Orbital cellulitis

Orbital cellulitis is an inflammatory process that involves the tissues located posterior to the orbital septum within the bony orbit, but the term generally is used to describe infectious inflammation. It manifests with erythema and edema of the eyelids, vision loss, fever, headache, proptosis, chemosis, and diplopia. OC usually originates from sinus infection, infection of the eyelids or face, and even hematogenous spread from distant locations. OC is an uncommon condition that can affect all age groups but is more frequent in the pediatric population, with an incidence of 1.6 per 100,000 and 0.1 per 100,000 in children and adults, respectively. Morbidity and mortality of OC have declined with improvement in diagnosis and therapy; however, OC can still lead to serious sight- and life-threatening complications in the modern antibiotics era. Therefore, prompt diagnosis and treatment remain crucial. Antibiotic coverage, computed tomography imaging, and surgical intervention when needed have benefitted patients and changed the disease prognosis. We review the worldwide characteristics of OC, predisposing factors, current evaluation strategies, and management of the disease.

1. Introduction

Orbital cellulitis (OC) is an inflammatory process that involves the tissues located posteriorly to the orbital septum within the bony orbit, but the term generally is used to describe infectious inflammation. It is not as common as preseptal cellulitis that affects tissues anterior to the orbital septum. OC is encountered at all age groups but more frequently affects the pediatric population, with an incidence of 1.6 per 100,000 and 0.1 per 100,000 in children and adults, respectively. Morbidity and mortality of OC have declined with improvement in diagnosis and therapy; however, since it may still have serious complications, prompt diagnosis and treatment are crucial. We review the worldwide characteristics of OC, predisposing factors, infectious causes, and current evaluation and management of the disease.
2. Predisposing factors

The most frequent predisposing factor in all age groups is secondary infection extending from the paranasal sinuses. This is established in studies in both the Western and the developing world.32,34,85,188,195 Specifically, it has been determined that 1.3%–5.6% of sinusitis results in OC, and 0.3%–5.1% develop orbital or subperiosteal abscesses.6,151 OC most commonly originates from the ethmoid sinuses, with a reported frequency of 43%22,61,68,76,82,113,127 to as high as 94.7% of cases in a study from Canada53 and 100% in another study from Massachusetts.8 The infection proceeds from the sinuses to the orbit, assisted by specific anatomical characteristics such as the thin medial orbital wall, lack of lymphatics, valveless veins of the orbit, and foramina of the orbital bones.104

Surveys that detect sinusitis radiologically find up to 91% of cases of sinus-related OC originate from the ethmoid and maxillary sinus.30,58 In a 10-year retrospective analysis from Taiwan, however, children aged 3–18 years diagnosed with OC underwent computed tomography (CT) scans, and the involved sinuses, in the order of frequency, were maxillary, ethmoid, frontal, and sphenoid.83 In fact, childhood OC involves more than 1 sinus in up to 38% of cases.34,62 In a study from Canada, pansinusitis was observed in 15.7% of cases in children.58 In adults, OC may be related to frontal sinus infection,75,84,120 whereas multiple sinus involvement does not exceed 11%.34,62

Spread of the infection from the upper respiratory tract to the orbit is also a major cause of OC.35,38,103,176 The affinity of OC with infections arising from the sinuses and the upper respiratory tract reflects the seasonal distribution of the disease, with peak occurrence in winter to early spring.34,62 This is proportional to the seasonal distribution of infections initiating in the aforementioned anatomical locations.32

Reported etiological factors of OC also differ between Western and developing countries. Trauma or surgery is a common cause of OC in developing countries.14,32,62,90 OC follows either direct inoculation from a penetrating injury or develops secondarily to orbital fracture that allows communication between the sinuses and the orbit.104 In a study from Pakistan, trauma was reported as a more common cause of OC compared to sinusitis in the age group 6–16 years.11 In India, injury was associated with OC in 24% of cases192 and was usually linked to the presence of a foreign body.108,195 Foreign body OC is caused either by organic materials or by metal objects (Fig. 1). Usually children and young males are affected because injuries are caused during playing or at work.49 Organic foreign bodies usually involve wood. Wooden foreign bodies carry a large amount of bacteria, and if not promptly removed, they lead to severe infections.179 These injuries are associated with a high risk of OC and complications such as recurrent cellulitis, cutaneous fistula, restrictive myopathy, periorbital abscess, and even panophthalmitis.104 Identification of the wooden foreign bodies with CT can be difficult. During the first days after the injury, wooden foreign bodies appear as low-density signal on CT scan and may be misdiagnosed as air. After a few months the wooden material presents the same density as the surrounding tissues, making it difficult to diagnose.105 In certain cases, additional imaging with magnetic resonance imaging (MRI) and especially T1-weighted images may further enhance the ability to identify a wooden or vegetable foreign body.179 Timely removal of these foreign bodies leads to resolution of inflammation and associated signs.110 Metal objects are more easily identified and surgically removed from the orbit; however, most metals are inert and, depending on their location in the orbit, may be treated conservatively without removal.83 Iron, copper, and lead, however, may cause serious complications, and gunshot injuries usually lead to severe ocular injury.28

In Nigeria, upper respiratory tract infections and facial and globe injuries were reported as the major predisposing factors for OC.14 Additionally, in children, insect bite (10%), hordeolum, and molluscum contagiosum of the lid with secondary bacterial infection were common predisposing factors.141 In developed countries, OC is not common after ophthalmic surgery; however, there are rare reports of OC after strabismus surgery,3,132 blepharoplasty,17 canaliculitis surgery,85 cataract surgery,101 peribulbar injection,111 hydroxyapatite111 and polyethylene108 orbital sockets, implanted aqueous drainage devices, keratoprosthesis, and silicone-sponge scleral buckle implants for rhegmatogenous retinal detachment.3,132

