Suppurative Intracranial Complications of Pediatric Sinusitis: A Single-Center Experience

William R. Otto,¹ William Z. Paden,² Meghan Connors,³ Torsten Joerger,¹ Adva Buzi,⁴ Mark Rizzi,⁴ Jimmy Huh,⁵ Phillip Storm,^{3,6} Gregory Heuer,^{3,6} Benjamin Kennedy,^{3,6} Jennifer McGuire,⁷ Sanjeev Swami,¹ and Shih-Shan Lang^{3,6}

¹Department of Pediatrics, Division of Infectious Diseases, Children's Hospital of Philadelphia, Philadelphia, Pennsylvania, USA; ²Drexel University College of Medicine, Philadelphia, Pennsylvania, USA; ³Center for Data Driven Discovery in Biomedicine, Children's Hospital of Philadelphia, Philadelphia, Pennsylvania, USA; ⁴Division of Otolaryngology, Children's Hospital of Philadelphia, Department of Otolaryngology, University of Pennsylvania School of Medicine, Philadelphia, Pennsylvania, USA; ⁵Department of Anesthesiology and Critical Care, Children's Hospital of Philadelphia and the University of Pennsylvania Perelman School of Medicine, Philadelphia, Pennsylvania, USA; ⁶Division of Neurosurgery, Children's Hospital of Philadelphia, Department of Neurosurgery, University of Pennsylvania Perelman School of Medicine, Philadelphia, Pennsylvania, USA; and ⁷Division of Neurology, Children's Hospital of Philadelphia, Department of Neurology, University of Pennsylvania Perelman School of Medicine, Philadelphia, Pennsylvania, USA

Background. Suppurative intracranial complications of sinusitis are rare events in children and can lead to harmful neurologic sequelae and significant morbidity. We sought to review the presentation and management of patients admitted at our hospital with these conditions.

Methods. This was a retrospective study of pediatric patients admitted to a quaternary children's hospital from 2007 to 2019 for operative management of sinusitis with intracranial extension. Clinical characteristics, including surgical and microbiological data, were collected and analyzed.

Results. Fifty-four patients were included; the median age was 11.0 years, and there was a male predominance. Eighty-nine percent of patients had prior healthcare visits for the current episode of sinusitis; 46% of patients had an abnormal neurologic exam on admission. Epidural abscess and subdural empyema were the most common complications, and subdural empyema was associated with repeat surgical intervention. The dominant pathogens were *Streptococcus anginosus* group organisms (74%). The majority of patients completed treatment parenterally, with a median duration of therapy of 35 days. Neurological sequelae, including epilepsy or ongoing focal deficits, occurred in 22% of patients. History of seizure or an abnormal neurological exam at admission were associated with neurological sequelae.

Conclusions. Clinicians should consider intracranial complications of sinusitis in patients with symptoms of sinusitis for >1 week. Patients should undergo urgent neuroimaging, as neurosurgical intervention is essential for these patients. Subdural empyema was associated with repeat neurosurgical intervention. Neurological sequelae occurred in 22% of patients, and new onset seizure or an abnormal neurological exam at admission were associated with neurological sequelae.

Keywords. brain abscess; children; epidural abscess; *Streptococcus anginosus*; subdural empyema.

Acute bacterial rhinosinusitis is a common infection in children, and 6%–7% of children who present with symptoms of an upper respiratory infection meet clinical criteria for this condition [1]. Although sinusitis is generally a mild condition, extension of sinus disease does rarely occur. Orbital extension is the most common complication of acute sinusitis, with intracranial extension, including epidural abscess, subdural empyema, meningitis, cerebritis, and/or brain abscess occurring much less frequently [2–5].

Though rare, intracranial complications of sinusitis can lead to significant morbidity and mortality, including stroke or seizures. Diagnosis of these conditions may be difficult as presenting symptoms may be nonspecific and patients may not present with neurological symptoms [2–4]. Furthermore, the literature surrounding intracranial extension of sinusitis is sparse and is largely limited to case reports and case series [2–9]. There are no large studies to guide management of these infections.

