Reducing Surgical Revisions in Intracranial Complications of Pediatric Acute Sinusitis

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No sponsorships or competing interests have been disclosed for this article.

Abstract

Objective. (1) To describe the demographics and clinical course of children with intracranial complications of sinusitis. (2) To elucidate factors that predict revision surgery in this population, such as type of initial surgery.

Study Design. Case series with chart review.

Setting. Tertiary care academic children’s hospital.

Subjects and Methods. A 15-year retrospective review identified 71 patients with intracranial complications of acute sinusitis. Primary outcome was need for revision surgery. Secondary outcomes were readmission, length of hospitalization, and long-term complications.

Results. This study is the largest to date examining this disease process. Overall, 69 (97%) patients had surgery; 33 (46%) required revision surgery. Half of the patients with frontal sinus opacification underwent frontal sinus surgery at presentation (endoscopic, trephination, or cranialization). There was no difference in revision surgery between patients who had frontal sinus surgery and those who did not. Patients with frontal sinus surgery did not have a higher rate of complications or chronic sinusitis (P > .05). Subdural abscess was associated with multiple surgical procedures (odds ratio, 20.0; P < .01). Thirty-four patients (49%) required neurosurgery. These patients had a longer length of stay (odds ratio, 11.0; P < .01) and a higher readmission rate (P = .02). During the mean 92-month follow-up, 22 patients (33%) had long-term complications, and there was 1 death (1.4%).

Conclusion. Almost half of this cohort required multiple surgical procedures. In particular, patients with subdural abscess had significantly higher rates of revision surgery. Type of frontal sinus surgery was not correlated with need for revision surgery and was not associated with an increased rate of complications.

Keywords
intracranial, trephination, frontal sinusitis, endoscopic sinus surgery

Acute bacterial sinusitis is a common problem affecting children, and it can have severe consequences, affecting the brain, orbit, and cranial nerves. In the emergency room setting, 0.7% of children with acute sinusitis develop either orbital or intracranial complications.¹ This increases in the inpatient setting, where the rate ranges from 2% to 30%.² Although intracranial complications of acute sinusitis are relatively rare, they can have significant associated morbidity and mortality. In 2008, it was estimated that intracranial complications of sinusitis carried a 10% to 20% mortality rate, even despite aggressive treatment.³ Among children, serious long-term complications were reported in more than one-third of cases, despite aggressive medical and surgical interventions.⁴

More than half of all extra-axial brain abscesses have sino-genic etiology⁵; therefore, an understanding of the relationship between sinusitis and intracranial infections is extremely important. Acute frontal sinusitis is the most common site of infection leading to intracranial spread. The odds ratio of having an intracranial complication is 1:20 for frontal sinusitis as compared with all other types of sinusitis.⁶ In this location, bacterial infection spreads directly through the frontal sinus table, via valveless diploic veins and thrombophlebitis, or hematogenously via septic emboli.⁷,⁸ The association between frontal sinusitis and intracranial spread is thought to be why intracranial complications are more common for adolescents, when the frontal sinuses are fully developed.¹,²

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Received December 12, 2016; revised February 16, 2018; accepted February 23, 2018.

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Frontal sinusitis with intracranial complications are treated with a combination of long-term antibiotics and surgery.\(^7,8\) In 1 series, only 4 of 21 patients were treated without surgery.\(^9\) The surgical management ranges from minimally invasive with balloon sinuplasty\(^8\) to more invasive with frontal sinus trephination and craniotomy, which is reported to be required for as many as 57% of patients with intracranial disease.\(^9\) It is important to study the need for trephination given recent advances in endoscopic sinus surgery. In acutely inflamed pediatric sinuses, it can be difficult to endoscopically identify the natural frontal recess, and it is possible to cause scarring that leads to long-term sinusitis complications.\(^8,10\) Trephination offers another way to access the frontal sinus.

Here, we describe the largest cohort to date of patients treated for intracranial complications of sinusitis. We retrospectively evaluated this group to determine risk factors for revision surgery. We hypothesized that type of frontal sinus surgery (endoscopic, trephination, or none) would influence the need for revision surgery. We also evaluated risk factors for secondary outcomes, including length of hospital stay, need for neurosurgery, need for readmission, and long-term complications.

