

Evaluation of treatment approaches for sinogenic intracranial abscess in children

Kristijonas Milinis¹, Janaki Thiagarajan², Sujata De³, Ravi Sharma⁴, Samuel Leong⁵, Ajay Sinha⁴, and Sunil Sharma⁶

¹Royal Liverpool and Broadgreen University Hospitals NHS Trust

²University of Liverpool

³University of Liverpool Faculty of Health and Life Sciences

⁴Alder Hey Children's Hospital

⁵University Hospital Aintree

⁶Barts Health NHS Trust

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Abstract

Objectives: To evaluate the management practices and outcomes in children with sinogenic intracranial suppuration. **Design:** Retrospective cohort study. **Setting:** A single paediatric tertiary unit. **Participants:** Patients younger than 18 years with radiologically confirmed intracranial abscess including subdural empyema (SDE), epidural (EDA) or intraparenchymal (IPA) abscess secondary to sinusitis. **Main outcome measures:** The rates of return to theatre, the length of hospital stay (LOS), death <90 days and neurological disability (ND) at 6 months. **Results:** A cohort of 39 consecutive patients (41% male, mean age 11.5) presenting between 2000-2020 were eligible for inclusion. SDE was the most common intracranial complication (n=25, 64%) followed by EDA (n=12, 31%) and IPA (n=7, 18%). The mean LOS was 42 days (SD 16). Sixteen patients (41%) were managed with combined ENT and neurosurgical interventions, 15 (38.5%) underwent ENT procedure alone and 4 (10.3%) had neurosurgical only drainage. Four patients initially underwent non-operative management. The rates of return to theatre, ND and 90-day mortality were 19 (48.7%), 9 (23.1%) and 3 (7.7%) respectively and were comparable across the four treatment arms. In the univariate logistic regression, only the size of an intracranial abscess (>10mm) was found to be associated with an increased likelihood of return to theatre (odds ratio 7, confidence interval 1.09-45.1), while combined ENT and neurosurgical intervention did not result in improved outcomes. **Conclusion:** Sinogenic intracranial abscesses are associated with a significant morbidity and mortality. The size of an intracranial abscess has a strong association with a need for a revision surgery.

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Conclusion: Sinogenic intracranial abscesses are associated with a significant morbidity and mortality. The size of an intracranial abscess has a strong association with a need for a revision surgery.

Key words: sinusitis, subdural empyema, epidural abscess, brain abscess, endoscopic sinus surgery

Key points

- A quarter of children with sinogenic intracranial abscess experience neurological disability and up to a half of patients require revision surgery.
- Initial combined ENT and neurosurgical procedures were performed in 41% of patients, while 38% underwent sinus drainage only.
- 9/15 children were successfully managed with sinus drainage only without the need of intracranial interventions.
- Combined ENT and neurosurgical approach was not found to be associated with the reduced rates of revision surgery, length of hospital stay or neurological disability.
- The size of intracranial abscess (≥ 10 mm) was associated with a significantly increased likelihood of revision surgery.

Introduction

Acute bacterial rhinosinusitis is common in children and adolescents and is frequently self-limiting. However, in a small proportion of patients (3.9%) sinusitis can be complicated by intracranial abscesses namely subdural empyema (SDE), intraparenchymal abscess (IPA) and extradural abscess (EDA)[1]. The spread of infection occurs either via direct extension (e.g. frontal bone osteomyelitis) or haematogenous dissemination of bacterial pathogens from the paranasal sinuses[2]. Children may present with non-specific symptoms such as malaise, headaches and fevers, which can result in a delay of correct diagnosis and subsequently worse outcomes[3]. Previous studies have reported significant morbidity with around half of patients requiring revision surgery, a quarter experiencing neurological disability and a mortality of 3-10%[4-6].

Optimal treatment of sinogenic intracranial suppuration in children is a contentious issue. A number of studies have reported the results of various treatment strategies; however, the evidence base is largely restricted to small retrospective case series[7-11]. The majority of the patients undergo either sinus drainage procedures or neurosurgical interventions or the combination of the two[3]. In addition, in a small proportion of patients a conservative medical treatment has also been reported[12]. The question of how extensive or aggressive the initial treatment strategy needs to be however remains unanswered. While some studies advocate joint interventions addressing both sinus and intracranial suppuration, others report that sinus surgery alone alongside antibiotic therapy may be sufficient to avoid a craniotomy[9,13,14]. However, due to the limited sample sizes and a lack of direct comparisons between the treatment arms, it is currently not clear which treatment strategies achieve the most favourable outcomes.