We therefore aimed to describe the clinical presentation, microbiology, management, and outcomes of a large cohort of pediatric patients hospitalized at a quaternary care pediatric hospital with intracranial complications of sinusitis necessitating neurosurgical intervention over a 13-year period.

METHODS

This retrospective study was conducted at Children's Hospital of Philadelphia, a quaternary children's hospital. The Committee

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Correspondence: Shih-Shan Lang, Perelman School of Medicine at the University of Pennsylvania, Children's Hospital of Philadelphia, 34th Street & Civic Center Blvd, 6 Wood Center, Philadelphia, PA 19104, USA (chens4@email.chop.edu).

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for the Protection of Human Subjects Institutional Review Board approved this protocol.

Data Collection

Surgical billing records from the Children's Hospital of Philadelphia Division of Neurosurgery were reviewed to identify children aged 1.0–21.0 years between 1 January 2007 and 31 July 2019 admitted with sinusitis who had undergone surgical drainage or washout of a subdural empyema, epidural abscess, or intraparenchymal abscess. The identified records were cross-referenced with a list of patients admitted to the hospital with an *International Classification of Diseases* code for acute sinusitis (461.0–461.9) and an intracranial complication (324.0, 324.9, 510, or 730.2) [10].

Patient data, including demographic characteristics, clinical presentation and course, laboratory and imaging results, treatment course, and follow-up data, were abstracted from the electronic medical record and entered into a standardized database. Medical records were reviewed through the last outpatient follow-up within the Infectious Diseases, Neurology, Neurosurgery, or Otolaryngology clinics. Patients with primary or secondary immunodeficiency, those with cystic fibrosis, those with intracranial infection but no evidence of sinusitis, those with neurosurgical hardware, and those with a prior history of neurosurgery were excluded.

Definitions

Sinusitis was defined as sinus opacification or thickening of the mucosa on computed tomography (CT) or magnetic resonance imaging (MRI). *Intracranial complications* were defined as evidence of epidural abscess, subdural empyema, parenchymal abscess, leptomeningeal enhancement, or cerebritis on CT or MRI. All radiographic features were as identified by a trained clinical pediatric radiologist.

An *abnormal neurological exam* was defined as the presence of altered mental status, focal neurological deficit, cranial nerve palsies, ataxia, aphasia or other speech disorder, or sensory or motor deficit, as documented by a medical provider.

Culture results were categorized as true pathogens, possible pathogens, or likely contaminants, as previously described [11]. A true pathogen was defined as growth of organisms classically associated with sinusitis, including *Streptococcus anginosus* group organism (*Streptococcus intermedius*, *Streptococcus anginosus*, *Streptococcus constellatus*), *Streptococcus pneumoniae*, *Streptococcus pyogenes*, other beta-hemolytic *Streptococcus* species, methicillin-resistant *Staphylococcus aureus* (MRSA), methicillin-susceptible *S. aureus* (MSSA), *Fusobacterium* spp., or *Haemophilus influenzae*. Possible pathogens included the viridans group *Streptococcus* spp., various oral anaerobes, and gram-negative organisms. Likely contaminants included organisms thought to be nonpathogenic, such as *Staphylococcus epidermidis* and other coagulase-negative *Staphylococcus* species, or *Micrococcus* species.

Data Analyses

Summary statistics were used to describe demographic and outcome data. Nonparametric methods were used due to our small sample size and to minimize the effect of outliers on statistical associations. Categorical variables were described using counts and frequencies and compared using the Pearson χ^2 test or Fisher exact test. Continuous variables were described using median and interquartile range (IQR) and compared using the Wilcoxon rank sum or Kruskal-Wallis test. All statistics were analyzed with STATA version 15.0 (StataCorp, College Station, TX).

RESULTS

Fifty-four children met inclusion criteria and were included in this study; the demographic and clinical characteristics at presentation are shown in Table 1. The median age was 11 years, and there was a male predominance (36/54 patients).