**Methods**

This project was approved by the Baylor College of Medicine Institutional Review Board (H-37188). With a text-based search of images from 2000 to 2016 in a picture archiving and communication system, imaging studies were identified that included “sinusitis” and “intracranial,” “meningitis,” “encephalitis,” “subdural,” “epidural,” or “absscess.” These reports and imaging studies were reviewed to ensure that patients had concurrent acute sinusitis adjacent to any type of intracranial disease. The patients’ charts were additionally reviewed to confirm the diagnosis. With this review, a total of 71 patients were identified between 2000 and 2015 at a single tertiary pediatric hospital. Patients who declined recommended treatments were excluded from further data analysis.

These patients’ charts were reviewed to gather demographic information, operative details, disease course, and treatment details. Each patient’s imaging studies were reviewed by a single author to confirm the degree of inflammation present in the frontal sinuses. The frontal sinus involvement was graded as no opacification, partial opacification, or total opacification. Any degree of aeration of the frontal sinus placed a patient in the partial opacification group. Patients were grouped according to surgical intervention (based on operative dictations): no frontal sinus intervention, endoscopic only, or sinus trephination.

The primary outcome was requirement for revision surgery. Secondary outcomes were length of hospital stay, need for readmission, and long-term sequelae. Univariate analysis was conducted with Fisher’s exact test for ordinal variables, and continuous variables were compared with the Wilcoxon rank test. Multivariate logistic regressions were performed for discrete variables. Odds ratios were reported.

Multivariate linear regression was performed for length of stay and duration of antibiotic course. Linear coefficients were reported. \(P < .05\) was considered significant. The comparisons were performed with SAS 9.3 (SAS Institute, Cary, North Carolina).

**Results**

During the 15-year study period, 71 children were treated for intracranial complications of acute sinusitis. The mean age at diagnosis was 13 years (range, 0-20; 95% CI, 12.2-13.8). Twenty-two (31%) patients were female. The mean follow-up period was 92 months (95% CI, 64.5-123.5). The types of complications were wide-ranging, as detailed in Table 1. Nineteen patients (27%) had multiple types of complications.

Imaging at presentation was not standard. The initial imaging studies were ordered by the emergency medicine or consulting physicians at presentation. At presentation, 21 patients (31%) had computed tomography (CT) alone; 2 (3%) had magnetic resonance imaging (MRI) alone; and 48 (68%) had both imaging studies.

Patients were managed medically and surgically. All patients were started on broad-spectrum intravenous antibiotics at time of presentation. Sixty-nine (97%) patients underwent surgery at some point during admission. Two children (3%) did not have surgery. One had a number of other medical comorbidities and started hospice care at the time of diagnosis. This patient was the only death in the cohort and was excluded from further data analysis. The other patient treated nonsurgically had a history of craniofacial surgery and had meningeal enhancement consistent with meningitis. His infection resolved with antibiotics alone.

The type of surgery was a clinical decision made by either the otolaryngologist or the neurosurgeon at the time of presentation based on extent of disease. Sinus surgery was common in this group, and 63 patients (89%) required endoscopic sinus surgery at some point during their treatment course (Figure 1). Timing of surgery was also determined by clinicians over the course of the disease process. The mean timing of surgery was 1.2 days (95% CI, 0.86-1.54) after presentation to the emergency room. The median timing of surgery was 1 day after admission. Twenty-six patients (37%) had surgery within 24 hours of presentation;

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**Table 1. Types of Complications.**

<table>
<thead>
<tr>
<th>Complication</th>
<th>n (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Meningitis/cerebritis</td>
<td>10 (14)</td>
</tr>
<tr>
<td>Epidural abscess</td>
<td>50 (70)</td>
</tr>
<tr>
<td>Subdural abscess</td>
<td>20 (28)</td>
</tr>
<tr>
<td>Intraparenchymal abscess</td>
<td>8 (11)</td>
</tr>
<tr>
<td>Venous sinus thrombosis</td>
<td>3 (4)</td>
</tr>
<tr>
<td>Concomitant orbital complication</td>
<td>33 (46)</td>
</tr>
</tbody>
</table>

*Some patients presented with multiple complications. Percentages represent children with each complication.*

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26 (37%) had surgery on day 1; and 17 (24%) had surgery on day 2 or later.