Fig. 1 – Foreign body causing endophthalmitis and orbital cellulitis. A: Photo of a patient with an intraocular foreign body of the left eye and B: axial CT scan of the orbits. A metal intraocular foreign body with the entry wound in the medial conjunctiva is causing endophthalmitis and orbital cellulitis of the left orbit. Although removal of metallic foreign bodies is not always necessary, the foreign body in this case must be removed. CT, computed tomography.
Other etiological factors of OC include dacryocystitis, dental infections from spread through the maxillary sinus,\textsuperscript{35,46} endophthalmitis, panophthalmitis,\textsuperscript{142} untreated preseptal cellulitis, and hematogenous spread in the setting of bacteremia from distant sources.\textsuperscript{5,30–32,34,39,62,63,65,108,125,138} In a study from Saudi Arabia, intraocular or orbital tumors—specifically retinoblastoma, rhabdomyosarcoma, and melanoma—were the underlying cause in 3.7% of patients with OC.\textsuperscript{34,126}

Finally, there are also case reports of OC from rare causes.\textsuperscript{132} In a study from Malaysia, swimming was considered a possible predisposing factor because the symptoms worsened following this activity.\textsuperscript{176} In a study from Saudi Arabia, the allergic reaction to topical neomycin drops was reported as the cause of OC in 2 cases,\textsuperscript{65} whereas Kim and colleagues reported a case of a 67-year-old Korean man diagnosed with epidemic keratoconjunctivitis than supposedly led to orbital inflammation.\textsuperscript{100}

3. Epidemiology

OC is not a common condition. Incidence of the disease has been calculated as 1.6 per 100,000 in the pediatric population and 0.1 per 100,000 in adults\textsuperscript{129}; however, a retrospective study from Nigeria found that 6.2% of ocular emergency admissions during a 3-year study period were for OC.\textsuperscript{14}

Although etiological factors of OC differ considerably between patients in the Western and developing world, there are no documented ethnicity differences in epidemiology.\textsuperscript{121} Average age at presentation has been reported from 19.9 to 25.7 years.\textsuperscript{34,139} OC commonly affects children and early adolescents, likely because until the age of 15 years the immunologic system is immature.\textsuperscript{14,32,34,138} In a report from India,\textsuperscript{141} however, 57% of cases were adults and 42% were children, with a mean age of 45 years in the adult group and 4 years in the pediatric group. In pediatric studies, the mean age varies from 6.1 to 8 years, with a range of 0.5–17 years.\textsuperscript{1,58,65,103,174} A study from Texas examined children with OC before the age of 12 months. Average age at presentation was 3.8 months, with a range of 1–9 months.\textsuperscript{123}

Gender distribution is usually equal\textsuperscript{13,22,27,32,41,68,72,82,87,108,113,115,123,135,141,180} and Streptococcus species\textsuperscript{32,68,82,87,108,141,143,153,155,160} as the most common causative organisms. Most recent studies from both developed and developing countries underline an increasing trend of OC cases caused by methicillin-resistant Staphylococcus aureus (MRSA).\textsuperscript{58,108,119,161} The incidence of MRSA in such infections varies from 21% to 72%.\textsuperscript{20,112,119,194} Community-acquired MRSA is increasing in various countries.\textsuperscript{21,29,124,141} The limited number of effective antibiotics in treating MRSA renders the increasing prevalence of this microorganism a major public health concern. A study from California underlines the increasing incidence and resistance among the pediatric population, reporting a significant danger of neonatal infection with MRSA.\textsuperscript{7} Peña and colleagues investigated the prevalence and antibiotic resistance patterns of pathogens associated with orbital complications from acute sinusitis after the widespread use of 7-valent pneumococcal conjugate vaccine (PCV7) vaccination and emphasized the significant increase in S. aureus OC, with a concurrent increase of MRSA.\textsuperscript{146}

Streptococcal infection is age related, with younger children more likely to present with infection from Streptococcus pneumoniae and older children from group A streptococcus.\textsuperscript{10} Additionally, Streptococcus milleri,\textsuperscript{138} Streptococcus viridians,\textsuperscript{87} and Streptococcus anginosus\textsuperscript{160} are the most commonly identified organisms. Peña and colleagues observed a decline in the incidence of S. pneumoniae as an etiologic pathogen.\textsuperscript{136}

Other frequently associated microorganisms in various studies over the world are coagulase-negative presented within 3 days of disease onset.\textsuperscript{14} The average reported duration of symptoms was 5.2–10.6 days, and average hospital stay was 9–13.7 days in the developing countries, with 57.6% of cases presenting a prolonged hospital stay of more than 10 days.\textsuperscript{14,65,139,141} In contrast, in the Western countries, the average duration of symptoms was 4.4 days, and the average hospital stay was 5.8–6.2 days.\textsuperscript{58,62,130}

4. Microbiology

The causative organisms associated with OC are difficult to identify because of the normal flora of the area, previous antibiotic therapy, and the multiple agents that are usually contributing to the infections.\textsuperscript{108} Blood cultures are rarely positive in patients with OC.\textsuperscript{58,68,87,139,141} Cultures from nasal swabs, throat swabs, and ocular secretions are generally more effective, but cultures of material recovered from orbital abscesses and sinus aspirates are the most reliable.\textsuperscript{108} While it is commonly understood that these invasive surgical techniques are more likely to achieve a positive culture result, their routine use is not generally recommended.\textsuperscript{119} Moreover, Ferguson and McNab found different results between cultures of conjunctival swabs and cultures of abscesses material from patients with positive cultures,\textsuperscript{62} whereas Oxford and McClay found that all patients with positive surgical and blood cultures had the same culture results.\textsuperscript{138}

The majority of studies performed in developed countries find Staphylococcus aureus and Streptococcus species\textsuperscript{32,68,82,87,108,141,143,153,155,160} as the most common causative organisms. Most recent studies from both developed and developing countries underline an increasing trend of OC cases caused by methicillin-resistant Staphylococcus aureus (MRSA).\textsuperscript{58,108,119,161} The incidence of MRSA in such infections varies from 21% to 72%.\textsuperscript{20,112,119,194} Community-acquired MRSA is increasing in various countries.\textsuperscript{21,29,124,141} The limited number of effective antibiotics in treating MRSA renders the increasing prevalence of this microorganism a major public health concern. A study from California underlines the increasing incidence and resistance among the pediatric population, reporting a significant danger of neonatal infection with MRSA.\textsuperscript{7} Peña and colleagues investigated the prevalence and antibiotic resistance patterns of pathogens associated with orbital complications from acute sinusitis after the widespread use of 7-valent pneumococcal conjugate vaccine (PCV7) vaccination and emphasized the significant increase in S. aureus OC, with a concurrent increase of MRSA.\textsuperscript{146}