Presenting Signs and Symptoms

All patients presented with at least 1 symptom; the most common symptoms were headache (78%), fever (74%), congestion (56%), and nausea or vomiting (39%). Neurological symptoms, including altered mental status, seizures, or other neurological impairment, were reported in less than one-third of patients, although an abnormal neurological exam was documented in 46% of patients. Notably, 18 patients (33%) reported neither neurological symptoms nor vomiting. The median duration of symptoms prior to hospitalization was 7 days. A total of 23/54 (43%) patients presented with 10 or more days of symptoms. Of the remaining patients, 19/31 (61%) presented with altered mental status, seizure activity, or facial swelling. Eight patients presented with acute onset of nausea and vomiting.

Nearly all patients (89%) reported that they had other healthcare visits prior to admission, with a median of 2 visits per patient (range, 1–3). Half of all patients were prescribed antibiotics prior to admission, 12 of whom (44%) reported taking antibiotics for >7 days prior to admission. Amoxicillin and amoxicillin/clavulanate were the most frequently prescribed antibiotics and were prescribed in nearly 60% of patients who received antibiotics (16/27). Other patients received clindamycin, azithromycin, trimethoprim/sulfamethoxazole, doxycycline, or fluoroquinolones.

Imaging Characteristics

All patients underwent neuroimaging to confirm the diagnosis of sinusitis with intracranial extension. All 54 patients underwent CT scan, and 52/54 patients underwent MRI. The most common areas to have sinusitis included the frontal (85%), ethmoid (81%), and maxillary sinuses (78%); inflammation of the sphenoid sinuses was less common (35%). Fourteen patients (26%) had pansinusitis.

Table 1. Demographics and Clinical Characteristics at Admission

Characteristic	Value
Age, median (IQR), y	11.0 (8.9–13.9)
Male, n (%)	36 (66.7)
Race/ethnicity, n (%)	
Black or African-American	24 (44.4)
White or caucasian	17 (31.5)
Hispanic or Latino	7 (13.0)
Other	6 (11.1)
Insurance status, n (%)	
Private	30 (55.6)
Public	20 (37.0)
Symptom, n (%)	
Headache	42 (77.8)
Fever	40 (74.1)
Congestion	30 (55.6)
Nausea/vomiting	21 (38.9)
Altered mental status	15 (27.8)
Cough	14 (25.9)
Eye swelling	14 (25.9)
New-onset seizure activity	9 (16.7)
Abnormal neurological exam at admission, n (%)	25 (46)
Days of sinusitis symptoms prior to diagnosis, median (IQR)	7 (5 to 14)
Had healthcare visits prior to diagnosis, n (%)	48 (88.9)
Antibiotics prior to diagnosis, n (%)	27 (50)

Abbreviation: IQR, interquartile range.

The most frequent suppurative intracranial complication was an epidural abscess (33/54, 61%), followed by subdural empyema (30/54, 56%). Leptomeningeal enhancement (18/54, 33%), cerebritis (14/54, 26%), and parenchymal abscesses (8/54, 15%) occurred less frequently. Other complications of sinusitis, including orbital cellulitis (33%), Pott's puffy tumor or frontal bone osteomyelitis (28%), preseptal cellulitis (15%), and cerebral venous sinus thrombosis (11%), were also present in children with intracranial extension of their sinusitis.

Operative Management

All patients underwent an invasive neurosurgical intervention to obtain cultures and achieve local source control, and a majority of patients (40/54, 74%) underwent concomitant endoscopic sinus surgery (Table 2). The most common neurosurgical procedure was a craniotomy, followed by a craniectomy. The decision to proceed with sinus surgery was individualized to each patient's specific sinonasal disease burden and their anticipated ability to withstand a concomitant procedure in addition to craniotomy. If frontal sinus cranialization was performed, functional endoscopic sinus surgery was not performed if presumed causative frontal sinusitis would be drained via cranialization or if the associated sinus disease was less extensive on imaging. The expectation in those cases was that sinusitis would respond to medical therapy once the suppurative intracranial infection was drained. Of patients

