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Management Strategy of Intracranial Complications of Sinusitis: Our Experience and Review of the Literature

Bassel Hallak, MD[1], Salim Bouayed, MD[1], Joseph André Ghika, MD[2], Pedro S. Teiga[1], and Vincent Alvarez, MD[2]

Abstract

Objective: Sinusitis or rhinosinusitis is a very common disease worldwide, and in some cases, it leads to intracranial complications (ICS). These are more common in immunocompromised patients or with underlying comorbidities, but even healthy individuals, can be affected. Nowadays, ICS have become less common thanks to improved antibiotic therapies, radiological diagnostic methods, surgical techniques and skills. Nonetheless, they can still cause significant morbidity and mortality. For this reason, management of these complications requires a multidisciplinary approach to plan and customize treatment options. This paper presents our strategy in the management of a series of intracranial complications induced by acute sinusitis and compares our experience and outcomes with the literature.

Study design: Single institute experience, retrospective analysis of cases series and literature review.

Methods: Adult and child patients who were treated for ICS in the Department of Otorhinolaryngology at Sion Hospital, in Switzerland from 2016 to 2020 were included. Their symptoms, medical history, clinical and radiological findings, treatment, and outcome were documented.

Results: Eight patients (6 males- 2 females) aged from 14 to 88 y.o., were enrolled. None had any previous history of chronic, or recurrent sinusitis. Moreover, very few presented specific rhinological symptoms, but with neurological or other symptoms. Computed tomography (CT) and Magnetic Resonance Imaging (MRI) were used to confirm the diagnosis of all ICS. All types of known intracranial complications were observed in our cohort with a wide range of extension and severity of sinusitis. A multidisciplinary approach with individual treatments was tailored to each patient. Outcomes were favorable in almost all patients with neither recurrence, nor neurological sequels being observed in the follow-up. Only one patient was lost due to fatal complications of advanced lung cancer.

Conclusion: ICS remain a challenging clinical problem due to substantial associated morbidity and mortality. The incidence of these complications is relatively low. Therapeutical management guidelines are lacking. Early detection and multidisciplinary approach are key to successful treatment.

Keywords

sinusitis, intracranial complications, infections, multidisciplinary management

Introduction

Acute rhinosinusitis (ARS) is a common medical condition affecting more than a billion persons every year representing around 6 to 15% of the population worldwide,[1] is considered a complication of a viral respiratory infection. Acute bacterial rhinosinusitis accounts for <10% of sinusitis and should be suspected when symptoms last longer than 10 to 14 days or for whom symptoms worsen after initial improvement.[2]

Chronic rhinosinusitis (CRS) is an inflammation of the nose and paranasal sinuses that lasts for more than 12 weeks and presents with similar symptoms as those of acute sinusitis. Complications of chronic rhinosinusitis are relatively common, while those related to acute sinusitis are relatively rare.[3]

Complications of sinusitis are classified as either intracranial, extracranial or systemic complications. Of these complications, intracranial complications rarely occur.[4]

The prevalence of these complications varies depending on socioeconomic conditions, climate and geographical

[1]Department of Otorhinolaryngology, Head and Neck Surgery, Sion Hospital, Sion, Switzerland
[2]Department of Neurology, Sion Hospital, Sion, Switzerland

Corresponding Author:
Bassel Hallak, Department of Otorhinolaryngology, Sion Hospital, Avenue du Grand-Champsec 80, 1950 Sion, Switzerland.
Email: bassel.hallak@hopitalvs.ch

Table 1. Patients Characteristics and Clinical Presentation.