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Staphylococcus,\textsuperscript{58,87,119,141} Klebsiella pneumoniae,\textsuperscript{87,141} Aspergillus,\textsuperscript{141} Moraxella catarrhalis,\textsuperscript{143} and Haemophilus influenzae.\textsuperscript{85} Rare etiologic factors for OC include Pseudomonas species,\textsuperscript{14} Neisseria, Eikenella corrodens, Corynebacterium, Prevotella melanogenica, Morganella morganii, Acinetobacter,\textsuperscript{87} Bacillus anthracis,\textsuperscript{141} Escherichia coli, Actinobacter species, Enterobacter species, and various anaerobes such as Propionibacterium acnes, Peptococcus species, Peptostreptococcus species, Veillonella species, Prevotella, Porphyromonas, Fusobacterium bacteroides, and Clostridium bifermentans.\textsuperscript{20,22–24,34,62,112,119}

Specific pathogens have been identified in certain situations. In posttraumatic cases, S. aureus and S. pyogenes are the main pathogens.\textsuperscript{108} Microbiology of odontogenic origin mainly includes mixed aerobic and anaerobic bacteria.\textsuperscript{23,24} Lee and colleagues reported that non–spore-forming anaerobic bacteria usually cause OC after human or animal bites.\textsuperscript{108}

Age has also been shown to influence bacteriology of OC. A considerable number of studies present anaerobes\textsuperscript{24,67} as common pathogens of pediatric OC. It is generally accepted that OC in children younger than 10 years is caused by single aerobic pathogens as compared to older children, who often present more complex infections by multiple aerobic and anaerobic pathogens.\textsuperscript{2,34,79} With age, the ostia of the sinus cavities narrow, creating convenient conditions for the development of anaerobic pathogens (Fig. 2). This is probably an explanation why responsiveness to antimicrobial therapy appears to be age related.\textsuperscript{51,79} Since in younger children treatment with medical therapy alone is adequate, whereas in older children, the combination of medical and surgical intervention is often necessary.\textsuperscript{25} Harris and colleagues found that 43.2\% of children with OC between the ages of 9–14 years present complex infections, more often with polymicrobial infections, and anaerobes were found in all cases.\textsuperscript{79} Anaerobic OC is much less common in adults.\textsuperscript{62}

Up to the early 1990s, H. influenzae was one of the most frequent pathogens associated with OC in children.\textsuperscript{8,51,141} H. influenzae was extremely aggressive, with bacteremia and meningitis.\textsuperscript{14,51,109,119} After the introduction of H. influenzae type B vaccine in 1985, there was a significant decline in OC caused by H. influenzae type B.\textsuperscript{3,34,62,108,134,154,162,188} Pandian and colleagues attributed this decline to additional factors such as the introduction and wide use of more effective antibiotics.\textsuperscript{141} In developing countries where vaccines are not accessible, H. influenzae remains a common cause of OC.\textsuperscript{108,143}

Orbital organic foreign bodies usually carry a large amount of bacteria. Previous studies have not shown a predominant organism. Similarly, fungal organisms have not been found commonly in cases of orbital wooden foreign bodies. In a recent review of 32 cases with orbital wooden foreign bodies, Staphylococcus epidermidis, S. aureus, Enterobacter agglomerans, and Clostridium perfringens were identified.\textsuperscript{179}

A high rate of suspicion for fungal OC should arise in high-risk patients, such as immunocompromised patients, patients with diabetes mellitus, or patients under chronic steroids or antibiotic treatment.\textsuperscript{60,80} Both Mucormycosis and Aspergillosis, the most common fungal rhinoorbital infections, often lead to severe complications such as ophthalmic vascular thrombosis, optic atrophy, palsies, meningoencephalitis, brain abscess, thrombosis of the cavernous sinus, subdural, or intracerebral hemorrhages, presenting finally a high mortality rate.\textsuperscript{181}

Streptococcus infection can lead to a dangerous necrotizing lid disease, necrotizing fasciitis.\textsuperscript{32,37,117,163,165} This is a condition that may cause systemic complications and progress to multorgan failure\textsuperscript{37,117} through the production of inflammatory proteins and exotoxins.\textsuperscript{12} Ng and colleagues presented a case of necrotizing OC with rapid development of severe systemic toxicity, extensive soft tissue necrosis, and formation of abscesses leading to severe complications including panophthalmitis requiring evisceration.\textsuperscript{133}

5. Classification

Historically, Chandler’s classification of orbital complications of acute sinusitis has been used, based on their location and severity.

Group 1: Preseptal cellulitis
Group 2: Orbital cellulitis
Group 3: Subperiosteal abscess
Group 4: Intraorbital abscess
Group 5: Cavernous sinus thrombosis (CST)

Group I comprises preseptal cellulitis, in which the inflammatory process is limited anteriorly to the orbital septum and does not invade the intraorbital structures. In group II (OC), the orbital tissues are affected. Group III includes the formation of a subperiosteal abscess, in which purulent

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**Fig. 2**—Imaging of paranasal sinuses in various age groups. Coronal CT scan of the paranasal sinuses of A: a 6-year-old child, B: 14-year-old child with mucosal thickening of the paranasal sinuses and C: a 19 year-old child. With age, the ostia of the sinus cavities narrow, creating convenient conditions for the development of anaerobic pathogens. This is probably an explanation why in children younger than 10 years, treatment with medical therapy alone is adequate, whereas in older children, the combination of medical and surgical intervention is often necessary. CT, computed tomography.
material collects periorbitally, between the bony walls of the orbit and the periorbita. In group IV—orbital abscess—there is a purulent collection inside the orbit. In group V—CST—there is an extension of orbital inflammation into the cavernous sinus that can lead to involvement of the third, fifth, and sixth cranial nerves.\(^{30}\)

Jain and Rubin recently simplified the classification system as follows:\(^{89}\)

