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Research Article

Utility of Middle Meatus Cultures and Blood Cultures in the Management of Pediatric Patients with Acute Bacterial Rhinosinusitis Who Required Surgical Intervention

Maria Espinosa, MD[1]; James Eng, MD[1]; Timothy Dale, MD[1]; Elton M Lambert, MD[1,2]

[1]Baylor College of Medicine, Department of Otolaryngology—Head and Neck Surgery, USA

[2]Texas Children's Hospital, Division of Pediatric Otolaryngology, USA

***Corresponding author:** Elton Lambert, MD, 6701 Fannin Street, Mark Wallace Tower D.640, Houston Tx, 77030, USA.

Email: Emashela@texaschildrens.org

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Abstract

Introduction: Orbital and intracranial complications of acute bacterial rhinosinusitis (ABRS) in children relies on empiric and/or culture-directed antibiotics for treatment

Objective: The goal of our study is to determine the reliability of preoperative cultures, including bedside Middle Meatus Cultures (MMCx) and Blood Cultures (BCx), and their correspondence to intraoperative sinus culture in children with orbital and intracranial complications of ABRS in children.

Methods: We performed a retrospective review of patients who underwent endoscopic sinus surgery (ESS) for orbital and intracranial complications of ABRS at a tertiary children's hospital. Demographic information and data including diagnosis, imaging, indications for surgery and surgery type, preoperative MMCx and BCx, and surgical sinus cultures were analyzed.

Results: Seventy-eight patients admitted for ABRS required surgical intervention. Patients were 76% male, and between 2 and 202 months of age (mean 127 months, SD 47.6). 34.6% experienced intracranial complications. Of the 78.2% with orbital complications, 48.7% were diagnosed with orbital cellulitis, and 38.4% with a subperiosteal abscess. The presence of an abscess was the most common indication for surgery, with a mean abscess length of 23.7mm on AP dimension. 59 patients required a repeat ESS. Fifteen patients underwent MMCx, while 55 had BCx. 60% of MMCx and 5.5% of BCx corresponded with surgical cultures. Eighty-seven percent of BCx had no growth of organisms. On Fischer's exact test, only growth of staphylococcus aureus on MMCx was statistically significant in predicting growth on surgical cultures ($p = 0.009$).

Conclusions: Most middle meatus cultures correlate with intraoperative sinus cultures. Growth of staphylococcus aureus on MMCx was statistically significant in predicting growth on surgical cultures. Blood cultures do not correlate with surgical cultures. Middle meatus cultures may be useful in tailoring antibiotic therapy in children with complications of ABRS.

Keywords: Acute bacterial rhinosinusitis; Pediatric; Middle meatus culture

Introduction

In the pediatric population, superimposed Acute Bacterial Rhinosinusitis (ABRS) develops after 5-10% of upper respiratory tract infections [1,2]. Acute Bacterial Rhinosinusitis (ABRS) is an infection of the paranasal sinuses lasting less than four weeks, while Chronic Rhinosinusitis (CRS), is defined as lasting 12 weeks or more [3]. An estimated 5% of pediatric patients hospitalized for ABRS experience complications related to direct or contiguous spread of infection from the paranasal sinuses to nearby structures such as the brain and orbit [4].

In 1970, Chandler et al. classified orbital complications of ABRS into five groups: (I) preseptal cellulitis, (II) orbital cellulitis, (III) Subperiosteal Abscess (SPOA), (IV) orbital abscess, and (V) cavernous sinus thrombosis [5]. The close proximity of the paranasal sinuses to the orbit and a shared valveless venous system facilitates the spread of infection from ABRS to the orbit which may progress to the complications classified by Chandler et al. Intracranial complications of ABRS may occur independent of or concurrent to orbital involvement of ABRS. These complications include meningitis, epidural, subdural and brain abscess or empyema, and intracranial thrombosis. The exact rate of orbital or intracranial complications resulting from ABRS is not well established in the current literature, however permanent morbidity can be seen in up to 10.5% of patients with orbital complications, and 33% of patients with intracranial complications [6,7].

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Management of ABRS and the above sequelae requires intensive medical therapy and sometimes surgical intervention. Empiric antibiotic therapy is usually initiated upon hospital admission to cover historically pathogens including *Streptococcus Pneumonia*, *Haemophilus Influenza*, and *Moraxella Catarrhalis*. However, more recent literature has shown higher prevalence of penicillin resistant *S. Pneumonia* and beta-lactamase producing organisms in middle meatus cultures of patients with ABRS [8]. Additionally, up to 56% of rhinosinusitis has been shown to be polymicrobial. As a result, determining the underlying causative microorganisms along with antibiotic susceptibility is paramount in targeting antibiotic therapy to ensure adequate recovery [9,10].

