Research Article / Özgün Araştırma

DOI: 10.4274/cayd.galenos.2024.70493
J Pediatr Emerg Intensive Care Med 2024;11:85-9

Nasogastric and Endotracheal Tubes as Risk Factors for Sinusitis in Critically Ill Children: A Retrospective Case-control Study

Kritik Hasta Çocuklarda Nazogastrik ve Endotrakeal Tüp Kullanımı ile Sinüzit Gelişimi Arasındaki İlişkinin İncelenmesi: Geriye Dönük Olgu-kontrol Çalışması

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Abstract

Introduction: Unknown fever in critically ill patients could be caused by occult sinusitis, which may also be related to healthcare interventions. The aim of this study was to uncover the correlation between a tube in the upper airways and children's susceptibility to sinusitis.

Methods: We retrieved data retrospectively and evaluated radiological images for the presence of nasogastric (NG) and endotracheal (ET) tubes, as well as any findings of sinusitis or nasopharyngeal (NF) secretions. We also recorded the intervals between the images.

Results: The study included 65 patients with a total of 162 images. The results showed a significant increase in the occurrence of sinusitis between the first (13/30, 43.3%) and second (20/30, 66.6%) images (p=0.039). The cut-off time for the onset of sinusitis was found to be 2.5 days [area under the curve: 0.50, 95% confidence interval (CI): 0.355-0.646]. There was no significant difference in the occurrence of sinusitis or NF secretion formation between single or double tubes (p=0.389). The presence of an NG or ET tube also did not show a significant relationship with sinusitis. However, the study found that NF secretions were present in 52% of images with an ET tube [p=0.004, odds ratio (OR): 6.21, 95% CI: 0.001-0.003] and 84% with an NG tube (p=0.003, OR: 6.9, 95% CI: 0.001-0.003).

Conclusion: The placement of NG and ET tubes, separately or combined, can raise the likelihood of sinusitis development in critically ill children due to reduced clearance of NF secretions.

Keywords: Sinusitis, nasogastric tube, endotracheal tube, critical care

Öz

Giriş: Erişkinlerde iyi belirlenmiş bir risk faktörü olan okült sinüzit kritik çocuk hastalarda nedeni bilinmeyen ateşe neden olabilir ve sağlık bakımı ile ilişkili olabilir. Bu çalışmanın amacı çocuklarda nazogastrik ve endotrakeal tüp kullanımı ile sinüzite yatkınlık arasındaki ilişkiyi ortaya koymaktır.

Yöntemler: Verileri geriye dönük olarak elde ettik ve radyolojik görüntüleri nazogastrik (NG) ve endotrakeal (ET) tüplerin varlığının yanı sıra sinüzit veya nazofaringeal (NF) sekresyon belirtileri açısından değerlendirdik. Ayrıca görüntüler arasındaki aralıkları da kaydettik.

Bulgular: Toplam 162 görüntü ile 65 hasta çalışmaya dahil edildi. Sonuçlar, birinci (13/30, %43,3) ve ikinci (20/30, %66,6) görüntüler arasında sinüzit oluşumunda anlamlı bir artış olduğunu gösterdi (p=0,039). Sinüzit başlangıcı için kritik süre 2,5 gün olarak belirlendi [eğri altında kalan alan: 0,50, %95 güven aralığı (GA): 0,355-0,646]. Tek ve çift tüp arasında sinüzit oluşumu ve NF sekresyonu açısından anlamlı fark yoktu (p=0,389). NG veya ET tüpünün varlığı da sinüzit ile anlamlı bir ilişki göstermedi. Ancak ET tüplü görüntülerin %52'sinde [p=0,004, olasılık oranı (OO): 6,21, %95 GA: 0,001-0,003], NG tüplü görüntülerin ise %84'ünde (p=0,003, OO: 6,9, %95 GA: 0,001-0,003) NF sekresyonlarının olduğu belirlendi.

Sonuç: NG ve ET tüplerinin ayrı ayrı veya birlikte kullanımı, NF sekresyonların temizlenmesinin azalması nedeniyle kritik hasta çocuklarda sinüzit gelişme olasılığını artırabilir.

Anahtar Kelimeler: Sinüzit, nazogastrik tüp, endotrakeal tüp, yoğun bakım

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Received/Geliş Tarihi: 06.02.2024 **Accepted/Kabul Tarihi:** 08.03.2024

Introduction

When treating critically ill pediatric patients, endotracheal (ET) and nasotracheal (NT) tubes are commonly used. The ET route is the preferred method of intubation for both adults and children. In contrast, nasotracheal intubation is less common, accounting for only 5.6% and 4% of advanced airway procedures in children and adults, respectively.[1,2] The use of ET and NT tubes has been identified as a significant risk factor for developing nosocomial sinusitis, which could lead to sepsis in critically ill adults.[3,4] Children may have a higher risk of developing sinusitis because of their smaller airways and anatomical differences compared with adults. This can be particularly concerning for pediatric intensive care unit (PICU) patients with intubation tubes.[5] According to research, proper aeration and clearance of mucosal secretions are crucial for preventing related sinusitis caused by NT. Typically, patients with an advanced airway receive their nutritional needs through nasogastric (NG) or orogastric tubes, but the link between these tubes and sinusitis in children is not well established.[6,7] This study investigated the potential development of sinusitis in PICU patients facilitated by NG or ET tubes.