1. Preseptal cellulitis
2. OC (with or without intracranial complications)
3. Orbital abscess (with or without intracranial complications)
   a. Intraorbital abscess, which may arise from collection of purulent material in an OC
   b. Subperiosteal abscess, which may lead to true infection of orbital soft tissues
   c. Subperiosteal abscess usually occurs as a complication of bacterial sinusitis\(^{30,32,79}\) and is commonly located adjacent to opacified paranasal sinuses, specifically at the medial orbital wall and the orbital floor.\(^{108}\) A subperiosteal abscess is the result of the accumulation of purulent material between the periorbita and the orbital bone (Fig. 4). Specifically, the

Additionally, constitutional signs develop, such as fever (32%–81.2%), leukocytosis (47%), headache (10.1%), general malaise, and loss of appetite.\(^{75,95}\) Generally, a history of acute sinusitis or upper respiratory tract infection during the days preceding should be sought.\(^{108}\)

Clinical signs and symptoms at presentation may also differ according to age. In a study from the United States, clinical characteristics were compared in children younger and older than 7 years. The younger group presented higher white blood cell counts and decreased frequency of proptosis and ophthalmoplegia.\(^{150}\) In children younger than 1 year, OC may present with fever, periorbital edema, periorbital erythema, reduced appetite, and lethargy.\(^{90,123}\)

7. Complications

OC may be associated with severe visual and life-threatening complications, including optic neuropathy, the formation of an orbital abscess, meningoencephalitis, intracranial abscesses, CST, and sepsis.\(^{36,108,158,159,196}\) Children are susceptible to serious complications such as optic neuropathy, endophthalmitis, meningitis, and brain abscess because of their immature immune system.\(^{323}\) Patients with sinusitis and OC in developing countries often seek treatment later in the course of their disease and develop complications more frequently compared to patients in Western countries.\(^{32}\)

Involvement of the optic nerve or the vasculature of the orbit and the eye are among the eye-threatening complications that may develop. The optic nerve can be affected by inflammatory infiltration, mechanical compression, or compression of the feeding arteries with resultant ischemia.\(^{2,50}\) This can lead to disc swelling or neuritis with rapid progression to optic atrophy and blindness. Other usual causes of loss of vision include ischemia from thrombophlebitis of the orbital veins and ischemia by compression and occlusion of the central retinal artery. Vascular causes usually lead to permanent visual loss, whereas compressive optic neuropathy may respond to treatment with antibiotics or surgical drainage.\(^{32}\) Before the broad use of antibiotics, permanent loss of vision occurred in over 20% of OC\(^{50}\) but has significantly fallen since.\(^{52,144}\) Up to 11% of cases resulted in visual loss until the late 80s.\(^{104,126,144}\) In recent years, the visual morbidity of OC has minimized in the developed countries and has significantly dropped in the developing world.\(^{32}\)

Other ocular complications of OC include exposure keratopathy resulting in corneal ulceration; infarction of the sclera, choroid, or the retina\(^{136,150}\); septic uveitis; iridocyclitis, choroiditis, or panophthalmitis, retinal detachment; and glaucoma with rapid elevation of intraocular pressure.\(^{32,34,43,61}\) One report refers to OC complicated with combined retinal and choroidal detachments.\(^{39}\)

A complication of OC that may potentially lead to irreversible visual loss is the development of an abscess.\(^{185}\) A subperiosteal abscess usually occurs as a complication of bacterial sinusitis\(^{30,32,79}\) and is commonly located adjacent to opacified paranasal sinuses, specifically at the medial orbital wall and the orbital floor.\(^{108}\) A subperiosteal abscess is the result of the accumulation of purulent material between the periorbita and the orbital bone (Fig. 4).

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Fig. 3 – Orbital cellulitis. A: Photo of a patient with orbital cellulitis of the left eye. The eyelid edema and redness are obvious. Additional signs are ptosis, mild proptosis, redness, and chemosis of the conjunctiva; B: photo of the patient after treatment.
ethmoidal sinuses are separated from the orbit by the lamina papyracea, the thinnest bone in the orbit. Additionally, the orbital floor that lies on top part of the maxillary sinus is also thin. In these areas, the periosteum in the orbit (the periorbita) is not firmly attached to the bone and can be elevated by an accumulation of purulent material, thus leading to the formation of a subperiosteal abscess.144,153

An orbital abscess, the accumulation of pus within the orbital elements, results from the organization of the orbital inflammatory process or the rupture of a subperiosteal abscess. It may lead to severe consequences, such as proptosis, ophthalmoplegia, and loss of vision.144,145,153 Orbital abscesses have led to devastating results in the past,145 even in cases receiving medical and surgical treatment. A study from 1969 refers to a percentage of 7.1%–23.6% of patients with orbital abscess experiencing permanent visual loss.55 Few cases of acute visual loss as a result to orbital abscess are reported in the recent literature, especially in developed countries, whereas in developing countries, many patients with OC still exhibit severe complications, mainly as a result of delayed treatment.52,55

The incidence of abscess formation has declined significantly, especially in developed countries. Among series with reported orbital complications of sinus disease, the incidence of subperiosteal abscess reached 79%144,153,155 in older studies and is estimated to be around 42% in more recent studies.155 In a 10-year retrospective study in Wisconsin of 228 patients with OC, 53 (23.8%) had CT-confirmed subperiosteal abscesses, whereas the majority of patients with subperiosteal abscesses belonged to the older children or adult group.144,153,55,155,157 Lately, there are reports suggesting that adults were less likely than children to present with abscesses.55 Ferguson and McNab present incidences of 29% of inflammatory changes, 62% subperiosteal abscess, and 9% orbital abscess in the children group, compared to 72%, 5%, and 22%, respectively, in the adult group.62

Intracranial complications of OC include meningitis, empyema or abscess of the epidural or subdural space, intracerebral abscess, Pott's puffy tumor, CST, and ischemic brain infarction.2,14,15,32,147,166 These are considered rare (4% of hospitalized patients with sinusitis) and are a grave danger to life.2,23 The aforementioned complications result from sinusitis or cellulitis by direct extension, hematogenous spread, or retrograde thrombophlebitis through the valveless venous system that interconnects the sinus or orbital veins with the intracranial venous system.23,153 Sinus infection is considered the major etiologic factor for intracranial abscesses, with frontal sinus involvement being the most common, followed by ethmoid and maxillary sinuses.32 When neurological signs are present in a patient with OC, intracranial extension must be suspected. Symptoms are not always present in patients with intracranial abscess, or they can be minimal, especially in children. The usual symptoms are nausea, vomiting, seizures, fever, and change in mental status.108,153