Table 2. Operative Management of Patients in the Cohort

Surgical Procedure	N (%)
Neurosurgical procedure	
Craniotomy	44 (81.5)
Craniectomy	7 (13.0)
Burr hole placement	3 (5.6)
Indication for neurosurgical procedure	
Epidural abscess drainage	17 (31.5)
Subdural empyema drainage	17 (31.5)
Epidural abscess and subdural empyema drainage	15 (27.8)
Intraparenchymal abscess drainage	2 (3.7)
Epidural abscess and intraparenchymal abscess drainage	2 (3.7)
Epidural abscess, subdural empyema, and intraparenchymal abscess drainage	1 (1.9)
Sinus surgical procedure	
Functional endoscopic sinus surgery	40 (74.1)
Frontal sinus cranialization	16 (29.6)

with orbital cellulitis on imaging, 8/18 (44%) underwent incision and drainage of an orbital abscess. During their treatment course, all patients were monitored clinically and underwent serial neuroimaging to assess response to treatment. Patients underwent a median of 2 CT scans (range, 1–3) and 4.5 MRI scans (range, 2–5) during their treatment course.

Twelve patients (23%) required repeat neurosurgical drainage, 1 of whom required 3 surgical procedures. Ten patients had evidence of worsening or persistent collections on repeat neuroimaging, while the other 2 patients had new collections noted on imaging. Eight patients had persistent symptoms or developed new symptoms after their first neurosurgical procedure. When compared with children who did not require repeat neurosurgical intervention, those who required repeat surgery were significantly more likely to have been diagnosed with a subdural empyema (92% vs 45%, $P = .004$), but there was no difference in other demographic, clinical, or laboratory characteristics (Table 3).

Microbiology

Overall, 46/54 patients (85%) had positive culture results from blood, sinuses, and/or intracranial specimens; microbiological data are summarized in Table 4. Blood cultures were performed in 39/54 patients, and cultures of cerebrospinal fluid were obtained in only 5/54 patients. The predominant organisms were members of the *S. anginosus* group (formerly known as the *Streptococcus milleri* group). These organisms, including *S. intermedius*, *S. anginosus*, and *S. constellatus*, were found in 34/46 patients with positive cultures (74%). *Staphylococcus aureus* was identified in only 7.5% of patients total. Fifteen patients had multiple organisms identified on culture. Notably, only 7 organisms were seen in monomicrobial cultures (*S. anginosus* group, *S. pneumoniae*, MRSA, MSSA, *Fusobacterium* spp., *S. pyogenes*, and other beta-hemolytic streptococci). On only 1 occasion did a blood culture identify an organism not identified

Table 3. Characteristics of Patients Who Required Repeat Surgery and Those Who Did Not

Factor	Repeat Surgery (n = 12)	No Repeat Surgery (n = 42)	P Value
Age at admission, median (IQR), y	12.0 (10.5–14.3)	10.8 (8.2–13.7)	.18
Male gender, n (%)	2 (17)	16 (38)	.16
Report of fever, n (%)	10 (83)	30 (71)	.41
Report of headache, n (%)	11 (92)	31 (74)	.19
Report of altered mental status, n (%)	6 (50)	9 (21)	.051
New-onset seizure activity, n (%)	2 (17)	7 (17)	1.00
Days of symptoms prior to admission, median (IQR)	7.0 (5.0–9.0)	8.0 (5.0–14.0)	.39
Prior visit to healthcare provider, n (%)	11 (92)	37 (88)	.73
Number of prior healthcare visits, median (IQR)	1.0 (1.0–2.0)	2.0 (1.0–2.0)	.38
Prescribed antibiotics prior to admission, n (%)	5 (42)	22 (52)	.51
Abnormal neurological exam at admission, n (%)	9 (75)	20 (48)	.093
White blood cell count at admission (cells × 10 ³ /μL), median (IQR)	15.0 (12.9–18.0)	14.5 (11.6–17.3)	.78
C-reactive protein level at admission (mg/dL), median (IQR)	6.0 (4.7–23.4)	8.8 (4.8–18.4)	.74
Erythrocyte sedimentation rate (mm/h), median (IQR)	76.0 (60.0–101.0)	74.5 (49.5–96.5)	.77
Epidural abscess, n (%)	5 (42)	28 (67)	.12
Subdural abscess, n (%)	11 (92)	19 (45)	.004
Brain abscess, n (%)	2 (17)	6 (14)	.84
Culture positive for <i>Streptococcus anginosus</i> spp., n (%)	9 (75)	25 (60)	.33