Image guided aspiration cultures, middle meatus swab cultures, and blood cultures are existing methods to determine underlying pathogens prior to obtaining intraoperative surgical cultures [4]. The aim of this study is to delineate the utility of the preoperative bedside middle meatus culture in pediatric ABRS with orbital or intracranial complications.

Methods

The records of 777 patients who underwent Endoscopic Sinus Surgery (ESS) at an urban tertiary children's hospital between 2014 and 2019 were reviewed. Patients with cystic fibrosis or invasive fungal sinusitis, and patients who underwent ESS as a scheduled same-day surgery were excluded. We collected demographic information including age, gender, length of hospitalization, symptomatology, length of oral and intravenous antibiotic therapy, duration and type of steroid therapy, complication type, imaging type, surgical procedures conducted, and preoperative and intraoperative sinus culture results. Preoperative middle meatus cultures were collected via endoscopic guidance using a culture swab.

Surgical procedures included Incision and Drainage (I&D) of soft tissue abscesses, frontal sinus trephination, Lynch incision with frontethmoidectomy, Caldwell Luc, and ESS which was further differentiated by laterality and the sinuses involved (maxillary, ethmoid, frontal, sphenoid). Culture results were obtained from middle meatus cultures, blood cultures, and intraoperative surgical cultures. Data was compiled in an Excel spreadsheet and univariate analysis was performed using Fisher's exact test with Excel and SPSS (IBM Corporation, Armonk, NY, USA).

Results

Seventy-eight patients with ABRS required surgical intervention. Patients were 76% (n = 59) male, and between 2 and 202 months of age, with an average age of 127 months. Orbital complication of ABRS was classified according to the Chandler classification system and some patients carried separate diagnoses for each eye. 41% (n = 32) of patients were diagnosed with preseptal cellulitis, 48.7% (n = 38) with orbital cellulitis, and 38.4% (n = 30) with a subperiosteal abscess, 7.7% (n = 6) with an orbital abscess, and 1.3% (n = 1) with a cavernous sinus thrombosis. As for intracranial complications, 20.5% (n = 16) of patients experienced a subdural abscess, 10.3% (n = 8) had an epidural abscess, and 9% (n = 7) had signs of meningitis. Overall, 34.6% (n = 27) experienced intracranial complications.

One patient was taken to surgery without prior imaging, while 91% (n = 71) underwent either a head or maxillofacial CT study. When intracranial pathology is suspected, further imaging with MRI was required. 53.8% of patients (n=37) had an MRI prior to surgery, reflecting the high rate of intracranial complications in our series.

Common indications for surgery included subjective vision changes, subperiosteal or orbital abscess formation, proptosis, periorbital edema, and cheek swelling. The presence of abscess (subperiosteal or orbital) was the most common indication for surgery, (n= 36). Subperiosteal or orbital abscess size in our cohort ranged between 4mm and 80mm with a mean abscess size of 23.7mm. All patients except for one had preoperative imaging including either a computed tomography (CT) of the head (n = 41), CT Maxillofacial (n = 47), or magnetic resonance imaging (MRI) (n = 37). Thirty patients did not undergo further imaging postoperatively. Only three patients received steroids preoperatively, each receiving weight-based dosing of intravenous dexamethasone.

Seventy-six patients underwent endoscopic sinus surgery. Of these patients, 97.4% underwent maxillary antrostomy (n=74) of which 29.7% were bilateral. 90.8% (n=69) had ethmoidectomies performed of which 30.4% were bilateral. In comparison, 46.1% (n=35) underwent a frontal sinusotomy of which 31.4% were bilateral. 11.8% (n=9) underwent sphenoidotomy of which 44.4% were bilateral. Frontal sinus trephination was required in 9 patients, a lynch incision was required in 3 patients, and Caldwell Luc was only performed in 1 patient. 77.6% (n=59) needed a revision ESS, with 6 patients also requiring concurrent incision and drainage.

Fifteen patients underwent a preoperative middle meatus culture, while 55 had preoperative blood cultures (Table 1). Twenty percent (n = 3) of MMCx and 87% (n = 48) of BCx had no growth of organisms. Streptoccus and staphylococcus species were the most commonly speciated organisms from surgical cultures. 28.2% (n = 22) of surgical cultures grew s*treptococcus intermedius*. Three surgical cultures grew *H. influenzae*, while no surgical cultures grew *M. catarrhalis* or *P. aeruginosa*. Seventy-three percent of middle meatus cultures and 5.5% of blood cultures corresponded with surgical cultures, respectively (Table 1). On Fischer exact test, only growth of staphylococcus aureus on MMCx was statistically significant in predicting growth on surgical cultures (p= 0.0092).