 Epidural and subdural empyemas are the 2 most common intracranial complications of sinusitis-related OC.2,138,184 Meningitis was considered the most common intracranial complication in a study from 1984,32 along with epidural, subdural, and brain parenchymal abscess.32 A retrospective study that reviewed the complications of acute sinusitis from a tertiary care children’s hospital in Texas between 1995 and 2002 found orbital abscesses in 42.3% of patients, epidural empyema in 6.7%, subdural empyema in 5.8%, Pott’s puffy tumor in 2.9%, intracerebral abscess in 1.9%, meningitis in 1.9%, and CST in 1.0%.138

CST represents one of the most severe complications of OC. CST should be suspected clinically when there is severe loss of visual acuity. Orbital pain, chemosis, eyelid edema, and limitation of globe motility are also marked and progress rapidly. There is retinal venous engorgement. Involvement of the III, IV, V, or VI cranial nerves adds a strong clinical suspicion for CST. Systematic deterioration is rapid, with general prostration, high fever, meningitis, and sepsis. The rate of blindness and death is up to 20%.138,183,187 Without prompt treatment, CST is a fatal situation. Morbidity in these cases is related to the contents of the cavernous sinus, cranial nerves III, IV, V1, V2, and VI, and internal carotid artery. Thrombosed ophthalmic veins and retinal infarction are other possible complications, whereas the thrombus from the cavernous sinus may lead to petrosal sinus, sigmoid sinus, or internal jugular vein thrombosis.23

The most common pathogens leading to these intracranial complications are anaerobes,32 and infections are often polymicrobial.21,32 S. milleri,21,138,183 and S. aureus4 have been described as the most common pathogens, whereas Streptococcus, Staphylococcus, Bacteroides, and Fusobacterium species are also significant etiologic factors.32

Various researchers have studied the long-term symptoms and signs of intracranial involvement. Oxford and Mc Clay in

Fig. 4 – Subperiosteal abscess. A: Photo of a patient with a subperiosteal abscess of the right orbit, B: sagittal CT scan of the orbits, and C: coronal CT scan of the orbits. The abscess is the result of the accumulation of purulent material between the periorbita and the orbital bone. It is located at the orbital roof. The right frontal sinus appears opacified and full of purulent material. CT, computed tomography.
2005 reported palsies of cranial nerves II, III, IV, and VI as a result of CST with facial nerve paresis, hemiparesis, unilateral lower extremity paresis, generalized motor weakness, aphasia, and altered level of consciousness. Others have reported ophthalmoplegia, blindness, aphasia, and motor deficits; hearing loss; cranial nerve palsies; and hemiparesis, probably from infarction of the internal capsule, and Kabre and colleagues reported no long-term neurological sequelae in 2 cases with intracranial abscesses.

In the preantibiotic era, intracranial complications resulted to death in a significant proportion of patients. A study performed between 1907 and 1930 reported a 19% mortality rate among 275 cases of OC. Over 50 years later in a study from 1989, 19 children had intracranial abscesses secondary to nasal, sinus, and orbital infection. A subdural abscess, representing the most dangerous intracranial complication, developed in 7 patients, with 3 of them eventually dying. The overall mortality rate in this series was 21% (4 out of 19 patients with intracranial abscess) despite aggressive treatment and specialist consultation.

The broad use of more effective antibiotics also led to significant decline in the incidence of meningitis. Studies from the preantibiotic era on the orbital complications of sinusitis reported death from meningitis in 17% of cases, whereas only 1.9% of patients in recent times developed meningitis.

8. Differential diagnosis

Various conditions can mimic OC, with the characteristics of proptosis, chemosis, and periorbital swelling. In order to ascertain the correct diagnosis, a thorough history, physical examination, laboratory, and imaging information are indispensable.

The differential diagnosis is quite extensive. A primary neoplasm, most commonly rhabdomyosarcoma or retinoblastoma, or even a malignant melanoma, can mimic OC. Additionally, various types of leukemia and lymphomas are included in the differential diagnosis, such as acute leukemia, ocular adnexal T-cell lymphoma, extranodal and natural killer/T-cell lymphoma (Fig. 5). Metastatic neoplasms to the orbit may mimic OC, such as esophageal adenocarcinoma and urothelial carcinoma, neuroblastomas, adenocarcinoma of the rectum, and lung carcinoma.

Rheumatologic diseases such as granulomatosis with angitis, polyarteritis nodosa, and giant cell arteritis can mimic an infectious process. Other rare conditions that may mimic OC and must be kept in mind when treating such patients are traumatic or spontaneous carotid cavernous fistula (Fig. 6), sickle cell disease, facial bone infarctions, ethmoidal bone fracture, hemorrhagic cysts, aneurysmal bone cysts, nasal foreign bodies, hemorrhagic infarct of the orbital bones, ossifying fibroma, pseudoaneurysm of orbital bones, cranioorbital cerebrospinal fluid leak, Langerhans cell histiocytosis, dacryops infection, idiopathic orbital inflammatory disease, thyroid ophthalmopathy, sarcoidosis, cat scratch disease, and even posterior scleritis.

In a retrospective study from Germany, 49 children with orbital swelling were reviewed. In 20 (40.8%), the signs were unrelated to OC and were attributed to atheroma, inflamed insect stings, dental abscesses, conjunctivitis, Herpes simplex infection, and an orbital tumor.

9. Imaging

CT scan is the imaging modality of choice in the diagnosis and monitoring of patients with OC. Cases with periorbital inflammation, severe eyelid edema, proptosis, ophthalmoplegia, and deteriorating visual acuity or color vision must be subjected to an orbital CT scan. Additional indications include the presence of central nervous system signs, no improvement or deterioration of the patient’s condition within 24 hours, and nonresolving pyrexia over 36 hours.