Patients cases	Gendre	Age	Symptoms at presentation	Imaging findidrongs
Case 1	male	52 year-old	Headaches, aphasia, right-side sensory-motor hemi syndrome, trouble of the state of consciousness.	Left-side pansinusitis + fronto-parietal subdural empyema + thrombosis of the superior sagittal sinus
Case 2	male	45 year-old	Headaches, drowsiness, vomiting.	Right-side maxillary sinusitis, frontal lobe abscess + bone lysis at the posterior wall of the right frontal sinus.
Case 3	male	27 year-old	Headaches, nasal discharge, left-side retro-orbital pain, epileptic crisis.	Left-side pansinusitis, right-side epidural abscess.
Case 4	male	73 year-old	Nasal obstruction, right-side proptosis, ptosis, diplopia and decreased of vision.	Bilateral pansinusitis + right-side intra-orbital abscess.
Case 5	male	40 year-old	Nasal discharge, left-side orbital ptosis, periorbital swelling, hypoesthesia V1 and V2	Left-side pansinusitis + ipsilateral supra-orbital abscess and frontal sub-periosteal abscess.
Case 6	male	14 year-old	Headaches, fever, frontal and bilateral palpebral swelling.	Bilateral pansinusitis + frontal sub-periosteal abscess.
Case 7	female	88 year-old	Progressive pulsatile frontal headaches.	Isolated left-side sphenoiditis + bony erosion at the posterior wall of the sinus
Case 8	female	62 year-old	Epileptic seizures, disorientation, sever memory disorder and psychomotor retardation.	Isolated right-side sphenoiditis + large bony defect of the sinus wall + three focus of fronto-temporal cerebritis on the right side.

region and increase in developing countries.[5] Epidemiologically, ICS affect a young population, between 20 and 30 y.o.[6]

The frontal sinus is the most frequently involved in the occurrence of intracranial complications, followed by the ethmoid and sphenoid sinuses. The infection spreads from the frontal or sphenoid sinus by two routes; hematogenous and/or anterograde venous route.[7] Direct spread from the affected sinus into the intracranial space through bony defects remains less common.

Orbital complications of sinusitis are more common, but intracranial complications are clearly the most serious and life threatening.[8] These complications include epidural abscess, subdural abscess, intracerebral abscess, meningitis, and cavernous or superior sagittal sinus thrombosis.[9] There is a lack of representative data on the occurrence of these phenomena in the larger scope and only data fragments are published in the literature.[5,7–10]

Because of the lack of evidence to guide management of these potentially devastating complications, we review cases series of ICS managed at our institution, present our strategy of management with outcomes and performed a review of the available literature.

Methods

This study was designed as retrospective cases series analysis of all patients treated with intracranial complications of acute sinusitis in the Department of Otorhinolaryngology- at Sion Hospital, in Switzerland during a 4-year period between 2016 and 2020.

Collected data include, gender, age, history of illness, diagnostic workup, imaging studies, physical examination, bacterial cultures, multidisciplinary approach, results and outcomes. Intracranial complications of origin other than the sinuses were not included in this study. The decision-making for the management of each clinical case was discussed in a multidisciplinary approach including an oto-rhinolaryngology, neurology, neurosurgery and infectiology evaluation and adapted to each case. The result of the bacteriological analysis guided the choice and duration of the antibiotic treatment. Follow-up was based on clinical and radiological evolution.

Results

Eight patients were diagnosed with ICS during the 4-year. No other origin for these intracranial complications apart from sinusitis was detected on the clinical, biological and radiological findings. Our cohort was composed of 6 males and 2 females with a median age of 50 years (range 14-88). Symptoms at the time of presentation are shown in Table 1. Those included headaches (62.5%), ocular manifestations (50%), nasal obstruction with discharge (37.5%), orbital swelling (37.5%), forehead swelling (25%), vomiting (12.5%), drowsiness (12.5%) and a variety of other neurological symptoms (62.5%). In our analysis, the clinical presentation of patients is in agreement with that reported in the literature.[11–15]

All patients had CT scan and/ or MRI imaging. CT scans accuracy rate for the detection of intracranial and orbital complications was 100%.

