International Journal of Otolaryngology and Head & Neck Surgery, 2025, 14(1), 57-67
https://www.scirp.org/journal/ijohns
ISSN Online: 2168-5460
ISSN Print: 2168-5452

Factors Associated with Complications of Acute Bacterial Rhinosinusitis in Children

Amadou Njifou Njimah[1], Louise Mouangue-Mbonjo[1*], Patricia Epée Eboumbou[2], Daniele-Christiane Kedy Mangamba Koum[2], François Djomou[3], Louis Richard Njock[3]

[1]Department of Surgery and Specialty, Faculty of Medicine and Pharmaceutical Sciences, University of Douala, Douala, Cameroon
[2]Department of Clinical Sciences, Faculty of Medicine and Pharmaceutical Sciences, University of Douala, Douala, Cameroon
[3]Department of Ophthalmology and Otorhinolaryngology, Faculty of Medicine and Biomedical Sciences, University of Yaoundé I, Yaoundé, Cameroon
Email: *lou-mouang@yahoo.fr

How to cite this paper: Njimah, A.N., Mouangue-Mbonjo, L., Eboumbou, P.E., Koum, D.-C.K.M., Djomou, F. and Njock, L.R. (2025) Factors Associated with Complications of Acute Bacterial Rhinosinusitis in Children. *International Journal of Otolaryngology and Head & Neck Surgery*, **14**, 57-67.
https://doi.org/10.4236/ijohns.2025.141007

Received: December 21, 2024
Accepted: January 20, 2025
Published: January 23, 2025

Abstract

Background: In children, acute bacterial rhinosinusitis (ABRS) is often complicated by ophthalmological and/or neurological involvement. These complications should be known and recognized, as they require urgent treatment with intravenous antibiotics and close in-hospital monitoring. In this study, we aimed to identify the main risk factors associated with the development of complications in children aged 2 - 17 years with ABRS. **Methods:** We conducted a retrospective cohort study of patients with ABRS complications in a primary hospital. Participants were divided into two groups: the control group comprising patients without complications (Group 1, n = 82) and the study group comprising patients with complications requiring hospitalization (Group 2, n = 41). We assessed the sociodemographic, clinical, and imaging data of both groups. Using multivariate logistic regression, we assessed risk factors of ABRS complications. **Results:** No socio-demographic characteristics were associated with ABRS complications ($p \geq 0.05$). Factors associated with complications were delay in consultation ($t = 5.282$; $p < 0.001$), ophthalmological signs on admission (Odds ratio, OR: 42.0 [5.27 - 334.50], $p < 0.001$), and presence of at least two affected sinuses (OR: 54.75 [17.02 - 176.13], $p < 0.001$). **Conclusions:** Intracranial and extracranial complications of ABRS in children have become rare in our setting. These complications can be serious and potentially fatal. Risk factors of these complications are delays in consultation, the presence of ophthalmological signs, and more than one affected sinus. Controlling modifiable factors would improve the treatment success of ABRS complications in children.

Keywords

Rhinosinusitis, Orbital Complications, Endocranial Complications, Imaging, Children, Surgery

1. Introduction

Acute bacterial rhinosinusitis (ABRS) is described as complicated when the infection spreads beyond the sinus cavities. Complications are mainly secondary to ethmoidal and frontal sinusitis and may involve the orbit or endocranium. Differentiating viral and bacterial etiologies in children is challenging in everyday clinical practice [1] [2]. ABRS in children has a controversial pathophysiology, clinical features, and treatment [1] [3] [4]. Complications of ABRS are rare; however, when they do occur, they progress rapidly and can be functionally or vitally life-threatening, requiring rapid multidisciplinary surgical intervention [5]. MRI is useful for clarifying the contents of the sinus and assessing the degree of invasion of the sinus soft tissues, endocranial structures, cavernous sinus and orbital contents [6] [7]. Bacteriological tests are not routinely performed. Aggressive treatment usually involves sinus drainage and broad-spectrum antibiotic therapy, subsequently adapted to findings on analysis of bacteriological samples [8]-[10]. An endonasal procedure might be indicated in some cases, but its use is minimized given the risk of iatrogenic accidents in a hemorrhagic and inflammatory environment. In certain situations, neurosurgical drainage of deep collections may also be required [11]. In all cases, clinical improvement should be observed within 48 hours; if not, imaging should be repeated and an additional procedure discussed. Several studies have identified the risk factors for RSBA in adults that must be observed in the management of this condition without looking specifically at the child. Our study aims to identify risk factors affecting the occurrence of early or late complications of ABRS.