Primary and Secondary Outcomes

The primary outcome was defined as requiring a second surgical procedure. After the initial surgery, patients were closely monitored for resolution of disease. Those patients with clinical examination and imaging findings of worsening infection had revision surgery. Thirty-three patients (46%) required a second surgery. In univariate analysis, 3 factors were associated with significantly higher rates of revision surgery: neurosurgery at any point ($P < .01$), subdural abscess ($P < .01$), and CT imaging alone on admission ($P = .04$; Figure 2). On multivariate analysis, only subdural abscess was associated with an increased rate of revision surgery (86% of patients with subdural abscess vs 32% without; odds ratio, 20.0; $P = .01$). Type of initial surgical intervention had no significant impact on primary or secondary outcomes (Table 2). Furthermore, having trephination at any point did not have any significant influence on rate of revision surgery (Table 3). Type of bacteria cultured and type of antibiotics started at presentation were not correlated with increased need for revision surgery. For secondary outcomes, requiring neurosurgery was associated with significantly longer length of hospital stay (odds ratio, 11.1; $P = .003$) on multivariate analysis. However, having neurosurgery was also associated with significantly higher need for readmission ($P = .02$).

Specific Populations

Subdural Abscess. Twenty-one patients (30%) had subdural abscesses. The outcomes for these patients are outlined in Table 4. All patients were treated surgically, and all underwent sinus surgery (endoscopic surgery, trephination, fronto sinus cranialization, or a combination). In addition to sinus surgery, 18 patients (86%) required neurosurgery (either craniotomy or craniectomy) at some point during treatment. Adjusting for other factors, patients with subdural empyema needed neurosurgery more frequently than those without it (odds ratio, 11.9; $P = .01$). During their initial surgery, 16 patients (76%) had neurosurgery; 4 (19%) had trephination without neurosurgery; and 1 (5%) had endoscopic sinus surgery alone. Eighteen patients with subdural abscess (86%) required revision surgery, again significantly more frequently than other complications on multivariate analysis ($P = .01$). For this population, mean length of stay was 28 days (range, 5-46; 95% CI, 22.6-33.4). Nine (43%) had long-term complications. Length of stay and long-term complications were not significantly higher than other complications.

Frontal Sinusitis. To further elucidate the risk factors for revision surgery, the subgroup of patients with frontal sinusitis...
were examined. Sixty-two patients (87%) had partial or
total frontal sinus opacification on initial CT imaging. Only
9 patients (13%) did not have any frontal sinus disease
(Figure 3). Among only patients with frontal sinus opacifi-
cation and operative reports available (n = 52), 37 (71)
had surgery to address the frontal sinus as part of the initial
surgical intervention. Of the patients who had frontal sinus
surgery primarily, 12 (32%) had endoscopic frontal sinusot-
omy, and 19 (51%) had frontal sinus trephination. The
remaining 6 patients had frontal sinus cranialization by neu-
rosurgery. No patients had frontal balloon sinuplasty during
the initial surgery. The type of frontal sinus surgery (none,
endoscopic, or trephination) was not significantly correlated
with need for revision surgery (Figure 4). Eight patients
who did not have frontal sinus surgery at first went on to have frontal sinus surgery.

Seven patients (13%) with frontal sinusitis never had frontal sinus surgery. These patients recovered with neurosurgery and/or sinus surgery alone without any specific frontal sinus intervention. Of the 7 patients who were managed nonsurgically, 2 (29%) had long-term complications: cognitive delay (n = 1) and death (n = 1; in a case that was converted to comfort care at time of presentation). No patients had chronic sinusitis at last follow-up. Forty-five patients (71%) had front nasal abscess surgery at some point during treatment, and 18 (40%) of them had long-term complications. Some patients had multiple complications. Complications were cognitive delay (n = 6), seizures (n = 5), central line infection (n = 3), chronic sinusitis (n = 4), hemiparesis (n = 1), and saddle nose deformity (n = 1). The rates of complications (P = .86) or chronic sinusitis (P = .31) were not significantly different between the group with frontal sinus surgery and that without.

Discussion

Over the 15-year period, 71 patients were treated at Texas Children’s Hospital for intracranial spread of sinusitis. This is the largest study of this disease process to date. The demographics of our cohort are similar to those previously reported, with adolescent males being most commonly affected. The most common intracranial complication in our population was epidural abscess, followed by subdural abscess (Table 1).