Sinus involvement was unilateral in 75% of patients and bilateral in 25% of patients (as shown in Table 1). The most frequently involved sinuses were the sphenoid sinus

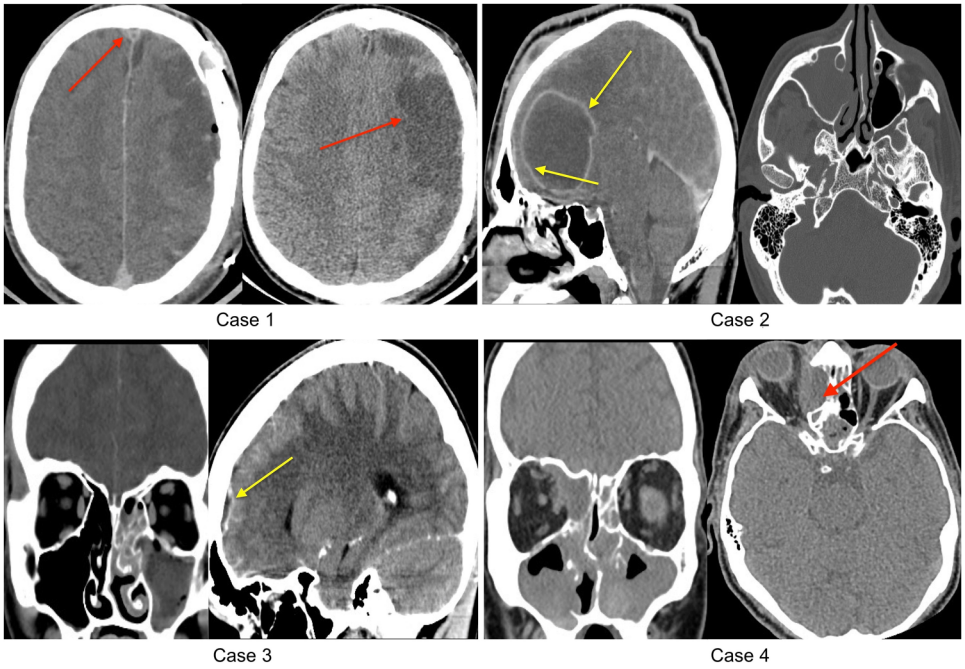

Figure 1. Case 1: axial CT show superior sagittal sinus thrombosis + subdural empyema. Case 2: sagittal CT shows intracranial abscess, axial CT shows isolated right-side maxillary sinusitis. Case 3: sagittal CT shoes epidural abscess, Coronal CT shows left-side pansinusitis. Case 4: axial CT shows right-side intra-orbital abscess, Coronal CT shows bilateral pansinusitis.

(75%), followed by the frontal and ethmoid (62.5%) and maxillary sinuses (50%).

The observed orbital and intracranial complications were subdural empyema (1), intracranial abscess (1), thrombosis of the superior sagittal sinus (1), epidural abscess (1), intra-orbital abscess (1), periorbital abscess (1), frontal subperiosteal abscess (2), meningitis (2) and encephalitis (1). These are detailed in Table 1 and can be seen in Figures 1 and 2. Combined complications were observed in three patients and isolated complications in five patients. In two patients, clinical suspicion of meningitis was confirmed by MRI (dural enhancement) and lumbar puncture. In these two patients, the involved sinus was the sphenoid with the microbiologic analysis showing a fungal infection (cases 7 and 8 Table 1). Among these two patients, one had additional MRI findings of encephalitis. The duration of hospital stays varied and ranged from 1 to 6 weeks.

Treatment

All patients who were included in this study benefited from a multidisciplinary management with different treatment modalities, which were specified to each case. All patients underwent surgical treatment of the sinus diseases by Endoscopy Sinus Surgery (ESS) alone or combined with an open approach for the frontal sinus in four patients (cases 1, 3, 5 and 6). The ESS was unilateral in six patients and bilateral in two patients. Imaging Guided Navigation System (IGNS) was used during all ESS.

