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Original Article

Clinical analysis of computed tomography-staged orbital cellulitis in children

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Background and Purpose: Bacterial infection of the orbital structures can affect all age groups, but is more frequent in pediatric populations. Prompt recognition, correct diagnosis, and adequate management are important if serious complications are to be avoided. This study sought to delineate the clinical, bacteriological and radiological findings, management and outcome of orbital cellulitis.
Methods: This retrospective study reviewed 80 children admitted to Chang Gung Children's Hospital with a diagnosis of orbital cellulitis who were staged by computed tomography (CT), between January 1999 and August 2005. The staging classification was as follows: stage I, inflammatory edema (preseptal); stage II, subperiosteal phlegmon and abscess; stage III, orbital cellulitis; stage IV, orbital abscess; and stage V, ophthalmic vein and cavernous sinus thrombosis. The patients were categorized into 2 groups: preseptal (stage I) and postseptal (stage II-V).
Results: Of the 80 children, 50 were male and the mean age was 6.8 years. Sinusitis and upper respiratory tract infection were the most common predisposing factors. Forty one percent of patients in stage I presented with symptoms that indicated postseptal involvement. The patients with postseptal involvement had a significantly higher rate of proptosis and limitation of extraocular motility. Bacterial pathogens were identified in 31 patients (39%), the 2 most common pathogens being *Staphylococcus* and *Streptococcus*. Ten patients (13%) had polymicrobial infection. Twenty three patients underwent sinus and/or orbital and/or intracranial surgery, including all 5 patients (100%) in stage IV, 3 of 6 patients (50%) in stage III, 13 of 35 patients (37%) in stage II, and 2 of 34 patients (6%) in stage I. Complete resolution without complication was achieved in 72 children. Eight patients had complications, including intracranial infection in 3, recollection of abscess in 2, ophthalmoplegia in 2, and corneal scar in 1.
Conclusions: Proptosis and limitation of extraocular motility may be considered the most important signs on CT examination in children with suspicious orbital cellulitis. Given that polymicrobial infection is common, broad-spectrum antibiotics are indicated initially. Surgery should be considered not only when an abscess is demonstrated by CT scan but also if clinical deterioration occurs within 24 to 36 h of adequate intravenous antibiotic treatment.

Key words: Cellulitis; Infection; Orbital diseases; Risk factors; Tomography, X-ray computed; Treatment outcome

Introduction

Bacterial infection of the orbital structures can affect all age groups, but is more frequent in pediatric populations [1,2]. Any inflammatory lesion that occurs in the preseptal and postseptal space can lead to periorbital swelling and erythema. Additional signs of chemosis, proptosis, painful and limitation of extraocular motility (EOM), and decreased vision acuity indicate postseptal involvement [3-5]. Without proper treatment, preseptal cellulitis may result in postseptal involvement and its complications, including subperiosteal abscess, orbital cellulitis/abscess, cavernous sinus thrombosis, intracranial infections, visual loss, and even death [6-12]. Prompt recognition, correct diagnosis, and adequate management are important. There has been limited information from Taiwan [13] on the epidemiological features, clinical manifestations, and bacterial etiology

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of orbital cellulitis in children. This study was conducted to analyze the clinical, bacteriological, and radiological aspects of orbital cellulitis in Taiwanese children. The management and outcome were also assessed.

Methods

Patient selection

From January 1999 through August 2005, a total of 373 patients with a diagnosis of periorbital/orbital cellulitis treated at the Chang Gung Children's Hospital were recruited into the study initially. Only patients who underwent computed tomography (CT) examination for accurate staging of the orbital inflammation and localization of the sinus infection were enrolled. 290 children not receiving CT examination for staging and 3 children with other conditions (2 patients with retinoblastoma and 1 with traumatic vitreous hemorrhage) were excluded. The decision as to whether a patient underwent CT examination was judged and determined by clinicians, mostly as suggested by ophthalmologists. Once a child underwent CT examination, he/she was included in this study for analysis, even with a diagnosis of preseptal cellulites (stage I in this study). A total of 80 pediatric patients were included in this study.

Data collection

Data on demographic characteristics, predisposing factors, clinical presentations, laboratory findings, imaging studies, microbiologic etiologies, management and outcomes of these patients were collected and analyzed.