CT provides imaging data of the anatomic elements of the orbit, such as the orbital walls, extraocular muscles, optic nerve, adipose tissue, and paranasal sinuses (Fig. 7). Therefore, orbital infections and lesions can be recognized, especially in cases where clinical examination is not adequate for the diagnosis. Additionally, CT provides information on the extension of the inflammatory changes in the orbital structures, identification of potential sources of the infection such as sinus disease, and the presence of a foreign body.

Fig. 5 – Natural killer lymphoma. A: Photo of a patient with natural killer lymphoma of the left orbit and B: coronal CT scan of the orbits. A correct approach to the differential diagnosis of orbital cellulitis is very important for the patient’s life. Imaging guides the diagnosis and shows a large mass that molds to the globe and is not subperiosteal in location. CT, computed tomography.
is also essential in monitoring the efficacy of treatment.\textsuperscript{44} In a 10-year retrospective review of 101 pediatric cases of OC, CT increased the prediction accuracy of cases needing surgical intervention.\textsuperscript{107}

Moreover, CT scanning provides evidence for the identification of an orbital abscess and defines its size and location. The recognition of subperiosteal abscesses is more accurate with the use of CT than clinically.\textsuperscript{32} Detection of an abscess can be difficult even with CT, however, especially at an early stage, and should not be excluded if suspected clinically.\textsuperscript{44} Initially, the abscess appears as a density of the soft tissues, usually at the medial orbital wall, in combination with a fluid-filled paranasal sinus. A larger abscess appears as a fluid collection with enhancement of its rim.\textsuperscript{44,157} Contrast media may be used for the differentiation between an abscess and inflammatory procedure of the orbit, as the walls of the abscess enhance.\textsuperscript{107,108}

Imaging studies are also essential when neurological signs are present to exclude intracranial extension of the inflammation, such as a brain abscess or CST.\textsuperscript{44}

MRI is also a useful tool in the identification of the orbital infection, especially when the CT findings are unclear. MRI provides superior resolution of orbital soft tissues compared to CT.\textsuperscript{161} Fat-saturated T2-weighted MRI and diffusion-weighted imaging MRI sequences are preferred\textsuperscript{96,161} because they are sensitive in the detection of OC and help differentiate from pathological entities that provide similar images, such as orbital inflammatory disease or lymphoid lesions.\textsuperscript{44} Subperiosteal and orbital abscesses and intracranial involvement are also better identified with MRI compared to CT. Finally, follow-up is safer with the use of MRI, as it does not expose the patient to radiation.\textsuperscript{107,108} Increased scanning time compared to standard CT, and decreased availability of MRI, often renders urgent imaging of the orbit impossible and are disadvantages of this technique.\textsuperscript{108,161}

Finally, ultrasonography of the orbit has been used for the identification of orbital abnormalities; however, ultrasonography does not have a major role in diagnosing OC.\textsuperscript{77,95} Ultrasoundography can be useful for the detection of orbital abscesses, especially of the anterior orbit or medial wall, although an acute abscess is not clearly delineated.\textsuperscript{32} Generally, ultrasonography lacks sensitivity in orbital imaging as compared to CT and MRI and is mostly used as an in-office screening procedure.\textsuperscript{44}