Materials and Methods

This research was conducted in the 16-bed PICU of Hacettepe University, a tertiary referral center in Turkey. The study included all patients (one month to 18 years old) who were referred to our PICU and underwent cranial radiological examination [computed tomography (CT) or magnetic resonance imaging (MRI)] from June 2011 to February 2018. Patients aged 4 months, those with primary immunodeficiency syndromes, recent chemotherapy for a neoplasm, fascial bone anomaly, known injury to facial bones or anterior cranial vault, and patients with only one image were excluded from the initial enrollment. In this study, patients with at least two cranial images were included and underwent radiological re-evaluations by a pediatric neuroradiologist. We recorded the presence of sinusitis, NG tube, ET tube, and secretions in the nasopharyngeal area and each study's timing and type of examination. The tube count of each test was also evaluated and categorized into "none," "one (NG or ET)," and two (NG+ET) tube groups. Ethical approval was obtained from the Ethical Committee of Hacettepe University Faculty of Medicine, and the study was performed according to the ethical standards of the 1964 Declaration of Helsinki and its later amendments.

Statistical Analysis

In this study, both normally and non-normally distributed variables were analyzed using SPSS v23.0. Mean and standard deviations were used to represent normally distributed variables, whereas median and interquartile range were used for non-normally distributed variables. Categorical variables are presented as proportions and percentages. The Mann-Whitney U test was used to compare the median age of patients with and without sinusitis. In addition, the chi-square test was used to compare the ratios of sinusitis and the presence of NG tube alone, ET tube alone, and NG + ET. The McNemar test was used for the dependent variables. The time between two consequent examinations was considered to be between the NG tube duration and sinusitis occurrence. ROC curve analysis was performed to search for a cut-off time, and significant cut-off values were presented in terms of sensitivity, specificity, and positive and negative predictive values. A p-value of 0.05 was considered significant.

Results

From 2011 to 2018, 3577 patients were monitored in the PICU. Of these patients, 229 had 694 head scans, either CT or MRI, for various reasons. Images of repeated scans of the same patients, single images, and scans of patients under 4 months of age or with facial trauma were excluded after the initial assessment. We conducted a second evaluation of the images and excluded those that did not cover all anatomical areas or had artifacts. We also removed the 4th and 5th images because of their small numbers. Our study included 65 patients and 162 images, of which 101 were CT and 61 were MRI (see Figure 1).

The median age of the patients was 6.4 years, ranging from 4 months to 17.4 years. Traumatic brain injury was the most common diagnosis (32.8%), followed by acute

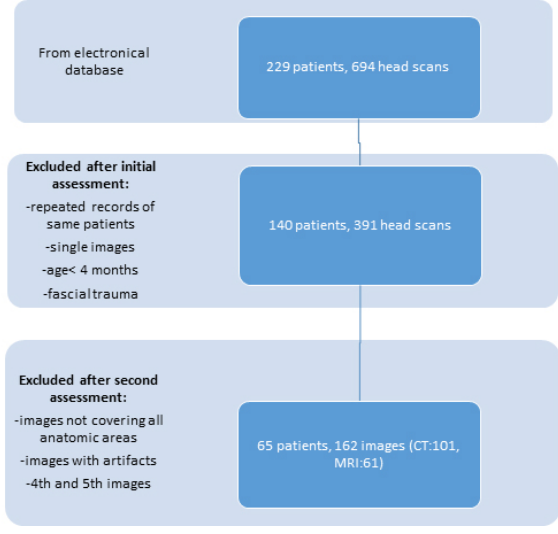

Figure 1. Patient selection to the study
MRI: Magnetic resonance imaging

neurological dysfunction (30.8%) due to various diseases such as hemorrhage, tumors, and meningitis. Approximately 15.2% of patients had a history of neoplasm, whereas others had respiratory diseases like pneumonia and acute respiratory distress syndrome, cardiovascular diseases like fatal arrhythmias and heart failure, shock, liver failure, and adrenal insufficiency.