Abbreviation: IQR, interquartile range.

on other cultures; this was in a patient with *S. pneumoniae* bacteremia but negative intracranial cultures.

Antibiotic Management

Antimicrobial susceptibility data were available for 43/46 patients with positive cultures (93%). All organisms were susceptible to the empirical regimen of vancomycin, a third-generation cephalosporin, and metronidazole. Only 4 patients had culture results with organisms resistant to third-generation cephalosporins. Two of these patients had growth of MRSA, 1 patient had growth of ceftriaxone-resistant *Streptococcus mitis/oralis*, and the last patient had growth of a viridans *Streptococcus* that was resistant to third-generation cephalosporins. No member of the *S. anginosus* group was resistant to third-generation cephalosporins. All patients received antibiotics during their hospitalization, with every patient ultimately receiving vancomycin, a third-generation cephalosporin, and metronidazole. One patient initially received vancomycin and ampicillin/sulbactam before transitioning to the 3-drug regimen. Patients received vancomycin for a median duration of 5 days (IQR, 4–13). The majority of patients then completed therapy with ceftriaxone and oral metronidazole. Fifteen patients (28%) ultimately transitioned to an oral antibiotic regimen, 12 to a quinolone- or fluoroquinolone-based regimen and 3 to a regimen that contained amoxicillin or amoxicillin-clavulanate. Three patients transitioned to oral therapy after less than 2 weeks of parenteral antibiotics after clear clinical improvement and evidence of limited residual collection on neuroimaging. The remainder transitioned to oral therapy after a median of 31.5 days of intravenous therapy, with a course of oral antibiotics used to complete a treatment course. Overall, patients received antibiotic therapy

for a median of 35 days (IQR, 29–46), with the overall duration of therapy determined by the treating physician.

In recent years, our general practice has been to use serial MRI to guide duration of therapy. Of patients who presented from 2015 to the end of the study, 6/24 had complete resolution of enhancement or other findings; 2 of these patients suffered neurological sequelae of infection. A total of 16/24 patients were noted to have improvement on neuroimaging, with only minimal persistent enhancement of the meninges or parenchyma; antibiotics were stopped after a median of 6 days after the last imaging study (IQR, 1–19). Of patients with improvement but not complete resolution of neuroimaging findings prior to stopping antibiotics, 7/16 patients had neurological sequelae of infection. Two patients had antibiotics stopped without repeat imaging.

Follow-up

Patients were discharged after a median of 10.5 days (IQR, 8–16); 7 patients (13%) were discharged to an inpatient rehabilitative unit, and the remainder were discharged home. No patient died. Twenty patients (37%) re-presented to the emergency department for repeat evaluation within 30 days of initial discharge; fever (8/20 patients), headache (6/20), and concerns related to the peripherally inserted central catheter (5/20) were the most common new concerns. Ultimately, 18 of the 54-patient cohort required readmission for observation. After discharge from the hospital, no patient had recurrent infection or required repeat surgery.