2. Methods

This was a retrospective cohort study, conducted between January 2015 and November 2024. The participants were children aged 2 - 17 years of both sexes diagnosed with complications of ABRS at the Yaoundé University Teaching Hospital (YUTH), Cameroon, who underwent surgery or not. Patients with a history of sinusitis and incomplete records were excluded.

Patients' sociodemographic, clinical, and imaging data were obtained from patient records in the otolaryngology, emergency, and neurosurgery departments of the YUTH during the study period. The variables of interest included age, sex, place of residence, medical and surgical history, symptom duration before consultation, and type of clinical and paraclinical complications. We used the following diagnostic criteria for his children: the history taken from the parents regarding a sudden increase in the severity of the symptoms of an upper respiratory tract

infection, a purulent posterior discharge and/or the presence of pus in the average meat has the anterior rhinoscopy at the time of the physical examination of the patient finally a CT to children with suspected complications in the orbit and the central nervous system to establish the diagnosis of ARS. Patients detected to have developed complications for reasons other than ABRS were excluded from the study. Given the age of the patients, we did not perform a sinus puncture, much less a pus culture. The primary endpoint was occurrence of one or more complications. To identify the factors associated with complications of ABRS, a matching ratio of two cases of uncomplicated rhinosinusitis for one case of complicated rhinosinusitis was used. In this study, rhinosinusitis refers to a simultaneous infection of the nasal mucosa (rhinitis) and the mucosa of the paranasal sinuses (sinusitis). Acute rhinosinusitis refers to rhinosinusitis lasting < 12 weeks, while chronic rhinosinusitis refers to rhinosinusitis lasting ≥ 12 weeks. ABRS is the presence of at least three of the following findings: purulent rhinorrhea, facial pain, fever with a temperature > 38˚C, elevated C-reactive protein level, and worsening of symptoms after transient improvement. The extension of the infectious process beyond the sinus cavities is described as complicated rhinosinusitis. Orbital cellulitis is a severe invasive bacterial infection of the post-septal tissues of the eye; it was classified using Chandler's classification as follows: Grade I, preseptal cellulitis or orbital inflammatory edema; Grade II, diffuse orbital cellulitis; Grade III, subperiosteal abscess; Grade IV, orbital abscess; and Grade V, cavernous sinus thrombosis [12].

All statistical analyses were performed using SPSS software version 23.0. Quantitative variables are expressed as mean ± standard deviation or median and interquartile range, and qualitative variables as numbers and percentages. Quantitative variables were compared using Student's t-test for independent variables or the Mann-Whitney U-test for non-parametric variables. Qualitative variables were compared using Pearson's chi-squared test or Fisher's exact test. A p value of <0.05 was considered as statistically significant. Multivariate logistic regression analysis was performed.

3. Results

3.1. Participants' Sociodemographic Characteristics

We enrolled 41 patients with ABRS complications. Their median age was 8.29 ± 3.84 years, with a range of 2 - 15 years. Most children were aged between 6 and 9 years (51.2%) and were boys (65.9%), giving a sex ratio of 1.93. Most children (63.4%) lived in urban areas (**Table 1**).

3.2. Participants' Clinical Characteristics

a) Relevant history

Twenty-two (53.7%) children had a history of allergic rhinitis (**Figure 1**).

b) Duration to consultation, symptoms on admission, and lesion characteristics

The median number of days before consultation was 7.93 ± 2.54 days, with a range of 4 - 15 days. Regarding symptoms on admission, the commonest were ophthalmological (Figure 2) and ear-nose-throat (ENT) symptoms, with rates of 34.1% and 31.7%, respectively (Table 2).