Objectives

The main aims of the study are to compare the outcomes of different treatment approaches used to treat patients with sinogenic intracranial abscesses and identify the key predictors of poor outcomes. The study

also aims to determine whether combined sinus and neurosurgical interventions are associated with improved outcomes.

Methods

Ethical considerations and governance protocols

The Health Research Authority online tool (<http://www.hra-decisiontools.org.uk/research/>) was used to confirm that this work did not qualify as research therefore no ethical approval was sought. The study proposal was reviewed by the local clinical governance department and was registered as a service evaluation project (number 3252).

Reporting guidelines

The study was carried out and reported in accordance with the STROBE guidance[15].

Study design and setting

Potentially eligible patients were identified using the International Classification of Disease – 10 (ICD-10) diagnosis of all types of intracranial abscesses (i.e. SDE, IPA, EDA) under the umbrella code of “intracranial abscess and granuloma” (G06.0) between 1st January 2000 and 31st December 2020. Medical records of the individual subjects were manually screened and only patients with the sinogenic intracranial abscesses were included in the study. A preliminary report on the outcomes of the first 14 patients have been previously reported by our group[16].

Participants and data sources

A retrospective review of paediatric patients (<18 years) presenting with sinusitis and one of the following intracranial complications confirmed on cross-sectional imaging including EDA, SDE and IPA was performed. Medical records were reviewed to obtain the demographic and clinical characteristics. Images and their reports were reviewed to confirm the diagnosis and document sinus involvement, the depth of an intracranial abscess and the type of collection.

Exclusion criteria

Intracranial collections secondary to sources other than sinusitis (e.g. mastoiditis, trauma) were excluded. Intracranial complications of sinusitis which did not have a concomitant abscess such as meningitis or venous sinus thrombosis were not eligible for inclusion.

Study end-points

The primary study outcomes were the rates of return to theatre during same admission, neurological deficits (ND) (e.g. paresis, dysphasia, cognitive impairment, etc.) at 6 months and the length of hospital stay (LOS). The secondary outcomes were death within 90 days of diagnosis and the rates of re-admission.

Data management and statistical analysis

The collected data were anonymised and stored on the secure hospital server. Statistical analysis was performed with SPSS version 27 (Armonk, NY). Comparisons between treatment approaches were analysed using the Chi-square test. The means for LOS and ages were compared using the Mann-Whitney U test. A univariate binary logistic regression analysis was carried out to investigate predictive factors (age, sex, combined ENT and neurosurgical intervention, size of collection, time to surgery, SDE).

Results

Demographic and clinical characteristics

A total of 39 patients (13 males, 41%) with a mean age of 11.5 (SD 2.7) (Table 1). Two thirds of patients were admitted between 2010-2020 (Figure 1). Twenty-four patients (61.5%) were transferred for treatment from other units. Mean length of hospital stay was 20 (SD 19) days. The most common organisms were

Streptococcus constellatus and *intermedius* (supplemental file). Median time from admission to surgery was 17 hours (range 3-189h).

Imaging findings

The most commonly involved sinuses, defined as opacification of the sinus cavity, were the frontal (n=33, 84%) and ethmoid (n=25, 64%) (Table 2). The most common intracranial complications were SDE (n=25, 64%) and EDA (n=12, 31%). Five patients had more than one simultaneous collection. Frontal bone osteomyelitis was found in three patients. Median time from admission to CT and MRI was six hours (range 2-58) and 15 hours (range 4-70) respectively. In eight patients MRI demonstrated an intracranial collection not detected by the CT alone.