Combined neurosurgical treatment was performed on two patients. Patient 1 underwent craniotomy twice to treat a subdural empyema, whereas patient 2 underwent craniotomy once only to treat frontal lobe abscess. Patient 3 underwent medical management of an epidural abscess with favorable evolution. Patient 4 presented with an intra-orbital abscess that was surgically drained endoscopically at the time of the sinus surgery. Patients 5 and 6 with supra orbital and frontal subperiosteal abscesses respectively, were treated by surgical drainage via open approach at the time of the sinus surgery. Patients 7 and 8 who were presented with meningitis and encephalitis were managed medically for the ICS combined with surgical treatment for the sphenoid sinus disease (Table 2). Patient 8 had a large bony defect in the walls of the sphenoid sinus (Figure 2) requiring clogging of the sinus using autologous fat and fascia lata grafts to separate the nasal cavity from the intracranial space and above all, to protect the carotid artery.

The results of the microbiologic analysis, antibiotic therapy, and management of the sinus disease, intracranial complications and duration of hospital stay are shown in Table 2. The causal agent in most cases (6/8) was bacterial and was fungal (aspergillus) in the 2 remaining cases. Of note, both fungal infections were the only ones associated with neurological complications (meningitis and encephalitis).

There was a single death (case1) with complications of advanced lung cancer. Neither recurrence of infectious disease or appearance of neurologic sequels were observed in the follow-up at 1 year.

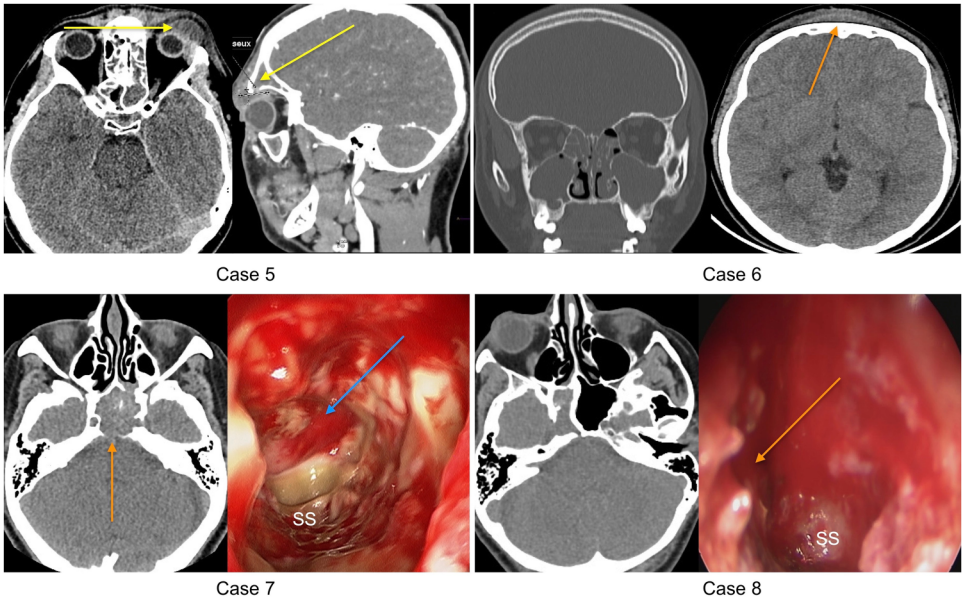

Figure 2. Case 5: axial and sagittal CT show left side supra orbital and frontal sub-periosteal abscess. Case 6: coronal CT shows bilateral pansinusitis. Axial CT shows frontal sub-perisoteal abscess. Case 7: axial CT shows left side sphenoid sinusitis and bony erosion on the posterior wall. Intraoperative endoscopic view shows area of extensive bony erosion on the posterior wall of the sphenoid sinus. Case 8: axial CT shows right side sphenoid sinusitis and bony erosion on the lateral wall. Intraoperative endoscopic view shows area of large bony erosion on the lateral wall of the sphenoid sinus.

Table 2. Investigations, Management and Outcomes.