Sinus involvement was mainly unilateral (85.4%) or multiple (78.0%). Pansinusitis was diagnosed in most cases (31.7%).

3.3. Paraclinical Characteristics of Lesions

Complications included cranioencephalic damage in most cases (34.1%, Figure 3). Grade II orbital cellulitis was the most common complication, accounting for 31.7% of cases (Table 3).

3.4. Management

Medico-surgical management was provided in 90.2% of the patients. Drainage surgery was the most performed surgery, in 48.8% of the patients (Table 4).

3.5. Factors Associated with ABRS Complications

No sociodemographic characteristic was associated with ABRS complications ($p \geq 0.05$) (Table 5). Patients who developed sinusitis complications had significantly longer days between symptom onset and consultation than those who did not ($t = 5.282$; $p < 0.001$). Regarding symptoms on admission, patients with ophthalmological signs had a greater risk of complications (Odds ratio, OR: 42.0 [5.27 - 334.50], $p < 0.001$), whereas those with ENT signs (OR: 0.28 [0.12 - 0.62], $p = 0.001$) or general signs (OR: 0.24 [0.08 - 0.68], $p = 0.003$) were less likely to develop ABRS complications. Children with at least two affected sinuses were 54 times more likely to develop a complication than those with only one affected sinus ($p < 0.001$). Isolated maxillary sinus involvement was the only factor associated with a reduced risk of complications (OR: 0.01 [0.004 - 0.04]; $p < 0.001$).

Table 1. Population distribution by socio-demographic characteristics.

Variables	Number (N = 41)	Frequency (%)
Age, years		
2 - 5	8	19.5
6 - 9	21	51.2
10 - 15	12	29.3
Sex		
Male	27	65,9
Female	14	34.1
Place of residency		
Urban	26	63.4
Rural	15	36.6

Table 2. Distribution of the population according to duration to consultation, symptoms on admission, and lesion characteristics.

Variables	Numbers (N = 41)	Frequency (%)
Duration to consultation, days		
< 7	11	26.8
7 - 10	14	34.1
11 - 15	16	39.0
Symptoms on admission		
Ophtalmological	14	34.1
ENT	13	31.7
Neuromeningeal	9	22.0
General	5	12.2
Laterality of the lesion		
Unilateral	35	85.4
Bilateral	6	14.6
Number of affected sinuses		
One	9	22.0
Two	19	46.3
Multiple	13	31.7
Sinuses affected		
Pansinusitis	13	31.7
Maxillofrontal	7	17.1
Ethmoidomaxillary	7	17.1
Maxillary	7	17.1
Ethmoidofrontal	3	7.3
Ethmoidosphenoidal	2	4.9
Frontal	1	2.4
Ethmoidal	1	2.4

Table 3. Distribution of the population according to the nature of complications.

Variables	Number (N = 41)	Frequency (%)
Site of complications		
Cranioencephalic	14	34.1
Oculo-orbital	20	48.8
Combined	7	17.1
Type of complications[a]		
Grade II orbital cellulitis	13	31.7
Grade III orbital cellulitis	7	17.1
Subdural empyema	7	17.1
Brain abscess	5	12.2
Grade I orbital cellulitis	5	12.2
Meningitis	3	7.3
Cavernous sinus thrombophlebitis	1	2.4

[a]Chandler's classification was used to classify orbital cellulitis.

Table 4. Distribution of the population according to therapeutic characteristics.

Variables	Numbers (N = 41)	Frequency (%)
Therapeutic methods		
Medico-surgical	37	90.2
Medical	4	9.8
Types of surgical treatment		
Drainage	20	48.8
Meatotomy	10	24.4
Craniotomy	7	17.1

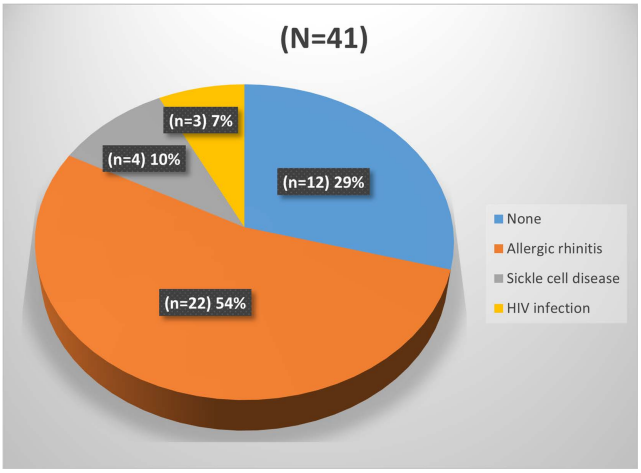

Figure 1. Distribution of the population according to background.

