($p=0.622$ and $p=0.626$, respectively).

Factors that influence LM Score and incidence of sinusitis

Patient age and presence of a tube were two factors that influenced the adjusted LM score and the incidence of sinusitis. As age increased, the mean LM scores decreased ($p < 0.001$). The mean LM score for patients with tubes present was 7 points higher than that for patients without tubes. Patients without tubes were 77% less likely to have sinus abnormalities compared to patients with nasal tubes present ($p < 0.001$).

DISCUSSION

This is the first population based pediatric study to evaluate the presence of sinusitis in PICU patients and to attempt to determine if endotracheal intubation increases the risk of sinusitis. For the purpose of this study we defined sinusitis using a validated imaging score. We found that in a subset of patients the incidence of sinusitis in PICU patients as demonstrated by head CT exceeds the incidence in non-PICU patients referred for CNS imaging (< 0.001), and that the incidence of sinusitis was greater in PICU patients with a tube present (nasotracheal, nasogastric, orotracheal, or orogastric) (< 0.001).

Our findings are important for several reasons. First, this study suggests that the frequency of sinus abnormalities in this PICU might be quite high. Our study population was restricted to PICU patients who received head CTs for any indication and nearly 50% of this population had sinusitis (defined as a LM > 3.5). Although sinusitis is frequently suspected as an occult cause of fever in adults, it is not commonly considered in the PICU setting. Our results suggest that sinusitis must be common, considering that head CT scans obtained in this PICU population were not obtained for sinus assessment. These were incidental findings for patients who were imaged for other indications. PICU patients with fever are commonly evaluated with chest x-rays, blood cultures, endotracheal tube cultures, and urine cultures, and are empirically started on antibiotic therapy. A formal sinus evaluation is rarely done when looking for an occult cause of their fever. Depending on the clinical picture, a negative fever evaluation often results in cessation of antibiotics after 48–72 hours. If these patients with fever have occult sinusitis, then we are undertreating them. Undertreatment or failure to recognize sinusitis may evolve into other complications such as bacteremia, sepsis, or VAP (8, 11–15, 17).

Another important contribution from this study is the identification of specific risk factors for sinusitis. We discovered that PICU patients with intra-facial tubes present had a higher risk of sinusitis. Younger age also constitutes a specific risk factor. It is noteworthy that in the most recent edition of Roger's textbook of pediatric intensive care the risk of sinusitis is limited to older children with nasal tubes (18).

Although no statistical difference was found between the presence of oral and nasal tubes, nasal tubes did have a significantly higher risk of sinusitis than having no tube present. Oral versus nasal tube placement varies between institution and providers, with some PICUs and some providers preferring nasal tube placement. Our results suggest that this may confer an increased risk for sinusitis, and had our study been powered to detect this difference a statistically significant difference may have been seen. In adults, nasal tubes do increase the risk of sinusitis, and sinusitis has been found to evolve into secondary complications (8, 11–15, 17). With the current nationwide push to develop strategies to minimize VAP, we suggest that nasal tubes should be used with caution and we hope that future studies will be conducted to strengthen the link between sinusitis and VAP in children.

This study has several limitations. It is a retrospective study that relied on CT images and a limited chart review. Interpretive imaging bias was minimized by having clearly defined inclusion criteria and careful training of the non-radiologist in the use of the LM scoring

system (25). We did not correlate CT findings with clinical symptoms, therefore it is possible that the findings on CT were simply mucosal inflammation and they do not represent “true” sinus disease. Others have expressed concern about the extreme sensitivity of the CT scan, acknowledging that CT may lead to over diagnosis of sinusitis. They determined that a “normal” or incidental Lund score in children without sinusitis was 2.8. The incidental findings were less common in children than similarly studied adult patients (25, 26). In our population we used a cutoff of 3.5 making it less likely that false positive results would occur, and that the sinus abnormalities seen represent “true” sinusitis. The positive and negative predictive value of CTs are dependent on the prevalence of sinusitis. In our study the prevalence of sinus changes was greater in the PICU population, thus interpretation of CT scans should include this clinical context (24). Finally, our study was powered to find a difference between the PICU and non-PICU populations, not to find a difference between oral and nasal tubes. Although we hypothesized that nasal tubes would confer an increased risk for sinus abnormalities compared to oral tubes, this failed to reach statistical significance ($p=0.218$). To detect an absolute difference of 10% at a power of 80% and an alpha of 0.05, we would have needed 350 cases in both the oral and nasal tube groups. Although cause and effect of the risk of a nasal tube over an oral tube cannot be proven from our data, significant trends have been identified.

CONCLUSIONS

Almost 50% of our PICU patients imaged for reasons other than evaluation for sinus disease had evidence of sinusitis. This finding raises the concern that sinusitis in PICU patients is common and should be considered in the differential diagnosis of fever in PICU patients. Future studies should focus on correlating sinus abnormalities with clinical symptoms, determining the best way of evaluating for sinusitis in the PICU setting, and elucidating whether or not nasal tubes confer an increased risk of sinusitis.

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Abbreviations

PICU	Pediatric Intensive Care Unit
LM	Lund-Mackay staging system
VAP	Ventilator associated pneumonia
HAP	Hospital acquired pneumonia
CT	Computed tomography
CNS	Central nervous system
NICU	Neonatal intensive care unit
SD	Standard deviation
ANOVA	Analysis of variance

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Table 1

Comparisons between Matched PICU Patients and Non-PICU Patients

	Non-PICU (n=197)	PICU (n=197)	p-value
Age (years), median (range)	3.3 (0, 17.6)	3.6 (0, 17.9)	0.387
Gender (Male), n (%)	131 (66.5)	131 (66.5)	1.0
Indication, n (%)			
Ventriculoperitoneal Shunt Malfunction	27 (35.5)	72 (50.7)	<0.001
Other	49 (24.9)	70 (35.5)	
Seizure	35 (17.8)	25 (12.7)	
Trauma	35 (17.8)	17 (8.6)	
Headache	23 (11.7)	0	
Altered mental status	12 (6.1)	13 (6.6)	
Vomiting	10 (5.1)	0	
Fever	4 (2.0)	0	
Tube Present, n (%)	9 (4.6)	74 (37.6)	<0.001 *
Sinusitis (LM > 3.5), n (%)	69 (35)	95 (48.2)	0.007 *
Adjusted Lund-Mackay scores, median (range)	0 (0, 24)	3 (0, 24)	0.007 **

* McNemar Test,

** Wilcoxon Signed Ranks Test

Table 2

Comparison of Sinusitis and Adjusted Lund-MacKay scores in PICU Patients

	Sinusitis (LM > 3.5) n (%)	p-value	Adjusted LM score (median, range)	p-value
<u>Tube Present</u>				
No (n=248)	88 (35.9)	<0.001	0 (0, 24)	<0.001
Yes (n=147)	108 (73.5)		12 (0, 24)	
<u>Type of tube</u>				
Nasal (n=61)	44 (72.1)	0.218	10 (0, 24)	0.622
Oral (n=41)	27 (65.9)		12 (0, 24)	
Both (nasal+oral) (n=45)	37 (82.2)		14.4 (0, 24)	
<u>Type of tube</u>				
Oral only (n=41)	27 (65.9)	0.193	12 (0, 24)	0.626
Nasal+Both (nasal+oral) (n=106)	81 (76.4)		12 (0, 24)	