In this series, 97% of patients required surgery, similar to previous reports. Our primary outcome was revision surgery, and 46% of patients required multiple surgical procedures. This rate is higher than that reported by Glickstein (33% of 21 patients) and Germiller (40% of 25 patients). Multivariate and univariate analyses were conducted to determine which factors were correlated with needing multiple surgical interventions during our follow-up period. In this analysis, patients with more extensive disease were more likely to require multiple operations. Of all the demographic and disease-specific information recorded, subdural abscess, neurosurgical intervention, and not having initial MRI were all statistically significantly correlated with having multiple surgical procedures on univariate analysis. Per multivariate analysis, only subdural abscess was significantly correlated with having a second surgical procedure.

Subdural empyema is recognized as a more severe infection, with a higher rate of mortality as compared with epidural abscess. The high number of subdural empyemas in this group could account for the high rate of revision surgery. Patients with subdural abscess had an 81% rate of requiring revision surgery, as opposed to a 32% rate in all other complications combined, which is consistent with previous studies. Furthermore, in the neurosurgery literature, large subdural abscess is generally an indication for neurosurgery and opening of the dura. Therefore, in this retrospective review, having neurosurgery serves as a marker for more severe disease. Logically, the patients with more extensive disease were more likely to require multiple surgical procedures. When the influence of infection type was accounted for as a confounder, neurosurgery alone was not correlated with needing revision surgery.

The final factor correlated with needing multiple surgical procedures was imaging. The standard imaging for intracranial complications of sinusitis is a combination of CT and MRI because CT alone may underdiagnose the extent of disease. In this group, patients with CT or MRI alone had a significantly higher rate of needing a second surgical procedure. In certain cases, the intracranial infection was not recognized on CT alone, and the disease progressed despite initial surgical intervention. There were other cases where the infection was so severe that it was clear on CT imaging alone and MRI was not required. In both situations, CT imaging alone correlated with more extensive disease, and these patients were more likely to need multiple operations. Previous studies showed that MRI is more sensitive and accurate for diagnosing intracranial complications of sinusitis, but this is the first study that correlates CT imaging alone with worse outcomes among these patients.

In further subgroup analysis, patients with radiographic evidence of frontal sinusitis were evaluated to determine factors correlated with revision surgery. One challenging clinical question in these children is how to surgically manage the frontal sinus. The frontal sinus is the most common source of sinonogenic intracranial infection. Addressing the frontal sinus surgically in a pediatric patient with acute inflammation may be technically challenging. As such, there is a range of surgical interventions used, from balloon sinuplasty to frontal sinus trephination. Because of the difficulty of surgery and the desire to avoid long-term complications of frontal sinus scarring, some surgeons do not endoscopically address the frontal sinus in this population. In this group, 13% of patients who had frontal sinusitis did not have frontal sinus surgery but went on to recover. Frontal sinus surgery (endoscopic or trephination) was not associated with an increased risk of complications; therefore, we conclude that frontal sinus surgery is safe in the acutely infected pediatric frontal sinus. However, low rates of each type of surgery make it difficult to conclude that any intervention is superior to the others. The patients who did not have frontal sinus surgery had a high rate of revision surgery (67%), but this was not significantly higher than that of patients who had any type of frontal sinus intervention. Because of the low number of patients in this group and the retrospective nature of this study, it is difficult to conclude that frontal sinus surgery is not needed for these patients—this group is susceptible to selection bias and may have had less severe disease. However, it is an interesting finding that deserves prospective evaluation.

This study is limited by its retrospective nature and the fact that surgical decisions were dependent on the attending surgeon on call. In this rare disease process, a large multicenter study is necessary to evaluate surgical management prospectively.
Conclusions

Intracranial complications of sinusitis remain a rare but challenging clinical entity with frequent need for revision surgery. In particular, patients with subdural abscess on initial imaging are at high risk of needing multiple surgical procedures and require aggressive management. Despite the challenges associated with frontal sinus surgery in an acutely inflamed pediatric sinus, there is not an increased risk of long-term complications as compared with patients who do not have frontal sinus surgery, particularly in the era of image-guided surgery and tools. Because of the relative rarity of the disease, larger studies are required for sufficient power to determine the best frontal sinus surgical technique.

Author Contributions

Sarah A. Gitomer, design, acquisition, analysis, interpretation of the data, drafting the work, final approval; Wei Zhang, analysis of the data, critical revisions, final approval; Lucila Marquez, analysis, interpretation of the data, critical revisions, final approval; Binoy M. Chandy, design, analysis, interpretation of the data, critical revisions, final approval.

Disclosures

Competing interests: None.
Sponsorships: None.
Funding source: None.

References