Figure 2. Right orbital cellulitis of sinus origin with palpebral edema and fluctuating medial fluid collection.

Figure 3. Image of an abscess and empyema in a 12-year-old patient with sickle cell disease.

Table 5. Association between patient characteristics and complications of sinusitis.

Variables	Case	Control	OR	Value
	N = 41; n (%)	N = 82; n (%)	(95% CI)	P*
Age, years				
2 - 5	8 (19.5)	10 (12.2)	1.74 (0.63 - 4.82)	0.207
6 - 9	21 (51.2)	53 (64.6)	0.57 (0.26 - 1.23)	0.108
10 - 15	12 (29.3)	19 (23.2)	1.37 (0.58 - 3.19)	0.301
Sex				
Male	27 (65.9)	44 (53.7)	0.60 (0.27 - 1.30)	0.136
Female	14 (65.9)	38 (46.3)	1.66 (0.76 - 3.62)	0.136
Residency				
Urban	26 (63.4)	54 (65.9)	1	0.471
Rural	15 (36.6)	28 (34.1)	1.11 (0.50 - 2.43)	0.471
Duration to consultation, days	9.49 ± 3.45	7.16 ± 1.42	5.282	<0.001
<7	11 (26,8)	29 (35.4)	0,67 (0.29 - 1.53)	0.228
7 - 10	14 (34.1)	53 (64.6)	0.28 (0.12 - 0.62)	0.001
>10	16 (39.0)	0 (0.0)	/	<0.001
Symptoms at admission				
Ophthalmologic	14 (34.1)	1 (1.2)	42.0 (5.27 - 334.50)	<0.001
ENT	13 (31.7)	51 (62.2)	0.28 (0.12 - 0.62)	0.001
Neuromeningeal	9 (22.0)	0 (0.0)	/	<0.001
General	5 (12.2)	30 (36.6)	0.24 (0.08 - 0.68)	0.003
Laterality of the lesion				
Unilateral	35 (85.4)	82 (100.0)	/	0.001
Bilateral	6 (14.6)	0 (0.0)	/	0.001
Number of affected sinuses				
One	9 (22.0)	77 (93.9)	0.018 (0.001 - 0.05)	<0.001
Many	32 (78.0)	5 (6.1)	54.75 (17.02 - 176.13)	<0.001
Sinuses affected				
Ethmoidal	1 (2.4)	0 (0.0)	/	0.333
Frontal	1 (2.4)	0 (0.0)	/	0.333
Ethmoidofrontal	3 (7.3)	0 (0.0)	/	0.035
Ethmoidomaxillary	7 (17.1)	0 (0.0)	/	<0.001
Ethmoidosphenoidal	2 (4.9)	0 (0.0)	/	0.109
Maxillary	7 (17.1)	77 (93.9)	0.01 (0.004 - 0.04)	<0.001
Maxillofrontal	7 (17.1)	5 (6.1)	3.17 (0.93 - 10.70)	0.057
Pansinusitis	13 (31.7)	0 (0.0)	/	<0.001

OR, Odds ratio; CI, confidence interval; *P values of ≤0.05 were considered significant.

4. Discussion

In this study, we aimed to identify risk factors of complications of ABRS in children aged 2 - 17 years. Risk factors of these complications are delays in consultation, the presence of ophthalmological signs, and more than one affected sinus.