For consistency of interpretation, all images were retrospectively reviewed by a pediatric board-certified radiologist, to determine the presence and location of the infectious process. Patients with a diagnosis of orbital cellulitis secondary to any cause were classified according to the modified Chandler classification [3-5]: stage I, inflammatory edema (preseptal); stage II, subperiosteal phlegmon and abscess; stage III, orbital cellulitis; stage IV, orbital abscess; and stage V, ophthalmic vein and cavernous sinus thrombosis. For comparison, the patients were categorized into two groups: preseptal (stage I) and postseptal (stages II-V).

Statistical analysis

Student's *t* test was used to analyze ordinal data, and the chi-squared test was used for dichotomous data. A p value <0.05 was considered statistically significant.

Results

Demographic characteristics

Of the 80 children, 50 (63%) were male and 30 (37%) were female. The mean age was 6.8 years, with a range of 13 days to 18 years. Most cases (60%) were under 6 years of age. The stage distribution was as follows: stage I, 34 patients (42.5%); stage II, 35 patients (43.8%); stage III, 6 patients (7.5%); stage IV, 5 patients (6.2%); and stage V, 0 patients (0.0%) [Table 1].

Predisposing factors

The predisposing factors of patients are shown in Table 2. Sinusitis and upper respiratory tract infection (URTI) were the two most common predisposing factors identified. Radiologically-confirmed sinusitis was found in 65 patients (81%), among whom 58 patients (73%) had involvement of multiple sinuses. The most commonly involved sites were maxillary and ethmoid sinuses. Thirty six cases (45%) were recorded as having preceding URTI and 18 patients (23%) had abscess of the periorbital region.

Clinical presentations

The majority of patients presented with local swelling, erythema, pain and/or systemic illness (Table 3). The average duration of symptoms prior to hospitalization was 2 days (range, 1-13 days). Fifty five children (69%) had fever on admission and the average duration of fever was 3.8 days (range, 1-22 days). Fourteen patients in stage I presented with symptoms that indicated postseptal involvement, including chemosis in 13 patients (38%), limitation of EOM in 7 (21%), decreased visual acuity in 3 (9%), and proptosis in 2 (6%). Compared with patients in stage I, patients with postseptal involvement had a significantly higher rate of proptosis (28/46 vs 2/34, $p<0.0001$), and limitation of EOM (35/46 vs 7/34, $p<0.0001$). There was no

Table 1. Demographic characteristics of 80 children with computed tomography-staged orbital cellulitis

Characteristic	Stage I (n = 34) No. (%)	Stage II (n = 35) No. (%)	Stage III (n = 6) No. (%)	Stage IV (n = 5) No. (%)	Total (n = 80) No. (%)
Male	19 (56)	24 (69)	4 (67)	3 (60)	50 (63)
Female	15 (44)	11 (31)	2 (33)	2 (40)	30 (37)
Age (years; mean) [range]	6.5 (0.6-18)	7.7 (0.03-18)	6.9 (3.9-12.9)	2.4 (0.3-5.8)	6.8 (0.03-18)

Table 2. Predisposing factors of 80 children with computed tomography-staged orbital cellulitis

Predisposing factor	Stage I (n = 34) No. (%)	Stage II (n = 35) No. (%)	Stage III (n = 6) No. (%)	Stage IV (n = 5) No. (%)	Total (n = 80) No. (%)
Upper respiratory tract infection	13 (38)	17 (49)	3 (50)	3 (60)	36 (45)
Sinusitis					
By radiology	24 (71)	31 (89)	5 (83)	5 (100)	65 (81)
Multiple	18 (53)	30 (86)	5 (83)	5 (100)	58 (73)
Maxillary	23 (68)	30 (86)	5 (83)	5 (100)	63 (79)
Ethmoid	17 (50)	30 (86)	5 (83)	5 (100)	57 (71)
Frontal	7 (21)	11 (31)	0 (0)	1 (20)	19 (24)
Sphenoid	7 (21)	10 (29)	2 (33)	1 (20)	20 (25)
By history	6 (18)	7 (20)	1 (17)	1 (20)	15 (19)
Trauma[a]	4 (12)	2 (6)	0 (0)	0 (0)	6 (8)
Foreign body[b]	0 (0)	0 (0)	1 (17)	0 (0)	1 (1)
Abscess of periorbital region[c]	8 (24)	10 (29)	0 (0)	0 (0)	18 (23)
Tumor	1 (3)	0 (0)	0 (0)	0 (0)	1 (1)
Dental caries	4 (12)	1 (3)	1 (17)	1 (20)	7 (9)
Recent ophthalmologic surgery[d]	2 (6)	2 (6)	0 (0)	0 (0)	4 (5)
None	5 (15)	7 (20)	2 (33)	0 (0)	14 (18)

[a]Included break in the skin, insect bite.
[b]One child had retinoblastoma status post enucleation and hydroxyappetite implant.
[c]Included hordeolum, conjunctivitis, dacyrocystitis.
[d]Included 2 cases with lacrimal duct probing, 1 with strabismus operation, and 1 with lower eyelids Snellen suture and levator muscle resection.

statistically significant difference in terms of duration of symptoms before admission, chemosis, decreased visual acuity, or hospitalization and fever duration between stage I and postseptal groups.