No findings were suggestive of an invasive fungal infection. Of the first images taken, 46% (n=30) showed signs of sinusitis, regardless of whether the patient had an NG or ET tube (Table 1). Among the images where there was no sinusitis present in the first image (n=35), 12 (34.2%) of them had sinusitis in the second image, making the incidence of sinusitis 60% in the second image. Three patients who had sinusitis in the first image showed no signs in the second image. One patient had no NG tube in either image, another had both images taken on the same day, and the last one had an NG tube in both images taken 11 days apart. The median age of patients affected by sinusitis and those who were not were similar (p=0.445).

The median time between admission and the first images taken was 1 day (1-30 days). The time between the first and second images was a median of 2 (1-6) days, and the time between the second and third images was 3.5 (1.5-8.5) days. There was no significant difference between single or double tube presence with sinusitis or NF secretion formation (p=0.389). Similarly, there was no significant relationship between the presence of an NG or ET tube. However, we found an NG tube in 84% of images with NF secretions and an ET tube in 52% (p=0.003 and p=0.004, respectively) (Table 2). Sinusitis was present in 17 (44.7%) of the images with at least one tube and 13 (48.1%) of the images without any tubing, with no significant difference between them (p=0.806). On the other hand, NF secretion was found in 17 of 38 images with at least one tube and in 2 of 27 images without a tube (p=0.001). Thirty patients had an NG tube in both the first and second images, and among these patients, there was a statistically significant increase in the incidence of sinusitis between the first (13/30, 43.3%) and second (20/30, 66.6%) images (p=0.039). ROC analysis showed that 2.5 days was the cut-off time for sinusitis, with an area under the curve of 0.50 and a 95% confidence interval (0.355-0.646). Thirteen (40.6%) of 32 patients with three sequential images had an NG tube during all three images, and there were no significant changes in the incidence of sinusitis and NF secretion over time (p=0.097 and p=0.264, respectively).

Table 1. The proportions of the NG tube, ET tube, sinusitis, and NF secretion of the sequential images

	First image (n=65)		Second image (n=65)		Third image (n=32)	
	+ n (%)	- n (%)	+ n (%)	- n (%)	+ n (%)	- n (%)
ET tube	17 (26)	48 (73)	14 (21)	51 (78)	9 (28)	23 (71)
NG tube	36 (55)	29 (44)	39 (60)	26 (40)	18 (56)	14 (43)
Sinusitis	30 (46)	35 (53)	39 (60)	26 (40)	17 (53)	15 (46)
NF secretion	19 (29)	46 (70)	25 (38)	40 (61)	10 (31)	22 (68)
Number of tubes						
None	27 (41)		25 (38)		12 (37)	
NG or ET tube	23 (35)		27 (41)		13 (40)	
NG plus ET tube	15 (23)		13 (20)		7 (21)	

ET: Endotracheal, NG: Nasogastric, NF: Nasopharyngeal

Table 2. The proportions of the presence of NG tube, ET tube, sinusitis, and NF secretion in the first image

	Sinusitis, n (%)*				NF secretion, n (%)*			
	Absent	Present	p	OR (95% CI)	Absent	Present	p	OR (95% CI)
ET tube								
Absent	27 (77)	21 (70)	0.514	1.62 (0.612-0.637)	39 (84)	9 (47)	0.004	6.21 (0.001-0.003)
Present	8 (22)	9 (30)			7 (15)	10 (52)		
NG tube								
Absent	15 (42)	14 (46)	0.758	1.16 (0.610-0.635)	26 (56)	3 (15)	0.003	6.9 (0.01-0.003)
Present	20 (57)	16 (53)			20 (43)	16 (84)		
Total	35	30			46	19		

*: Percentages represent within columns, ET: Endotracheal, NG: Nasogastric, NF: Nasopharyngeal, CI: Confidence interval, OR: Odds ratio

Discussion

In this retrospective study, we found that NG and ET tubes were significantly associated with increased nasopharyngeal secretions, which may increase the risk of sinusitis in critically ill children. The nasal cycle influences the mucosal lining over the nasal septum and nasal turbinates, which is responsible for alternating changes in turbinate sizes due to mucosal engorgement.[8] A foreign object such as NG, NT, or ET tubes may quickly interrupt this finely balanced mechanism. Although ET tubes do not seem to block any nasopharyngeal region, they are shown to be an independent risk factor for sinusitis in adults. A large adult study showed that compared with patients with only an NG tube, the risk for sinusitis was 41% greater in patients with an ET tube and 200% greater in patients with both tubes.[9] Another adult study reported sinusitis as a cause of fever of unknown origin (13.8%).[10] We hypothesized that lower age may be a risk factor for sinusitis because the pneumatization pattern is unique to each group of sinuses and the continuous change in the size and aeration of the sinus as a child grows. However, we did not find any significant relationship between age and the risk of sinusitis. This may be due to the small sample size.