Patients underwent outpatient follow-up within the Division of Infectious Diseases (43/54), Neurology (16/54), Neurosurgery (46/54), and/or Otolaryngology (29/54) or

Table 4. Organisms Recovered From Culture Specimens

Organism	Blood, n	Sinus, n	Intracranial, n	Total, n (%) ^a
True pathogens				
<i>Streptococcus anginosus</i> group	4	21	29	34 (74)
<i>Fusobacterium</i> spp.	0	4	3	6 (13)
<i>Streptococcus pneumoniae</i>	1	1	3	4 (9)
Beta-hemolytic <i>Streptococcus</i> spp.	0	1	2	3 (7)
<i>Staphylococcus aureus</i>				
Methicillin-susceptible	0	2	0	2 (4)
Methicillin-resistant	0	1	1	2 (4)
<i>Streptococcus pyogenes</i>	0	0	1	1 (2)
<i>Haemophilus influenzae</i>	0	0	1	1 (2)
Possible pathogens				
<i>Prevotella</i> spp.	0	3	3	5 (11)
<i>Streptococcus mitis/oralis</i>	0	2	2	3 (7)
<i>Eikenella</i> spp.	0	1	2	3 (7)
Other viridans group <i>Streptococcus</i> spp.	0	2	0	2 (4)
<i>Gemella</i> spp.	0	0	2	2 (4)
<i>Streptococcus salivarius</i>	0	1	1	2 (4)
<i>Escherichia coli</i>	0	1	0	1 (2)
<i>Pseudomonas aeruginosa</i>	0	1	0	1 (2)
<i>Peptostreptococcus</i> spp.	0	0	1	1 (2)
<i>Aggregatibacter aphrophilus</i>	0	1	0	1 (2)
Anaerobic bacteria, not speciated	0	0	1	1 (2)
Contaminants				
Coagulase-negative <i>Staphylococcus</i> spp.	0	4	0	4 (9)
<i>Staphylococcus epidermidis</i>	0	1	0	1 (2)
<i>Micrococcus</i> spp.	0	1	0	1 (2)
Saprophytic <i>Neisseria</i> spp.	0	0	1	1 (2)
Yeast, not speciated	0	1	0	1 (2)

Listed organisms may be part of a mixed infection.

^aPercentage (%) of total patients (n = 46) from whom organisms were recovered.

at the Neurological Infections Clinic (13/54) for a median of 3.5 months (IQR, 1.8 to 10.8; overall range, 0.6 to 61.6). At the time of last follow-up, 12/54 (22%) patients had persistent neurological deficits, including seizures (n = 5), focal neurological deficits (n = 4), or poor school performance (n = 3, only 1 of whom underwent formal neurocognitive testing). Children with a persistent neurologic deficit more often presented with seizures (42% vs 11%, $P = .008$) and had an abnormal neurological exam at admission (83% vs 45%, $P = .02$) compared with those without persistent deficits (Table 5). There were no associations between age, sex, intracranial complication (eg, epidural abscess, subdural empyema, others), or need for repeat surgery with persistent neurologic deficits on follow-up.

DISCUSSION

We describe a case series of 54 children with sinusitis complicated by intracranial extension, focusing on the clinical presentation, microbiology, and management of these infections. To our knowledge, this is the largest reported study of suppurative intracranial complications of pediatric sinusitis.

Consistent with prior reports, the majority of patients in this study were preadolescent to adolescent males [2, 7, 8, 12, 13]. Patients frequently presented with nonspecific symptoms (fever, headache, congestion) that may not necessarily cause providers to pursue diagnostic imaging [2, 3]. Patients often had multiple healthcare visits prior to their definitive diagnosis, and many received antibiotics prior to hospitalization. Providers need to have a high index of suspicion for this complication in patients who present with symptoms for >1 week, especially those who have not improved despite antibiotic treatment. A vast majority of patients in the cohort presented with either symptoms for 10 or more days (23/54) or, if presenting sooner, with acute onset of symptoms concerning for intracranial pathology (27/54).