### 10. Treatment

#### 10.1. Medical management

Rapid diagnosis of OC and initiation of the treatment scheme are mandatory in order to minimize complications. Hence, almost all patients require admission, especially when the following signs are present: periorbital swelling, diplopia, reduced visual acuity, abnormal light reflexes, proptosis, ophthalmoplegia, drowsiness, vomiting, headache, and seizures.\textsuperscript{86} Medical management focuses primarily on aggressive antibiotic therapy and concurrent therapy of underlying predisposing factors such as sinusitis.\textsuperscript{108} Duration of antibiotic treatment varies from 1 to 2 weeks intravenously, followed by oral treatment in order to complete a 4-week regimen (Table 1).\textsuperscript{104} Clinical signs should be assessed at least twice daily along with frequent laboratory and imaging investigation (Fig. 8). In case a complication is suspected, hourly evaluation of the patient should be performed.\textsuperscript{86} On discharge
<table>
<thead>
<tr>
<th>Study group</th>
<th>Year, country</th>
<th>Total number of patients with orbital cellulitis</th>
<th>Mean age (years)</th>
<th>Duration of hospital stay (days)</th>
<th>Number of patients presenting orbital/subperiosteal abscess (%)</th>
<th>Commonest symptoms described</th>
<th>Commonest predisposing factors</th>
<th>Three major organisms involved</th>
<th>Main intravenous antibiotics used</th>
<th>Number of patients submitted in surgery (%)</th>
<th>Imaging method</th>
</tr>
</thead>
</table>
| Ferguson and McNab<sup>61</sup> | 1999, Australia
Pediatric group: 34 | 61 | 3 months−16 years | 6.2 | 32.4 | Proptosis  
Ophthalmoplegia  
Fever >37.5°C  
Leukocytosis  
Decreased visual acuity  
Chemosis | Sinus disease | Streptococcus viridans  
Staphylococcus aureus  
Anaerobic bacteria | Third-generation cephalosporin  
Flucloxacillin  
Metronidazole | 73.5 || CT |
| Ferguson and McNab<sup>61</sup> | 1999, Australia
Adult group: 18 17−86 years | 61 | 6.4 | 22.2 | Proptosis  
Ophthalmoplegia  
Proptosis  
Leukocytosis  
Decreased visual acuity  
Chemosis  
Fever >37.5°C | Sinus disease  
Dacryocystitis  
Retained metallic foreign body  
Uveitis leading to panophthalmitis  
Secondary infected nasal neuroblastoma | S. aureus  
Staphylococcus epidermidis  
Staphylococcus coagulase (−) | Third-generation cephalosporin  
Flucloxacillin  
Metronidazole  
Vancomycin  
Amoxicillin/penicillin | 33.3 || CT |
| Oxford and McClay<sup>136</sup> | 2005, USA | 95 | 7.3 | 5.9 | 46.3 | Restricted ocular motility  
Visual loss  
Nonreactive pupil  
Neurological deficits  
Seizures | Sinusitis  
Streptococcus milleri  
Hemolytic  
Streptococcus  
Staphylococcus aureus  
Nonhemolytic streptococcus  
Group A -hemolytic  
Streptococcus  
Peptostreptococcus | 37.5 || CT |
| Nageswaran et al.<sup>128</sup> | 2006, USA | 41 | 7.5 ± 5.0  
5.8 ± 2.9 | 83 | Sinusitis (ethmoid sinusitis in 98%) | Ampicillin-sulbactam  
Nafcinil + third-generation cephalosporin  
Clindamycin + third-generation cephalosporin | 71 || CT |
| Liu et al.<sup>12</sup> | 2006, Taiwan
Sum: 27 | 112 | 41.5 (3−83 years) | 29.6 | Erythematous swelling  
Ophthalmoplegia  
Chemosis  
Proptosis  
CRP elevation  
Fever  
Blurred vision  
Headache/drowsiness  
Leukocytosis  
Diplopia  
Discharge/tearing  
Abnormal pupillary | Sinusitis  
Upper respiratory infection  
Tumor  
Diabetes  
Hypertension  
Dacryoedentitis  
Dental abscess  
Dacryocystitis  
Endophthalmitis  
Malignancy  
Bacteremia | First-generation cephalosporin  
Nafcinil + aminoglycoside | 18.5 || CT |
<p>| Author(s)            | Year | Location        | Group | Age | Swelling | Proptosis | Pain | Decreased visual acuity | Headache | Diplopia | RAPD | Sinusitis | Trauma | Endophthalmitis | Orbital implants | Dacryocystitis | Dental infection | Retained foreign body | Scleral buckle | Sinusitis and trauma | Tumors | Staphylococcus spp. | Streptococcus spp. | Propionibacterium acnes | Cephalosporins | Aminoglycosides | Fluocloxacin | Vancomycin | Cefturoxime | co-amoxicillin/ | clavulanic acid |
|---------------------|------|-----------------|-------|-----|----------|-----------|------|--------------------------|----------|-----------|------|------------|--------|----------------|----------------|--------------|----------------|---------------------|----------------|------------------|--------|------------------|----------------|------------------|----------------|----------------|----------------|-----------------|-------------------|</p>
<table>
<thead>
<tr>
<th>Study group</th>
<th>Year, country</th>
<th>Total number of patients with orbital cellulitis</th>
<th>Mean age (years)</th>
<th>Duration of hospital stay (days)</th>
<th>Number of patients presenting orbital/subperiosteal abscess (%)</th>
<th>Commonest symptoms described</th>
<th>Commonest predisposing factors</th>
<th>Three major organisms involved</th>
<th>Main intravenous antibiotics used</th>
<th>Number of patients submitted in surgery (%)</th>
<th>Imaging method</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fanella et al.57</td>
<td>2011, Canada</td>
<td>38</td>
<td>7.5 (1 -16 years)</td>
<td>7.0 ± 2.7</td>
<td>42.1</td>
<td>Eye swelling, Fever, Eye pain, Coryza, Proptosis, Abnormal extraocular movements, Headache, Cough</td>
<td>Sinusitis (ethmoid sinusitis and Pansinusitis)</td>
<td>S. pyogenes, S. aureus, S. viridans</td>
<td>Cefuroxime Clindamycin + cephalosporin Cloxacillin + cefotaxime</td>
<td>21.1</td>
<td>CT</td>
</tr>
<tr>
<td>Huang et al.60</td>
<td>2011, Taiwan</td>
<td>64</td>
<td>6.95 ± 5.37 (12 days – 6 years: 9.16 and for 7–18 years: 13.17)</td>
<td>12 days (–6 years: 9.16 and for 7–18 years: 13.17)</td>
<td>56.2</td>
<td>Diplopia, Vision, Proptosis, Chemosis, Purulent rhinorrhea, Fever, Increase of WBCs, Increase of C-reactive protein</td>
<td>Sinusitis</td>
<td>S. aureus, S. viridans, S. coagulase (–)</td>
<td>Amoxicillin-clavulanate Cefuroxime + gentamicin Oxacillin + gentamicin</td>
<td>46.9</td>
<td>CT</td>
</tr>
<tr>
<td>Pandian et al.139</td>
<td>2011, India Sum: 33</td>
<td>13.69 ± 9.76</td>
<td></td>
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<tr>
<td>Pandian et al.139</td>
<td>2011, India Pediatric group: 19</td>
<td>4</td>
<td></td>
<td></td>
<td>10.5</td>
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<tr>
<td>Pandian et al.139</td>
<td>2011, India Adult group: 14</td>
<td>45</td>
<td></td>
<td></td>
<td>7.1</td>
<td></td>
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<tr>
<td>Bagheri et al.13</td>
<td>2012, Iran</td>
<td>39</td>
<td>27.4 ± 23.9 (6 months –48 years)</td>
<td></td>
<td>46.2</td>
<td>Lid redness, Lid edema, Ophthalmoplegia, Periocular pain, Proptosis, Clinical abscess, Reduced vision, Ptsosis, Periorbital erythema, and edema</td>
<td>Sinusitis, Periocular surgery, Trauma</td>
<td>S. aureus, Streptococcus β-hemolytic Klebsiella</td>
<td>Ceftazidime Cloxacillin Gentamicin Cephalothin Ceftriaxone Vancomycin</td>
<td>48.7</td>
<td>CT/MRI</td>
</tr>
<tr>
<td>Ozkurt et al.137</td>
<td>2014, Turkey</td>
<td>19</td>
<td>18.79 ± 18.01 (2 years –62 years)</td>
<td>10.05 ± 3.93 (5 years –18)</td>
<td>78.9</td>
<td>Sinusitis</td>
<td></td>
<td></td>
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<td></td>
<td>CT</td>
</tr>
<tr>
<td>Study</td>
<td>Year, Location</td>
<td>N</td>
<td>Age Range</td>
<td>CT</td>
<td>Findings</td>
<td>Pathogens</td>
<td>Treatment</td>
<td></td>
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<tr>
<td>Sharma et al.</td>
<td>2015, Canada</td>
<td>101</td>
<td>7.1 ± 4.0 6.1 ± 2.9</td>
<td>71.3</td>
<td>Sinusitis</td>
<td>S. pyogenes S. Coagulase (−) H. influenzae</td>
<td>Ceftriaxone + clindamycin Cefazolin Cefuroxime</td>
<td></td>
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<tr>
<td>Friling et al.</td>
<td>2014, Israel</td>
<td>51</td>
<td>6.1 (0.5 −17 years)</td>
<td>39.2</td>
<td>Fever (&gt;38°C) RAPD Proptosis Extraocular motility restriction Ocular pain</td>
<td>S. pneumoniae Anaerobic bacteria S. aureus</td>
<td>Ceftriaxone + clindamycin</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Marchiano et al.</td>
<td>USA, 2016</td>
<td>14,149</td>
<td>28.0 + 26.0 3.7 + 3.4</td>
<td>12.1</td>
<td>Sinusitis</td>
<td>S. pyogenes S. anginosus H. influenzae</td>
<td>Cefotaxime + flucloxacillin</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Crobie et al.</td>
<td>Scotland, 2016</td>
<td>30</td>
<td>76.7</td>
<td></td>
<td>Sinusitis</td>
<td>S. pyogenes Streptococcus anginosus H. influenzae</td>
<td>Cefotaxime + flucloxacillin</td>
<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td>Elshafei et al.</td>
<td>Egypt, 2017</td>
<td>102</td>
<td>25.56 + 18.87 (2 −70 years)</td>
<td>15.7</td>
<td>Proptosis Periorbital edema Tenderness Restriction of ocular motility Fever RAPD Fever Punctate keratitis</td>
<td>Paranasal sinusitis Orbital trauma Panophthalmitis secondary to extension of infection from the globe Dental abscess</td>
<td>Vancomycin + ceftazidime Clindamycin Metronidazole</td>
<td></td>
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</tbody>
</table>