Patients cases	Treatment of sinus diseases	Management of ICS	Micriobiologic analysis	Antibiotics	Hospital stay
Case 1	Left-side ESS + open approach for frontal sinus	Twice craniotomy	Fusobacterium nucleatum, prevotella intermedia	Tazobac 4.5gr IV. In addition, anti-coagulation therapy.	6 weeks.
Case 2	Right-side ESS	Singe one craniotomy	Staphylococcus haemolyticus.	Ceftriaxone 2gr IV + Metronidazole 500mg	6 weeks.
Case 3	Left-side ESS + open approach of the frontal sinus.	Medical treatment.	Staphylococcus epidermidis	Rocephine 2gr IV + Metroni dazole 500mg.	2 weeks.
Case 4	Bilateral ESS	Surgical drainage by endoscopic approach	Streptococcus constellates	Amoxicillin clavulanic acid 1.2 gr IV.	2 weeks
Case 5	Left-side ESS + open approach for frontal sinus	Drainage by open approach	Staphylococcus epidermidis	Co-amoxicillin 1.2 gr IV	2 weeks.
Case 6	Bilateral ESS + open approach for frontal sinus	Drainage by open approach	Commensal flora	Co-amoxicillin 1.2 gr IV	1 week.
Case 7	Left-side ESS	Medical management	Aspergillus	Voriconazole IV.	2 weeks.
Case 8	Right-side ESS	Medical management	Aspergillus	Voriconazole IV.	6 weeks.

Discussion

Most sinus infections are secondary following either an upper respiratory tract infection or an allergy.[8] These infections are not limited to the sinuses; they originate in the nose and then spread to the sinuses, hence the term rhinosinusitis.

Anatomical proximity as well as the thin bony walls of the paranasal sinuses with the orbit and skull-base facilitates the spread of sinus infection into both cavities. Any bony defect or dehiscence whether congenital or traumatic can lead to direct spread of infection.[8]

Likewise, spread of infection from the paranasal sinuses can occur either by anterograde venous or hematogenous route. The anterograde venous pathway corresponds to the appearance of septic thrombophlebitis in the venous network of the sinus mucosa, which converges in the diploic Breschet's veins of the frontal sinus. These veins are valveless which facilitates extension through the anterior

Table 3. Clinical Series in the Literature.

Series	N	Subdural empyema	Intracranial abscesses	Epidural empyema	Meningitis	Cavernous sinus thrombosis	Sagittal sinus thrombosis	osteomyelitis
Singh (1995)[12]	219	58%	17%	8%	10%			
Clayman (1991)[14]	24	8%	46%		29%	8%	4%	4%
Younis (2001)[9]	39	13%	10%	18%	54%			
Altman (1997)[20]	7							42%
Jones (1995)[27]	12	33%	17%	25%		8%		
Sable (1984)[28]	16	88%	13%		6%			6%
Gallagher (1998)[18]	15	18%	14%	23%	18%	9%	9%	9%
Bradley (1984)[11]	54	48%	37%	6%				
Albu (2001)[26]	16	25%	38%	31%	38%	13%		
Marshall (2000)[29]	7	14%		14%				100%
Giannoni (1997)[13]	12	33%	42%	42%	42%			
Giannoni (1998)[30]	10	40%	50%	20%	30%			
Jones (2002)[10]	47	38%	30%	23%	2%	2%		
Wiltold (2018)[25]	51	17%	5%	31%	29%	5%		49%
John (2008)[24]	23	43%	8%	34%	13%			

and posterior cortex of the frontal sinus.[16–21] These veins drain posteriorly into the meningeal veins. This venous system explains that from a frontal sinusitis, one can observe an osteitis of the posterior wall, an extradural abscess[16–19] or a subdural empyema corresponding to the septic dissemination by the meningeal veins. Likewise, the anterior diffusion explains an osteitis of the anterior wall and the frontal sub-periosteal abscess (Pott's puffy tumor).

The occurrence of thrombophlebitis of the cavernous sinus from a sphenoid sinusitis or even thrombophlebitis of the superior sagittal sinus from a frontal sinusitis shares the same physiopathology.

Hematogenous extension accounts for the occurrence of cerebral abscess.[22] They develop in areas of stagnant venous flow and correspond to retrograde diffusion of septic thrombosis.