Our microbiological data are similar to those from prior reports of sinogenic brain abscesses, with polymicrobial cultures and a predominance of *S. anginosus* organisms [14–17]. The burden of disease secondary to *S. anginosus* bacteria in our cohort is higher than in prior reports of the microbiology of sinusitis [11, 18], though similar to that reported by Kou et al [17]. *Streptococcus anginosus* bacteria are members of the normal flora of the oropharynx and sinuses and can cause aggressive, suppurative infections [19]. These bacteria are frequently

Table 5. Characteristics of Patients Who Developed Neurological Sequelae of Infection

Factor	Neurological Sequelae (n = 12)	No Neurological Sequelae (n = 42)	P Value
Age at admission, median (IQR), y	10.0 (7.2–14.6)	11.2 (9.3–13.7)	.63
Male gender, n (%)	2 (17)	16 (38)	.16
Report of fever, n (%)	8 (67)	32 (76)	.51
Report of headache, n (%)	10 (83)	32 (76)	.60
Report of altered mental status, n (%)	4 (33)	11 (26)	.63
New-onset seizure activity, n (%)	5 (42)	4 (10)	.008
Days of symptoms prior to admission, median (IQR)	7.0 (4.5–11.0)	7.0 (5.0–14.0)	.47
Prior visit to healthcare provider, n (%)	11 (92)	37 (88)	.73
Number of prior healthcare visits, median (IQR)	2.0 (1.0–2.0)	2.0 (1.0–2.0)	.75
Prescribed antibiotics prior to admission, n (%)	8 (67)	19 (45)	.19
Abnormal neurological exam at admission, n (%)	10 (83)	19 (45)	.02
White blood cell count at admission (cells × 10 ³ /μL), median (IQR)	13.8 (12.1–17.5)	15.4 (11.6–17.3)	.89
C-reactive protein level at admission (mg/dL), median (IQR)	13.8 (3.4–22.4)	7.7 (4.8–18.8)	.94
Erythrocyte sedimentation rate (mm/h), median (IQR)	76.0 (73.0–99.0)	72.0 (44.0–101.0)	.65
Epidural abscess, n (%)	5 (42)	28 (67)	.12
Subdural abscess, n (%)	8 (67)	22 (52)	.38
Brain abscess, n (%)	2 (17)	6 (14)	.84
Cerebritis, n (%)	1 (8)	13 (31)	.11
Meningitis, n (%)	5 (42)	13 (31)	.49
Need for repeat neurosurgery, n (%)	4 (33)	8 (19)	.29
Culture positive for <i>Streptococcus anginosus</i> spp., n (%)	8 (67)	26 (62)	.76

Abbreviation: IQR, interquartile range.

reported to be involved in sinogenic brain abscesses, and studies have shown that patients with *S. anginosus* group infections have a more protracted hospital course, increased likelihood of neurosurgical intervention, and longer durations of antibiotic therapy [16, 20, 21]. In this cohort, which was restricted to those who underwent neurosurgical intervention, infection with *S. anginosus* group organisms was not associated with the need for repeat neurosurgical intervention or adverse neurological outcomes. Rates of sinus infections with *S. anginosus* group bacteria are increasing [21, 22], and further study is needed to better determine the incidence and impact of *S. anginosus* in sinusitis.

There are few large-scale studies of suppurative intracranial complications of sinusitis. Twenty-two percent of patients in our cohort required repeat neurosurgical intervention; this is less than reported in previous studies [6, 23, 24]. Our data are similar to those presented by Gitomer et al in that patients who required repeat neurosurgical intervention were more likely to have subdural empyema [24]. Data on outcomes of these infections are similarly sparse, but neurological sequelae such as focal motor deficits, cranial nerve palsies, and persistent seizures have been reported. Neurological sequelae developed in 22% of patients in our cohort, which is less than that reported in other, smaller studies [2, 3, 5], but the overall distribution of complications was similar.

There are no standard guidelines or recommendations in the United States for the management of intracranial complications of sinusitis, so management of this condition varies across centers. We recommend that neuroimaging be considered in

patients with prolonged symptoms of sinusitis who have not improved with antibiotic therapy. MRI scans are more sensitive and specific than CT scans in the detection of intracranial infection [25–27], and MRI would be preferred as long as the patient is clinically stable and performing the MRI does not delay a needed surgical intervention. If neuroimaging identifies a lesion that is concerning for intracranial infection, antibiotic therapy should be initiated promptly and surgical drainage should be considered. After initial drainage, patients should be monitored with repeat imaging to ensure that there has not been re-collection of their intracranial infection. We typically obtain a post-operative MRI within the first 24–48 hours and then as needed based on symptoms such as fever and headache or new clinical signs. Most patients also undergo a repeat MRI prior to the completion of antibiotic therapy.