Table 1: Comparison of Intraoperative and blood culture results of patients with beside middle meatus cultures.

Patient	Middle Meatus Culture Results	Intraoperative sinus Culture Results	Blood Culture Results
1	*Staphylococcus aureus*	*Staphylococcus aureus, Staphylococcus NOS*	No growth
2	*Staphylococcus aureus*	No growth	N/A
3	*Eikenella corrodens, Strep intermedius*	*Eikenella corrodens*	No growth
4	*Haemophilus influenza, Staphylococcus aureus*	*Staphylocccus NOS, Veillonella*	N/A
5	*Prevotella*	No growth	No growth
6	*Moraxella, Hemophilus influenza*	*Haemophilus influenza*	N/A
7	No growth	No growth	N/A
8	*Staphylococcus aureus, Pseudomonas, Streptococcus pyogenes*	*Streptococcus NOS, Eikenella*	No growth
9	*Staphylococcus aureus*	*Staphylococcus aureus, streptococcus NOS*	*Staphylococcus aureus*
10	No growth	*Streptococcus NOS, Peptostreptococcus micros*	No growth
11	*Streptococcus pyogenes*	*Streptococcus NOS*	N/A
12	*Staphylococcus aureus*	*Rothia mucilaginosa. Staphylococcus NOS*	No growth
13	No growth	*Staphylococcus NOS, Corynebacterium*	No growth
14	*Staphylococcus aureus, Eikenella corrodens*	No growth	N/A
15	*Staphylococcus aureus*	*Staphylococcus aureus*	No growth

MMCx: Middle Meatus Culture; BCx: Blood Culture; N/A: Not Applicable; NOS: Not Otherwise Specified

Discussion

The management of orbital and intracranial complications of ABRS can be complicated by the balancing of medical and surgical therapy. Obtaining cultures reflective of the causative organism in ARS can be paramount in guiding antibiotic therapy when surgery is not indicated or in the workup prior to surgical intervention.

Maxillary antral punctures or other image guided aspiration procedures were initially the gold standard culture technique but have fallen out of favor since the 1980's due to poor patient tolerance and need for anesthetic in the pediatric population [19,20]. Nasal swabs and nasopharyngeal cultures have been proven to be inaccurate in identifying causative organisms in sinusitis [21,22]. None of the above culture techniques are performed at our institution.

The advent of modern endoscopic techniques has allowed for more precise acquisition of middle meatus swab cultures. Several studies advocate that middle meatus cultures are equivalent to antral puncture in diagnostic value in both ABRS and CRS in adults when carefully obtained [3,21,22]. Additionally, this method allows for confirmation of bacterial sinusitis with visualization of mucopurulent discharge from the sinus ostia [3,20-22]. In a study of aerobic middle meatus cultures and aerobic cultures obtained through a maxillary antrostomy in the adult population, Gold and Tami found an 85.7% correlation [23]. Orobello et al. found a similar correlation rate of 83% of middle meatus and maxillary sinus cultures among pediatric patients with CRS [15]. Vaidya et al. induced sinusitis in 24 rabbits, and found a 100% correlation between middle meatus and maxillary sinus cultures [25]. The utility of the middle meatus culture for ARS specifically in the pediatric population has not been adequately studied in the existing literature [8].

Healy had previously recommended that all patients with Chandler II-V classification of orbital complications should undergo sinus cultures [5]. Only 19.4% of our cohort underwent middle meatus culture, suggesting that patients at our institution are more likely to be treated with broad spectrum antibiotics until surgical cultures result. In contrast 70.5% (n=55) had blood cultures, which reflects the preferences of the Emergency Department and Pediatrics services at our institution.

Previous studies have shown that up to 25% of operative cultures may return sterile, while the majority may be polymicrobial [12,24]. Thirty-two percent of our patients had received outpatient antibiotics before any cultures were taken, while 23% received IV antibiotics prior to surgical cultures. This may account for the high rates of no growth seen in both the blood cultures and surgical cultures, although both still fall in line with rates of sterile cultures described by other authors. The effect of antibiotics should be equal on both middle meatus and maxillary cultures, therefore the correlation between the two culture sites is likely unaffected by prior antibiotic use. Other factors contributing to sterile cultures include culture technique, dilution of intraoperative samples at time of retrieval, delay from time of collection to inoculation, and laboratory error.