The incidence of complications related to ARS is estimated world widely at three cases per million of the population per year.[3] These complications are classified as orbital (60-80%), intracranial (15-20%) or osseous (5%). Data in the literature mention that adolescents carry a greater risk for ICS because of the highly vascularized diploic venous system at this age group.[9] Second peak in incidence of ICS is observed in elderly patients, explained by advanced age induced declining of immune functions and other comorbidities. Males are more predisposed to developing ICS than females.[23]

The most common ICS is meningitis and it is frequently the result of sphenoid sinusitis or ethmoiditis. Neurological sequelae are common in patients with meningitis, primarily seizure disorders and sensorineural deficits but mortality is rare. Epidural abscess is the second most common ICS and seen almost exclusively in patients with frontal sinusitis. Subdural abscess is the third most seen complication, it is usually precipitated by a frontal sinusitis, mortality is estimated to be as high as 25% to 35% and approximately 30% of patients are left neurologically impaired.[8]

Intracerebral abscesses are uncommon complication of sinusitis; it usually involves the frontal and frontotemporal lobes and is associated with a mortality rate as high as 20% to 30%.[8] Subdural empyema is characterized by rapidly worsening physical and neurological state of the patient because the subdural space does not contain any natural barriers that can limit the spread of the infection.[24]

According to the literature, the existence of an orbital complication or Pott's puffy tumor is correlated with an increased risk of intracranial complications.[12,25] Thus, Bradley noted in 32.4% of cases an association between intracranial abscess and periorbital cellulitis.[6] An association between Pott's puffy tumor and epidural empyema was noted in the series of Dolan and Singh.[11,16] More generally, Pott's puffy tumor is associated in a large proportion with intracranial complications; 45% in the series of Jones,[9] 85.5% for Singh[11] [and 72% for Mammen-Prasad.[26]

Almost all cases of ICS are published as case reports, series of clinical cases or single institution's experience. Data from the literature concerning the occurrence of ICS on all the series studied are shown in Table 3.[7] According to this data, combined complications were observed in seven series; Singh 7%,[11] Altman 71%,[19] Jones 8%,[9] Sable 13%,[27] Bradley 9%,[6] Marshall 29%[28] and Giannoni 40%.[29] Szyfter et al [30] reported that 80% of meningitis cases occurred in association with other intracranial complications. A systemic review of pediatric ICS by Patel et al[31] Identified 180 patients in the literature and reported the most common complication was subdural empyema (49%), and meningitis was responsible for only 10% of cases.

Neuroimaging should be considered in patients with prolonged symptoms of sinusitis who have not improved with antibiotic therapy, when complications are suspected or

when surgery is being considered. Contrast-enhanced CT is typically the imaging modality chosen to diagnose intracranial complications due to availability, ease of use and clear definition of bony structures.[3] However, MRI is more sensitive and specific than CT-scans in the detection of intracranial complications[32,33] and may be beneficial when reviewing soft tissue changes, moreover, it lacks ionizing radiation. In a series of 82 patients with the diagnosis of ICS, reported by Younis et al,[21] the sensitivity for CT scans and MRI in detecting an intracranial abscess was 92% and 100%, respectively. Mortality from ICS in the pre-CT era was as high as 66%,[34] but has decreased to 2% to 7% [13–17] in the post-CT era.

The bacteriology implicated in ICS has been widely studied and many organisms have been identified including anaerobic and aerobic Streptococcal species, Streptococcus pneumonia, polymicrobial, micro-aerophilic Streptococci, non-beta haemolytic Streptococcus or Staphylococci.[12,14,35–37] Recent studies have highlighted the Streptococcus milleri group.[38] In a pediatric series of 21 patients studied by Glickstein et al,[39] only one patient demonstrated the Streptococcus milleri group, however, oral flora and polymicrobial infections were prominent. Kombogiorgas et al[40] reported in a series of 11 pediatric patients with ICS found Streptococcus species followed by anaerobes as the most common pathogen.

There are no universally accepted management guidelines for ICS. However, the literature shows that early diagnosis with a multidisciplinary approach, as well as a prompt medical and an aggressive surgical treatment are crucial to improve outcomes and reduce neurological sequels and mortality. The role of neurosurgical treatment with drainage is clear for large intracranial abscess (> 1 cm), both in pediatric and adult patients.[23–34,41] Small intracranial abscess (< 1 cm) can be treated with initial medical management with intravenous antibiotics and serial radiologic evaluation to assess for improvement or progression of disease.[23] However, neurosurgical drainage should be considered if no clinical and radiological improvement is observed.