Laboratory findings

Leukocytosis (white blood cell [WBC] count >15,000/mm^3) was found in 25 patients (31%). The mean WBC count on admission was 13,487/mm^3 (range, 6300-28,100/mm^3). Fifty six patients (70%) had elevated serum C-reactive protein (CRP) level (>5 mg/L), with a mean value of 71 mg/L and a range of 0.7 to 389.9 mg/L. There was no statistically significant difference in terms of WBC count and serum CRP level between stage I and postseptal groups.

Table 4 shows the identified pathogens according to the sample sites. The specimens taken from abscesses were most likely to produce a positive culture, especially from sinus/nasal aspiration (100%), intracranial abscess (100%) and incision abscess (79%). Other sites produced low yield rates. Bacterial pathogens were identified in 31 patients (39%). The most common pathogen was

Table 3. Initial symptoms, signs, and duration of hospitalization in 80 children with computed tomography-staged orbital cellulitis

Symptoms/signs	Stage I (n = 34) No. (%)	Stage II (n = 35) No. (%)	Stage III (n = 6) No. (%)	Stage IV (n = 5) No. (%)	Total (n = 80) No. (%)
Duration of symptoms before admission (day[s]; mean) [range]	1.7 (1-13)	2.2 (1-13)	1.2 (1-2)	4 (1-8)	2 (1-13)
Fever ≥38°C	21 (62)	24 (69)	5 (83)	5 (100)	55 (69)
Duration (day[s]; mean) [range]	3.2 (1-22)	3.9 (1-20)	4.4 (1-8)	6.6 (5-9)	3.8 (1-22)
Proptosis	2 (6)	21 (60)	4 (67)	3 (60)	30 (38)
Chemosis	13 (38)	21 (60)	2 (33)	3 (60)	39 (49)
EOM limitation	7 (21)	25 (71)	5 (83)	5 (100)	42 (53)
Decreased visual acuity	3 (9)	6 (17)	0 (0)	0 (0)	9 (11)
Hard to conduct full examination	2 (6)	1 (3)	0 (0)	0 (0)	3 (4)
Duration of hospitalization (day[s]; mean) [range]	8 (2-48)	8 (1-18)	8 (4-14)	19 (7-54)	8.9 (1-54)

Abbreviation: EOM = extraocular motility

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Table 4. Sample site and pathogen in 80 children with computed tomography-staged orbital cellulitis

Pathogen	Sample site (number of pathogens identified)						
	I/D	Sinus/nasal	Orbital	Intracranial	Blood	Conjunctiva	CSF
MSSA	4	1	1	0	1	0	0
MRSA	8	2	3	0	1	1	0
CoNS	0	1	0	0	0	0	0
Viridans streptococci	1	2	0	1	1	0	0
Streptococcus pneumoniae	1	0	0	0	0	0	0
GAS	0	0	0	0	0	1	0
Mixed	1	6	1	2	0	0	0
Positive/total	15/19	12/12	5/9	3/3	3/73	2/5	0/4

Abbreviations: I/D = incision and drainage; CSF = cerebrospinal fluid; MSSA = methicillin-susceptible *Staphyloccocus aureus*; MRSA = methicillin-resistant *Staphyloccocus aureus*; CoNS = coagulase-negative *Staphyloccocus*; GAS = group A *Streptococcus*

Staphylococcus aureus (28%), of which 15 isolates (68%) were methicillin-resistant, followed by *Streptococcus* (8%). Ten patients (13%) had polymicrobial infection, including mixed aerobic and anaerobic infections in 8 patients and mixed aerobic pathogens in 2 patients.