In a similar study by Hsin et al., 41 cultures were obtained from the middle meatus and from maxillary sinus punctures in 26 pediatric patients. They found a correlation between 32 of the 41 specimens (78%), in comparison to the 60% correlation noted in our study [26]. They noted that all specimen pairs that showed disagreement were obtained in children less than seven years of age, and attributed small nasal cavity volume as a contributory factor in sampling error when obtaining the middle meatus culture [26].

Multiple studies have shown the *Streptococcus Milleri* group to be the most commonly cultured pathogens. This group comprises of commensal oral organisms, including *S. Anginosus*, *S. Constellatus*, and *S. Intermedius*, and is commonly associated with abscess formation [7,13,27,28]. In multiple reports, the growth of *Streptococcus* species was found to be associated with a significantly higher rate of neurosurgical intervention [14.28]. The 28.6% growth of *S. Milleri* in our cohort is comparable to the 32.4% described by Oxfort et al. The second most common cultured organisms were *alpha-hemolytic Streptococcus* grown in 22% of our patients (n=17), again reflecting the findings of Oxford et al [7].

Concurrent bacteremia has been sited to be as high as 30% in patients less than 5 years of age [29]. This was not supported this series in which of the 55 patients who had blood cultures, 87.3% (n=48) exhibited no growth. Schramm et al described *H. Influenzae* as the most frequently cultured organism from blood cultures, but there was no growth of *H. Influenzae* in our cohort [29]. The widespread use of vaccines against *H. Influenzae* and *S. Pneumonia* may account for the change in microbiology underlying ABRS [28].

Our findings reflect similar trends that have been reported in prior pediatric ABRS studies. The predominance of teenage males seen in our cohort and lower rates of orbital complications (78.2%) and higher rates of intracranial complications (34.6%) are in agreement with pediatric ABRS studies from Segal et al and Oxford et al [11,7]. Intracranial extension is more common in older children, usually greater than 7-8 years of age [12]. Similar to prior studies, subdural abscesses accounted for the majority of intracranial complication in our population, while meningitis and cavernous sinus thrombosis were relatively rare [13,14].

Previous studies have shown that 50% of patients with orbital complications, and the majority of those with intracranial complications require surgical intervention, and sometimes multiple surgical procedures are needed [12]. Of the 76 patients in our cohort who underwent ESS, 59 required a subsequent ESS, and six also required an incision and drainage procedure.

In our study, the mean duration of oral antibiotic therapy prior to hospital presentation was less than two days, possibly contributing to the severity of disease upon presentation. However, previous retrospective analyses have shown that more aggressive outpatient antibiotic treatment does not always confer benefit, with some studies noting development of orbital and intracranial involvement despite prolonged antibiotic therapy [3,7,15,16]. Additionally, prior trials with patients with clinically suspected ABRS found small benefit in outpatient antibiotic therapy, with one study showing only five additional cures per 100 patients [17,18]. This recent data may explain why only a minority of our patients received antibiotics prior to hospital admission. Twenty-three percent (n=18) of patients were initially managed medically, but subsequently required surgical intervention given clinical worsening, or lack of clinical improvement.

Only three patients were started on steroid therapy during their hospital course. All three were given dexamethasone with weight-based dosing between 0.3 and 0.5 mg/kg/day. The use of perioperative steroids in complications of ABRS remains controversial, with the optimal drug type and dosage still unknown.[6]

Conclusion

There are several limitations to this study. Firstly, this is a single center retrospective review. Another drawback is the failure to identify comorbidities, which may have contributed to pathogenesis and virulence of the underlying organisms. There exists inherent bias due to the variation in clinical practice preferences between different providers. A prospective study in which all patients undergo standardized endoscopy of the sinuses with middle meatus cultures would overcome the main disadvantage within this study and shed more light on the implications of middle meatus cultures.

With increasing rates of antibiotic resistance, empiric medical therapy has become more uncertain. Many patients who present with ARS and subsequent sequelae are placed on empiric broad spectrum antibiotics, which may be unnecessary. Obtaining middle meatus cultures early in the hospital course may assist in earlier streamlining of the antibiotic regimen once organism species and antibiotic susceptibility are known. However, given the appropriate outcomes of ARS patients treated at our institution despite the low percentage of patients undergoing middle meatus cultures, such cultures may not be critical. At our institution, ampicillin-sublactam is often started empirically and middle meatus cultures are utilized to tailor therapy and identify methicillin resistant organisms.

Ultimately, the coordination of care between pediatricians, otolaryngologists, ophthalmologists, and neurosurgeons remains paramount in adequately treating and preventing permanent morbidity or mortality from ARS and its associated complications.

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Ethics Statement

This study obtained Institutional Board Review approval from Baylor College of Medicine [H-46694].

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