We recommend the use of vancomycin, ceftriaxone, and metronidazole as an empirical antibiotic regimen, with discontinuation of vancomycin once microbiological data show no evidence of resistance to third-generation cephalosporins. The use of third-generation cephalosporins and metronidazole alone may be adequate unless there are specific risk factors for MRSA infection [18]. However, administration of vancomycin carries minimal risk if discontinued promptly after the return of culture and antimicrobial susceptibility data.

It is our general practice to place a peripherally inserted central catheter and give outpatient parenteral antibiotic therapy. Some have advocated for early transition to oral therapy in suppurative central nervous system infections, though it has not been rigorously studied in a prospective trial [28]. We have

recently transitioned select patients with low burden of disease, good source control on imaging, and antimicrobial susceptibility data to fluoroquinolone-based oral therapy early in the treatment course. No patients with early transition developed recrudescence of their infection. These results should be interpreted with caution—it is possible that early transition to oral therapy can be performed for these infections without significant adverse outcomes, but comparative studies should be performed to better inform clinical practice.

After discharge, many patients are seen in our Neurological Infections Clinic, a joint clinic with the Division of Neurology and the Division of Infectious Diseases, to better coordinate care and allow for multidisciplinary discussion prior to decision-making. We generally provide antibiotic therapy for a minimum of 4 weeks after source control is achieved; antibiotic therapy is frequently discontinued if there is significant improvement on repeat neuroimaging. Treatment is extended if there is evidence of persistence of infection or other clinical concern on serial neuroimaging. In this study, we were not able to answer the question of whether patients should be treated until complete resolution of neuroimaging findings or if antibiotics can be stopped earlier if imaging has significantly improved. However, outcomes were similar in patients whose antibiotics were stopped after resolution on neuroimaging and in those whose antibiotics were stopped after significant improvement but not complete resolution. Future studies should explore this important clinical question.

This study has several limitations. We only included patients who underwent neurosurgery and excluded patients who may have been managed medically, without surgical intervention. Therefore, we cannot comment on the management of those patients. This is a retrospective study, and during the study period, the hospital system changed its electronic medical record system. It is possible that a patient with intracranial complications of sinusitis who required surgery may have been missed, but we used 2 potential patient sources and cross-checked the results, so this is unlikely. We were able to access all patient records during the study period, and there were little to no missing data. Some of the data relied on patient reporting or physician charting and may be subject to recall bias. Additionally, patients could have completed their follow-up at another institution, so the follow-up or outcome data may be incomplete. Last, this is a single-center study with a relatively small sample size, so our results may not be generalizable to other institutions. However, much of our data are similar to that reported in earlier case series and case reports.

CONCLUSIONS

This study contributes to the literature surrounding the clinical presentation and management of suppurative intracranial complications of pediatric sinusitis. Neuroimaging should be considered in patients with prolonged symptoms of sinusitis.

Epidural abscesses were the most common intracranial complication, followed by subdural empyemas. Presence of subdural empyema was associated with the need for repeat neurosurgery, and patients with subdural empyema require vigilance for persistent suppurative infection despite drainage. The most common organisms identified were *S. anginosus* group bacteria, which is consistent with recent reports of an increasing number of infections with those organisms. Notably, MRSA was not a major pathogen in this cohort, and resistance to third-generation cephalosporins was otherwise low. Antibiotic treatment for a minimum of 4 weeks after source control appears to be effective in treating these infections, though neurological complications are not uncommon. Patients who present with new-onset seizures or abnormal neurological examination were more likely to develop neurological sequelae of their infection.

Notes

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