Previous studies have reported varying incidences of rhinosinusitis ranging from 3% to 11% based on the diagnostic criteria used [13] [14]. The incidence of intracranial complications of acute rhinosinusitis is approximately 3% - 17% [15]. The frequency of RSBA tends to decrease as elsewhere in the world, largely thanks to available vaccines. Indeed Haemophilus influenzae was found in most of the samples. In our context, the vaccine against H. influenzae type b (Hib) has become widely available thanks to its introduction into the Expanded Program on Immunization (EPI) [16]. Acute rhinosinusitis is frequent in youths aged 10 - 30, with a clear male predominance. This is consistent with our study findings: the patients' average age was 8 years. In our study, most patients were between 6 and 9 years old; however, age was not a significant risk factor for ABRS complications. Moreover, sex and history of sinusitis were not risk factors for ABRS complications. In a review examining thirty-two articles meeting the inclusion criteria for the meta-analysis of research plus three additional articles, all studies were level 4 evidence according to the Oxford Center for Evidence-based Medicine guidelines, almost all studies showed a male predominance; suggesting that the female immune system is more competent [17] [18].

Another risk factor for ABRS complications in this study was the long duration of symptoms before consultation. In an American study by Herrman *et al*. [15], delayed diagnosis, inadequate treatment, and/or lack of health coverage were independent risk factors for ABRS complications. Therefore, reinforcing information dissemination, education/counseling, and communication programs adapted to these patients and their parents, particularly during routine consultations and/or vaccination sessions, are very important. Also, the presence of ophthalmological signs was associated with a greater risk of complications (OR: 42.0 [5.27 - 334.50], $p < 0.001$), and it was a significant predictive factor for the occurrence of ABRS complications on multivariate analysis. Of note, one-third of the children in our study presented with ophthalmological symptoms, underscoring the fragile nature of this population treated for ABRS complications.

Regarding the pathophysiology of ABRS complications, the infection spreads via dehiscence in the papyraceous lamina, requiring surgical drainage by orbitotomy, with or without sinus drainage, and/or neurosurgical drainage combined with parenteral antibiotic therapy (such as ceftriaxone, metronidazole, and gentamicin) [2] [6] [19] [20]. If there is no favorable response to treatment, the choice of antibiotics is based on expert opinion grade C recommendations [21]. In an Australian study by Terence *et al*. [22], methicillin-resistant Staphylococcus aureus (MRSA) was isolated in cases of ABRS with orbital involvement. These children with orbital involvement require rapid drainage under locoregional anesthesia. In a study by Hsu *et al*. [23], MRSA was isolated on cultured samples

obtained from the orbits (n = 33), sinuses (n = 31), and dural cavities (n = 4) in 66.7%, 61.3%, and 75%, respectively, compared with 17.6% for blood cultures (n = 69). This again underlines the importance of antibiotic combination regimens prescribed according to resistance patterns, risk factors for infection by resistant pathogens, and published evidence-based guidelines.

Finally, in our study, children with at least two affected sinuses were 54 times more likely to develop an ABRS complication than those with only one affected sinus ($p < 0.001$). This suggests that optimal early management of colds and allergic rhinitis would reduce complications. In addition, isolated maxillary sinus involvement was a protective factor for ABRS complications (OR: 0.01 [0.004 - 0.04], $p < 0.001$). Surgery is performed according to imaging findings. The prognosis is currently improved by early diagnosis and reported advances in surgery.

We suggest the introduction of the risk factors suggested in the study into a rating system with pediatrics, otorhinolaryngology, neurosurgery and emergency departments to identify these children and initiate multidisciplinary, rapid, adequate care according to standard protocols and that other multicenter studies evaluate this scoring system. Also a standard format for reporting complications is recommended for better harmonization of multidisciplinary work in record keeping.

This study has some limitations. First, the retrospective single-center nature of our study infers inherent biases. Second, the sample size was small, and many participants were not included in the study due to unavailable computed tomography (CT) findings; these patients did not have the financial means to pay for the examination. Despite these limitations, the strength of our study lies in the fact that we identified risk factors for ABRS, a disease that has become rare with the advent of medical imaging and effective antibiotic therapy. However, our study can serve as a benchmark for future studies using the Bradford Hill criteria [24]. Overall, ABRS complications have a good prognosis. Early diagnosis and appropriate intervention for these complications can limit management to intravenous antibiotic therapy and avoid the need for more aggressive surgical management in children.