Intracranial subdural empyema is a rapidly fatal condition if not recognized early and managed promptly. Treatment is neurosurgical emergency drainage.[42] Early surgical drainage combined with eradication of the primary source of sepsis through intravenous administration of high doses of appropriate antibiotic agents represents the main methods of treatment.[43] However, an initial conservative therapeutic approach to the sinus-related intracranial epidural abscess has also been supported.[44] A clinical series of 23 patients with ICS found that five out of six patients with subdural empyema that were initially managed with antibiotics and ESS eventually underwent craniotomy due to the nonresponsive rapidly progressive condition.[23]

Analysis of the literature shows a controversial role of the ESS in the management of ICS. Some authors suggest ESS as an initial management to reduce the number of neurosurgical procedures,[45,46] in contrast, other studies showed that ESS as the first treatment may not prevent neurosurgical drainage. As most cases of ICS result from indirect spread of infection, surgical drainage of the sinuses does not seem to have a significant immediate result. On one hand, ESS is to be suggested in case of direct spread of the infection from the sinus to the intracranial space.[23–39,41] On the other hand, performing ESS combined with medical therapy, as initial management of ICS related to indirect spread of infection did not demonstrate a beneficial effect in terms to reduce of the need for craniotomy.[23]

The duration of the antibiotic treatment for ICS remains a challenging issue. The question is whether patients should be treated until complete resolution of neuroimaging findings or if treatment can be stopped earlier if imaging has significantly improved. In a series of 54 patients with ICS,[47] outcomes were similar in patients whose antibiotics were stopped after resolution on neuroimaging and those whose antibiotics were stopped after significant improvement but not complete resolution.

Analysis of the literature shows that before the antibiotic's era, mortality from ICS was very high.[48,49] Thanks to the new imaging methods (CT and MRI), the use of the next-generation antibiotics, the perfectioning of the sinus surgery skills (FESS), the development of surgical skull-base approaches and the use of neuronavigation system all played a significant role in decreasing mortality rates, which are currently between 7% and 15%.[17,23,46,50,51]

Our cohort represents almost all known types of ICS. The small number of patients included in the study may be proportional to the small population in our region with an estimated average of two cases per year. Our approach to management for ICS was consistent with literature data; neurosurgical drainage of the subdural and large intracranial abscess, medical management for the epidural abscess, open and endoscopic drainage for the peri-and intraorbital abscess as well as for the frontal subperiosteal abscess. In contrast to the literature, all sinuses diseases were managed surgically by performing ESS in all patients because we believe that the complete eradication of the primary sinus infection focus is a key point in the control of the infectious disease. Even though it may not be enough to avoid neurosurgical drainage and craniotomy.

Conclusion

Overall, the incidence of ICS is relatively low, but its severity should not be underestimated, it can be fatal and have potentially devastating.

Therapeutical management guidelines are lacking and surgeon's experience proves decisive, remaining a challenging clinical problem. Early detection, multidisciplinary approach and prompt and aggressive treatment are key to a successful outcome.

Futures studies are warranted to evaluate disease and better guide treatment.

Abbreviation

ICS	Intracranial complications of sinusitis
CT	Computed tomography
MRI	Magnetic resonance imaging
ARS	Acute rhinosinusitis
CRS	Chronic rhinosinusitis
ESS	Endoscopic sinus surgery
FESS	Functional endoscopic sinus surgery
IGNS	Imaging-guided navigation system

Author contribution(s)

Bassel Hallak: Investigation; Methodology; Writing – original draft.
Salim Bouayed: Project administration; Visualization.
Joseph André Ghika: Project administration; Supervision.
Vincent Alvarez: Project administration; Supervision.

Competing interests

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ORCID iD

Bassel Hallak https://orcid.org/0000-0002-1359-4325

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