Treatment approaches

The most common treatment approach was a combined ENT and neurosurgical intervention (16/39, 41%) followed by an ENT procedure alone (15/39, 38.5%) (Table 3, Table 4). The remaining patients were managed with neurosurgical only drainage (4/39, 10.2%) or conservative treatment (3/39, 10.2%). The most common ENT operation was antral washout (28/39, 72%) followed by frontal trephine surgery (9/39, 23%) and endoscopic sinus drainage (6/39, 15%). A craniotomy was performed in 15 (38%) and burr holes placed in 5 (12.8%). No significant changes in the treatment approaches were observed after mid-point of recruitment period (2010).

Table 5 summarises the comparisons of the key clinical characteristics between the main treatment groups. Although no statistically significant findings were detected, the size of intracranial abscess was found to be smallest in the ENT only group (median 5.5mm). Patients treated by combined neurosurgery and ENT interventions had the largest proportion of patients with SDE (13/16, 81.3%).

Main outcomes

Regarding the total cohort, 19/39 (48.7%) needed to return to theatre for another surgery after initial treatment. Furthermore, 9/39 (23.1%) of patients had ND at 6 months and 3/39 (7.7%) died within 90 days of admission. The rate of re-admission related to sinogenic intracranial infection was 3/39 (7.7%). Mean length of hospital stay was 20 (SD 19) days. Overall, all outcomes except for ND were comparable across the four treatment approaches (table 5). The risk of ND was significantly higher (p=0.033) in patients treated with neurosurgery alone (3/4, 75%) compared to those treated with ENT intervention alone (1/15, 6.7%).

Six of 15 (40%) patients initially treated with sinus only interventions required further neurosurgical interventions, while 10/16 (62.5%) required revision neurosurgical drainage in the combined treatment group. Three out of 4 patients were successfully treated with intravenous antibiotics without requiring surgical intervention. Median time for revision surgery was 5 days (interquartile range 20).

Outcome predictors

Table 6 summarises the results of the univariate logistic regression analyses for three main outcomes: return to theatre, hospital stay (>21 days) and ND. Combined neurosurgical and ENT interventions did not result in lower morbidity. The size of an intracranial abscess (≥10mm) was found to be associated with a significantly increased likelihood of return to theatre (odds ratio 7, confidence interval 1.09-45.1, p=0.041), while the remaining predictors were not found to be significant.

Discussion

Synopsis of key findings

The current study represents one of the largest cohort of children with sinogenic intracranial suppuration reported in the literature. The study findings confirm significant short and long-term morbidity previously described: 48.7% required revision surgery and 23.1% are left with neurological disability. The treatment course is complex and lengthy with most children requiring 3 weeks of inpatient treatment and a total of 6 weeks of antibiotic therapy. Majority of the patients were found to have either SDE (64%) or EDA

(31%) with frontal sinus involvement observed in 85%. Consistent with the literature joint neurosurgical and sinus interventions were most frequently employed as an initial treatment approach (41%), however it was not found to result in improved outcomes. A significant proportion (38%) were managed with sinus interventions alone. The size of an intracranial abscess was the most important predictor for requiring revision surgery and patients were 7 times more likely to return to theatre if measured $\geq 10\text{mm}$.

Comparison with other studies and clinical implications

Within the limitations of the retrospective data which are discussed below, the outcomes of the initial treatment approach were evaluated and compared. The rates of revision surgery were similar across the four groups with approximately a half of patients requiring second operation after 5 days due to progression of intracranial abscess. Notably, 9 out of 15 patients were successfully treated with sinus drainage thus avoiding a craniotomy. While we recognise that there was a trend of larger intracranial abscesses found in patients treated with neurosurgical drainage, the findings suggest that ENT only interventions may have a role in reducing the number of patients undergoing a craniotomy and its associated morbidity. The key question remains as to which patient group is most suited for this approach. Garin et al. have previously reported that the presence of SDE was a contraindication to endoscopic sinus surgery (ESS) only approach as 87% ultimately required a craniotomy[9]. On the contrary, 3 out of 4 patients with EDA were successfully managed with ESS alone. In the present study, we found that that 60% of patients managed with sinus interventions only did not require a craniotomy despite the high proportion of patients with SDE (60%). This begs the question whether factors other than the type of intracranial abscess has more deterministic effect on the need for revision surgery. Indeed, in the univariate logistic regression analysis we found that the size of an intracranial abscess ($\geq 10\text{mm}$) had the strongest prediction for the need to return to theatre, while the presence of SDE was not found to be significant. Our results are in contrast with those reported in the study by Gitomer et al.[14], which found that the presence SDE was the key predictor for the need to return to theatre, however the authors did not include the size of an abscess in the analyses. Therefore, it remains to be determined whether patients with small intracranial abscesses including SDE may be suited for ESS only. Non-operative initial treatment with close observation may also be an option. Three out of 4 patients in our cohort were successfully managed with intravenous antibiotics alone. None of the patients had neurological disability and had markedly shorter hospital stay (median 12.5 days). However, no firm recommendations can be made regarding the indications for conservative treatment.