5. Conclusion

The risk factors for ABRS complications in children include delay in consultation, which is responsible for the significant extension of lesions, the presence of ophthalmological signs on admission, and having more than two affected sinuses on CT scan. Isolated maxillary sinus involvement was also a protective factor. Early multidisciplinary management with the identification of risk factors, combined with personalized postoperative monitoring, could further improve outcomes of ABRS complications in children.

Acknowledgements

The authors would like to thank the staff of the department of Otorhinolaryngology

and Cervico-maxillofacial Surgery, Yaounde Central Hospital.

Informed Consent

The children's legal guardians provided written informed consent for participation and dissemination of the images related to the study.

Author Contributions

All authors contributed to data collection, drafting of the manuscript, and approval of the final version of the article.

Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

References

[1] Klossek, J., Quinet, B., Bingen, E., Francois, M., Gaudelus, J., Larnaudie, S., *et al.* (2007) État actuel de la prise en charge des infections rhinosinusiennes aiguës de l'enfant en France. *Médecine et Maladies Infectieuses*, **37**, 127-152. https://doi.org/10.1016/j.medmal.2006.11.008

[2] Garau, J. and Dagan, R. (2003) Accurate Diagnosis and Appropriate Treatment of Acute Bacterial Rhinosinusitis: Minimizing Bacterial Resistance. *Clinical Therapeutics*, **25**, 1936-1951. https://doi.org/10.1016/s0149-2918(03)80197-2

[3] Kaplan, A. (2014) Canadian Guidelines for Acute Bacterial Rhinosinusitis: Clinical Summary. *Canadian Family Physician*, **60**, e149-e156. (In French)

[4] Amat, F. (2010) Complications des sinusites bactériennes du grand enfant. À propos d'un cas et revue de la littérature. *Archives de Pédiatrie*, **17**, 258-262. https://doi.org/10.1016/j.arcped.2009.11.012

[5] Miloundja, J., Bamba, J.S., Mouba, J.F., Ella Ondo, T., Mwanyombet, L., Mandji Lawson, J.M., *et al.* (2011) Cranioencephalic Complications of Bacterial Sinusitis in Children and Adolescents: Eight Cases in Libreville (GABON). *Cahiers Santé*, **21**, 215-220. https://doi.org/10.1684/san.2011.0275

[6] Poole, M.D., Jacobs, M.R., Anon, J.B., Marchant, C.D., Hoberman, A. and Harrison, C.J. (2002) Antimicrobial Guidelines for the Treatment of Acute Bacterial Rhinosinusitis in Immunocompetent Children. *International Journal of Pediatric Otorhinolaryngology*, **63**, 1-13. https://doi.org/10.1016/s0165-5876(01)00631-0

[7] Desrosiers, M., Klossek, J. and Benninger, M. (2006) Management of Acute Bacterial Rhinosinusitis: Current Issues and Future Perspectives. *International Journal of Clinical Practice*, **60**, 190-200. https://doi.org/10.1111/j.1742-1241.2006.00753.x

[8] Hadley, J.A. and Pfaller, M.A. (2007) Oral β-Lactams in the Treatment of Acute Bacterial Rhinosinusitis. *Diagnostic Microbiology and Infectious Disease*, **57**, S47-S54. https://doi.org/10.1016/j.diagmicrobio.2006.11.018

[9] Marple, B.F., Brunton, S. and Ferguson, B.J. (2006) Acute Bacterial Rhinosinusitis: A Review of U.S. Treatment Guidelines. *Otolaryngology—Head and Neck Surgery*, **135**, 341-348. https://doi.org/10.1016/j.otohns.2005.12.021

[10] Randall, D.A. (2007) Re: Acute Bacterial Rhinosinusitis—A Review of US Treatment Guidelines. *Otolaryngology—Head and Neck Surgery*, **136**, 681. https://doi.org/10.1016/j.otohns.2006.11.028