The optimal imaging method for sinusitis is a topic of ongoing research and debate. Cranial CT scans are not typically recommended for routine diagnosis of sinusitis because they are not specific to the paranasal sinuses and may not provide the detailed imaging required for accurate assessment of sinus pathology. Paranasal sinus CT scans are specifically designed to visualize the paranasal sinuses. They have also been identified as the best imaging method for diagnosing sinusitis in children, emphasizing its importance in pediatric cases.[11,12] Furthermore, MRI provides excellent images for complex sinus disease, intracranial tumor extension, and aggressive fungal sinusitis without ionizing radiation, making it a valuable alternative to CT imaging.[13] Therefore, while cranial CT scans may provide some information about sinus pathology, they are not as specific or suitable as paranasal sinus CT scans for accurately diagnosing and evaluating sinusitis.[12] We used only cranial CT and/or MRI scans that were taken for other reasons, such as traumatic brain injury, seizures, and central nervous system infections. Thus, this may have caused misinterpretation of the imaging findings, leading to statistically insignificant results in this study.

Among PICU patients undergoing cranial imaging for any reason, we observed a high incidence of sinusitis (46%) and a 30% increase over time. NG and ET tubes were associated with increased secretions and sinusitis. Although the AUC statistics showed weak strength and a lack of data regarding contributing factors such as preexisting adenoid vegetation and a history of allergic diseases, the threshold time for developing sinusitis was 2.5 days. Nevertheless, having a facilitating factor for developing sinusitis and the need for a tube in the upper airways could accelerate the risk of sinusitis, and it could be faster than usual with a critical illness. Therefore, healthcare professionals should be aware of occult sinusitis as an etiology of fever, even in the short term. Healthcare-related infections, such as venous or urine catheter-related infections, have a crucial impact on morbidity and mortality. The burden of these infections is significant because of their preventable nature. Sinusitis is a common healthcare-related condition that frequently occurs in adult intensive care settings. It may be associated with fever of unknown origin and sepsis.[3]

Sinusitis is the most common (40.2%) predisposing factor in pediatric patients with orbital or preseptal cellulitis.[14] It can cause localized neurological diseases such as brain abscesses and subdural empyema, which could require intensive care treatments.[15] The incidental sinusitis rate in the PICU is approximately 50%.[5] We found that 46% of the 65 patients had sinusitis in their first cranial examination, which supports previous reports. Because PICU patients are often intubated and sedated or obtunded, sinusitis is often difficult to diagnose because there are no complaints of nasal congestion or drainage, facial pain, cough, or headache. Thus, radiological evaluation is the best screening tool for such patients.[16]

For intensive care patients, it is inevitable to have an artificial material for specific treatments, nutrition, and fluid balance monitoring (intravenous catheters, ET and NG tubes, urinary catheters, etc.). All these materials have their own risk of complications and increase the risk of nosocomial infections. It is wise to use them when necessary, and they should be removed as soon as possible to avoid the abovementioned risks. If they are needed longer, alternatives such as tracheostomy and gastrostomy should be considered and not delayed. In critically ill children with fever of unknown origin, occult sinusitis should not be missed, and empiric antibiotic treatment should be ordered accordingly. It has been reported that antibiotic-resistant Gram-positive bacteria, such as pneumococci, could be a source of septic shock in critical care settings.[17,18] Thus, local surveillance results should be considered when choosing antibiotics.

Study Limitations

The current study's limitations were the retrospective nature, small sample size, precise duration between sequential images, and lack of data regarding fever, the need for change of antibiotic regimes, and inflammatory markers of the patients. The Lund-Mackay score for CT scans is an objective tool for adults; however, a validated scoring system in the pediatric population has yet to be widely used.[19] Although we did not use paranasal imaging and a well-defined scoring

system, a well-educated and experienced pediatric radiologist re-evaluated the images. We did not evaluate the CT and MRI images separately to avoid a significant decrease in size.

Conclusion

The placement of NG and ET tubes, either alone or in combination, unequivocally leads to the accumulation of nasopharyngeal secretions, which significantly impairs clearance and predisposes critically ill children to sinusitis. This risk progressively increases over time and should be considered when managing critically ill children with these tubes.

Ethics

Ethics Committee Approval: Ethical approval was obtained from the Ethical Committee of Hacettepe University Faculty of Medicine, and the study was performed according to the ethical standards of the 1964 Declaration of Helsinki and its later amendments.

Informed Consent: Informed consent was obtained.

Authorship Contributions

Surgical and Medical Practices: Ö.S.N., M.E., Concept: B.B., E.G., Design: B.B., S.K., Data Collection or Processing: E.G., Ö.S.N., Analysis or Interpretation: Ö.S.N., E.G., Literature Search: M.E., Writing: Ö.S.N., S.K.

Conflict of Interest: No conflict of interest was declared by the authors.

Financial Disclosure: The authors declared that this study received no financial support.

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