Treatment

All patients received intravenous antibiotics after admission. The antibiotics used in these patients were very diverse. Beta-lactams were used mostly and included beta-lactam alone in 47 cases (oxacillin, 16; amoxicillin-clavulanate, 23; cephalosporins 6, ampicillin 1, penicillin 1) or combined with gentamicin in 17 cases or with clindamycin in 4 cases. Vancomycin alone was used in 3 cases and combined with a third-generation cephalosporin in 3 cases. A combination of 3 antibiotics was used in 4 cases. The remaining 2 children received either teicoplanin combined with rifampicin or trimethoprim-sulfamethoxazole. The mean duration of antibiotic treatment (intravenous and oral) was 14 days. Three patients in stage I underwent incision and drainage and 1 underwent lacrimal probe removal. Twenty three other patients (29%) underwent sinus and/or orbital and/or intracranial surgery, including all 5 patients (100%) in stage IV, 3 of 6 patients (50%) in stage III, 13 of 35 patients (37%) in stage II, and 2 of 34 patients (6%) in stage I (Table 5). Most operations (79%) were performed within 2 days of hospitalization. Compared with the patients in stage I, the patients with postseptal involvement had a significantly higher rate of operation (21/46 vs 6/34, p=0.009). Patients receiving surgical intervention had a longer duration of fever (mean, 5 vs 2 days; p=0.038) than the patients not receiving operation. There was no statistically significant difference in terms of gender, age, duration of symptoms before admission, hospitalization duration, complication rate, WBC count and CRP level between these two groups.

Outcome

Table 6 shows the complications in each group. Complete resolution without complication was achieved in 71 children (90%). Fifty children (63%) recovered from the infection with only conservative medical management. They included 26 patients in stage I, 22 in stage

Table 5. Intervention procedures and interval between imaging study and procedure in 80 children with computed tomography-staged orbital cellulitis

Procedure	Stage I (n = 34) No. (%)	Stage II (n = 35) No. (%)	Stage III (n = 6) No. (%)	Stage IV (n = 5) No. (%)
Incision and drainage	3 (9)	0 (0)	0 (0)	0 (0)
Sinus surgery[a]	2 (6)	7 (20)	2 (33)	0 (0)
Orbital surgery[b]	0 (0)	3 (9)	1 (17)	2 (40)
Combined sinus and orbital	0 (0)	2 (6)	0 (0)	3 (60)
Neurosurgery	0 (0)	1 (3)	0 (0)	0 (0)
Removal of lacrimal probe	1 (3)	0 (0)	0 (0)	0 (0)
Total	6 (18)	13 (37)	3 (50)	5 (100)
Interval between imaging and procedure (days) [range]	2.7 (0-7)	1.7 (0-5)	1.7 (1-3)	1.4 (1-2)

[a]Functional endoscopic sinus surgery.
[b]Orbitotomy with abscess drainage.

Table 6. Complications at last follow-up in 80 cases of computed tomography-staged orbital cellulitis

Complication	Stage I (n = 34) No. (%)	Stage II (n = 35) No. (%)	Stage III (n = 6) No. (%)	Stage IV (n = 5) No. (%)	Total (n = 80) No. (%)
Intracranial infection[a]	1 (3)[b]	1 (3)	0 (0)	1 (20)	4 (5)
Recollection of abscess	0 (0)	1 (3)	1 (17)	0 (0)	2 (3)
Ophthalmoplegia	0 (0)	0 (0)	1 (17)	1 (20)	2 (3)
Corneal scar	1 (3)	0 (0)	0 (0)	0 (0)	1 (1)
None	31 (91)	33 (94)	4 (67)	3 (60)	71 (89)

[a]Included subdural empyema, intracerebral abscess, extradural abscess, meningitis.
[b]A boy aged 10 years 8 months with initial presentation of decreased visual acuity and limitation of extraocular motility. Methicillin-susceptible *Staphyloccocus aureus* sepsis with septic embolism and epidural empyema developed subsequently. Another case with bacterial meningitis has been excluded.

II, 2 in stage III, and none in stage IV. There were 8 patients with complications. Three patients had intracranial infection. The first patient, a boy aged 10 years 8 months, presented to the emergency department with a 24-h history of fever, decreased visual acuity of the right eye, limitation of EOM and diplopia. CT scan was performed immediately and revealed right preseptal cellulitis (stage I) and frontal epidural empyema. Methicillin-susceptible *S. aureus* sepsis with septic embolism (brain and lung) was diagnosed subsequently. The patient received conservative medical treatment and follow-up magnetic resonance imaging 6 weeks later showed right frontal encephalomalacia. The second patient in stage II, a 16-year-old boy, subsequently died from viridans *Streptococcus* sepsis with disseminated intravascular coagulopathy and subdural abscess. The involvement of orbit in these 2 cases may be due to hematogenous spread. Brain abscess occurred in the third case in stage IV. There were 2 patients with recollection of abscesses, 2 with ophthalmoplegia, and 1 with corneal scar. There was no significant difference in complication rate between patients in stage I and those with postseptal involvement. There was no statistically significant difference in terms of gender, age, duration of symptoms before admission, fever and hospitalization duration, operation rate, WBC count and CRP level between patients with and without complications.