[11] Paul-Cédric, M., *et al.* (2021) Encephalic Complications of Sinusitis: Series of 11 Cases. *African Journal of Neurological Sciences*, **40**, 36-41. https://ajns.paans.org/encephalic-complications-of-sinusitis-series-of-11-cases/

[12] Chandler, J.R., Langenbrunner, D.J. and Stevens, E.R. (1970) The Pathogenesis of Orbital Complications in Acute Sinusitis. *The Laryngoscope*, **80**, 1414-1428. https://doi.org/10.1288/00005537-197009000-00007

[13] Kharrat, S., Sahtout, S., Zainine, R., Dridi, I., Temimi, S., Beltaief, N., *et al.* (2011) Endocranial Complications of Sinusitis. *La tunisie medicale*, **89**, 534-538. (In French)

[14] Savage, T.J., Kronman, M.P., Sreedhara, S.K., Russo, M., Lee, S.B., Oduol, T., *et al.* (2023) Trends in the Antibiotic Treatment of Acute Sinusitis: 2003-2020. *Pediatrics*, **151**, e2022060685. https://doi.org/10.1542/peds.2022-060685

[15] Herrmann, B.W. and Forsen, J.W. (2004) Simultaneous Intracranial and Orbital Complications of Acute Rhinosinusitis in Children. *International Journal of Pediatric Otorhinolaryngology*, **68**, 619-625. https://doi.org/10.1016/j.ijporl.2003.12.010

[16] Ambati, B. (2000) Periorbital and Orbital Cellulitis before and after the Advent of Haemophilus Influenzae Type B Vaccination. *Ophthalmology*, **107**, 1450-1453. https://doi.org/10.1016/s0161-6420(00)00178-0

[17] Zhao, E.E., Koochakzadeh, S., Nguyen, S.A., Yoo, F., Pecha, P. and Schlosser, R.J. (2020) Orbital Complications of Acute Bacterial Rhinosinusitis in the Pediatric Population: A Systematic Review and Meta-Analysis. *International Journal of Pediatric Otorhinolaryngology*, **135**, Article ID: 110078. https://doi.org/10.1016/j.ijporl.2020.110078

[18] Levy, D.A., Pecha, P.P., Nguyen, S.A. and Schlosser, R.J. (2020) Trends in Complications of Pediatric Rhinosinusitis in the United States from 2006 to 2016. *International Journal of Pediatric Otorhinolaryngology*, **128**, Article ID: 109695. https://doi.org/10.1016/j.ijporl.2019.109695

[19] Anosike, B.I., Ganapathy, V. and Nakamura, M.M. (2022) Epidemiology and Management of Orbital Cellulitis in Children. *Journal of the Pediatric Infectious Diseases Society*, **11**, 214-220. https://doi.org/10.1093/jpids/piac006

[20] Mukherjee, G., Sufcak, K., Hames, N. and Lantis, P. (2023) Bugs behind the Bulging Eyeball: Microbiology and Antibiotic Management in Orbital Cellulitis with or without Subperiosteal Abscess. *Clinical Pediatrics*, **63**, 214-221. https://doi.org/10.1177/00099228231202158

[21] Haute Autorité de santé (HAS) (2011) Recommendations for Best Practice. Systemic Antibiotic Therapy in Routine Practice for Upper Respiratory Infections in Adults and Children. (In French)

[22] Ang, T., Cameron, C., Tong, J.Y., Wilcsek, G., Tan, J., Patel, S., *et al.* (2023) Methicillin-Resistant Staphylococcus Aureus-Associated Orbital Cellulitis: A Case Series. *International Ophthalmology*, **43**, 2925-2933. https://doi.org/10.1007/s10792-023-02698-y

[23] Hsu, J., Lanza, D.C. and Kennedy, D.W. (1998) Antimicrobial Resistance in Bacterial Chronic Sinusitis. *American Journal of Rhinology*, **12**, 243-248. https://doi.org/10.2500/105065898781390055

[24] Lucas, R.M. and McMichael, A.J. (2005) Association or Causality: Evaluation of the Links between "Environment and Disease". *Bulletin of the World Health Organization*, **83**, 792-795.