Irrespective of the initial approach, two thirds of our cohort underwent neurosurgical intervention at some point during the inpatient stay. While ESS may prevent the need for a craniotomy in some patients, its role when used in conjunction with neurosurgical intervention is controversial. We found that two thirds of patients required revision surgery despite a joint neurosurgical and ENT approach, the highest proportion when compared to the other treatment arms. Combined treatment was also not found to affect the rates of revision surgery, neurological disability and hospital length of stay. As mentioned before, inherent selection bias may be responsible for the lack of apparent benefit of combined procedures, however the clinical and disease characteristics were largely comparable across the treatment groups as summarised in table 5. The current study findings are also consistent with the results from previous studies in adults[13,17]. In a retrospective cohort study on 255 adult patients with sinogenic intracranial suppuration, Koizumi et al. investigated the effects of ESS in addition to neurosurgical drainage[17]. The authors did not find that ESS resulted in an improvement in any of the study outcomes including mortality, requirement for blood transfusion, revision surgery, readmission and the LOS. These findings raise an important question as to whether sinus interventions, which can be more technically challenging in children are warranted in the acute setting considering the likelihood of increased operative time, bleeding and orbital injury. This is particularly relevant in centres where rhinological expertise may not be available. Some authors argue that ESS may serve as an important diagnostic tool by enabling the surgeon to obtain microbiological samples[9]. However, in the present study we found that in only 3/20 cases intracranial samples did not yield a culture growth and the wash out from the sinuses provided microbiological data instead.

The present study found significantly increased risk of ND in patients treated with neurosurgery alone (75%)

when compared to ENT only interventions (6.7%). The findings should be interpreted with caution due to the limited cases in the neurosurgery group (n=4). This observation is most likely as a result of a considerable difference in the median size of an intracranial abscesses across the groups (median 10mm in the neurosurgery vs. 5.5mm in the ENT only), although not statistically significant.

Finally, three deaths were observed in our cohort, two of which were in the ENT only group. All three patients presented with severe sepsis. One patient was deemed too unwell to undergo a craniotomy and only antral wash out was performed. In a second patient, the abscess was located in the pons and was not surgically accessible. A third patient passed away from the complications related to sepsis despite a craniotomy and antral wash out.

Limitations

The study has several important limitations. Firstly, the retrospective nature of the data introduces significant source of selection bias. All the comparisons of outcomes between the treatment groups should be interpreted cautiously. While we attempted to assess and compare a number of possible sources of bias (time to surgery, size of collection etc.) between the groups, it is possible that some important factors were not accounted. Secondly, as it was a retrospective review, we were unable to extract the clinicians' reasoning behind choosing one treatment strategy over another. Thirdly, small sample of patients treated with conservative and neurosurgery only approaches, prevents meaningful comparisons and risk type 2 error. The data on the individual procedures was provided, however subgroup analysis stratified by the type of sinus intervention was not feasible due to low patient numbers. Finally, no patient reported outcomes were collected.

Study strengths

The study presents one of the largest series in the literature and captures cases over a 20-year period. All the cases were consecutive and a complete follow-up was available. A variety of factors were considered to address the source of bias. The regression analysis was performed to identify the key prognostic factors.

Conclusions

The current study presents the outcomes of four treatment strategies commonly employed in managing sinogenic intracranial suppuration in children. The key factor in predicting the need for return to theatre was the size of an intracranial abscess. While sinus interventions were found to be successful in averting the need of a craniotomy in 60% of patients, its role when employed alongside neurosurgical drainage is less clear.

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