Discussion

In this study, paranasal sinus diseases and URTI were the commonest predisposing causes of orbital infections. However, 33 of the 36 patients (92%) with URTI also had sinusitis. Most patients (81%) in this study had radiologically-confirmed sinusitis, and the ethmoid and maxillary sinuses were the most commonly affected, consistent with previous reports [14-22].

Chemosis, proptosis, painful and limitation of EOM, and decreased vision acuity usually indicate postseptal involvement [3-5]. The amount of information that can be obtained from the clinical examination is related to the age and cooperation of the child [23]. The assessment of vision is sometimes difficult, especially in young children with pronounced edema in the eyelids [8,23]. CT scan is the investigation of choice for orbital cellulitis [15-18,20-22,24,25], permitting accurate localization of the sinus infection and staging of the orbital inflammation. In this study, the patients in the postseptal group had a significantly higher rate of proptosis, and limitation of EOM. These two signs may be considered the most important in patients with orbital cellulitis for CT examination.

Baseline CT scan should not be performed routinely; rather, it should be obtained if a surgery is planned because of orbital compression or no clinical response to the appropriate treatment after 48 h [24,26]. In this study, 41% of patients in stage I presented with symptoms that indicated postseptal involvement. Since CT scan may underestimate the severity of orbital infection, close monitoring of clinical progression is most important.

In this study, cultures from abscess and infected sinus had the highest positive yields (84-100%) while only 3 out of 73 blood cultures yielded positive results, consistent with previous reports [2,15,26]. The most common pathogen identified was *S. aureus* and 52% of these isolates were isolated from abscess specimens. Streptococci were the second most common. These two organisms have been reported to be the most common pathogens of orbital infection in patients of all ages [15,24,25,27,28]. Although *Haemophilus influenzae* was once considered a common cause of orbital cellulitis, this organism was not identified, in agreement with other studies after the advent of *H. influenzae* type b

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(Hib) vaccination [25,28-30]. In this study, 25% of 31 patients with pathogens identified had polymicrobial infection. Given the common incidence of polymicrobial infection in pediatric patients with orbital cellulitis, broad-spectrum antibiotics are indicated initially.

Due to the risk of postseptal involvement and even possible cerebral extension, prompt and adequate antibiotic treatment is essential [10]. It is controversial whether conservative medical management is adequate for orbital infection [15,25,31-33]. Garcia and Harris suggest a balance between securing adequate time for evaluation of clinical response to systemic antibiotics and minimizing risk of progression to complications [33]. In this study, about two-thirds of children recovered from the infection with only conservative medical management. Patients with postseptal involvement had a significantly higher rate of operation, while patients receiving surgical intervention had a longer duration of fever.

Complications were noted in 8 children (10%) in the current study, a rate similar to that of previous studies after widespread usage of antibiotics [13,34-37]. Sinus source has often been shown to precede intracranial extension [38]. With intracranial complication, the mortality rate was from >5% to 25% despite early and aggressive therapy [11,12]. In this review, 3 patients had intracranial infection and 2 of them were considered to have a sinus source. One of the 3 patients died from septic shock with disseminated intravascular coagulopathy and subdural abscess.

To confirm the diagnosis and accurate staging of orbital cellulitis, we only included patients receiving a CT examination of orbits in this study, which accounted for only one-fifth of 373 children with a discharge diagnosis of periorbital/orbital cellulitis during the study period. It was considered that most patients who did not undergo CT scan examination might be in stage I. This selection bias apparently reduced the case number in stage I and may subsequently affect the percentages of predisposing factors, clinical presentations, duration of hospitalization, and identified pathogens. This is an inherent limitation of this study arising from its retrospective nature.

In conclusion, early recognition and management of orbital cellulitis are important to avoid disease progression and complications. CT examination is indicated if there is clinical suspicion of postseptal orbital invasion or no clinical response to the initial appropriate treatment within 48 h. Proptosis and limitation of EOM may be considered the critical aim of CT examination. Given that polymicrobial infection is not infrequently seen, broad-spectrum antibiotics are indicated initially. Surgery should be considered not only in cases of obvious abscess demonstrated by CT scan but also in clinical deterioration within 24 to 36 h of adequate intravenous antibiotic treatment.

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