CT, computed tomography; MRI, magnetic resonance imaging; CRP, C reactive protein; ESR, erythrocyte sedimentation rate; RAPD, relative afferent pupillary defect; WBC, white blood cells.
from the hospital, patients usually continue treatment with oral antibiotics for varying periods of time.\textsuperscript{38,74} Initiation of intravenous antibiotics must be immediate.\textsuperscript{86,108} The mainstay of therapy for OC is empiric coverage with broad-spectrum antibiotics against the most common pathogens; however, cultures should be obtained, and when needed, treatment is altered accordingly. Empiric treatment depends on the incidence of pathogens producing OC in each geographic area and the age of the patient. The regimens described in the literature have been inconsistent because the pathogens leading to OC vary among different geographic locations.\textsuperscript{86,108} Generally, antibiotic protocol depends on local microbiological sensitivities. A well-accepted proposed treatment scheme includes a broad-spectrum antibiotic, specifically a third-generation cephalosporin such as ceftriaxone with flucloxacillin. This scheme is effective against most usual bacteria, both gram-positive and gram-negative bacteria. Coverage for anaerobic bacteria is initiated in cases where there is no clinical improvement or in case of pyrexia after 24–36 hours after initiation of treatment. Metronidazole or clindamycin is preferred.\textsuperscript{40,108} As previously mentioned, children younger than 9 years present simpler infections, usually caused by a single aerobic pathogen, that respond easily to medical treatment. Older children and adults present more often with infections caused by multiple aerobic and anaerobic organisms, which may necessitate both medical and surgical treatment.\textsuperscript{34,74} In cases that MRSA is suspected, vancomycin is administered.\textsuperscript{86}

Various studies worldwide advocate treatment regimens used in their centers. The American Academy of Pediatrics advises that empiric treatment should target against the most common pathogens (\textit{S. pneumoniae}, \textit{H. influenzae}, and \textit{M. catarrhalis}).\textsuperscript{9} Based on this, Lee and colleagues prefer empiric coverage against gram-positive organisms, since \textit{Staphylococcus} and \textit{Streptococcus} species are the most common pathogens.\textsuperscript{108} Specifically, empiric use of vancomycin is recommended, based on the reported increased incidence of Community-acquired MRSA infections. They also advocate the use of cefotaxime and metronidazole or clindamycin to provide concurrent coverage against gram-negative and anaerobic organisms. Empiric antibiotic treatment should in general cover against sinus pathogens, prevent \textit{b}-lactamase resistance, and penetrate cerebrospinal fluid.\textsuperscript{137} In a study from the United Kingdom, contemporary empiric treatment with cefotaxime and metronidazole is advocated.\textsuperscript{86} Chaudhry and colleagues in a center in Saudi Arabia use a combination of a third-generation cephalosporin and flucloxacillin for the coverage against \textit{Staphylococcus}, \textit{Streptococcus}, and \textit{Haemophilus} species.\textsuperscript{32} Friling and colleagues from Israel treat OC with \textit{cefuroxime} and \textit{metronidazole}, which cover against \textit{penicillin-resistant S. pneumoniae}, anaerobic bacteria, and \textit{S. aureus}.\textsuperscript{65} Abdouramani and colleagues in Cameroon treat with
ceftiraxone, gentamicin, and metronidazole for concurrent coverage against aerobic and anaerobic organisms.2

Aggressive intervention is required in cases of intracranial complications, with a multidisciplinary approach of oculoplastic surgeons, otolaryngologists, neurosurgeons, and experts in infectious diseases.32 Medical treatment of intracranial complications includes wide-spectrum antibiotics that exhibit anaerobic coverage and central nervous system penetration.67,153 In early stages of cerebritis, when the brain abscess is not yet formed, aggressive antimicrobial treatment may prevent abscess formation. Penicillin, chloramphenicol, third-generation cephalosporins, and metronidazole penetrate well into the intracranial space and combined are effective against most antibiotics.17 After the brain abscess has formed, the surgical treatment is combined with a long course of antibiotics (4–8 weeks). Mannitol, hyperventilation, and steroids are also used for the increased intracranial pressure.23

CST is generally treated with broad-spectrum antibiotics that cover against aerobic and anaerobic organisms (vancomycin, cephalosporin, and metronidazole).170 Anticoagulants are additionally used to prevent further thrombosis and to dissolve the clot; however, treatment with anticoagulants in these cases is still controversial.149,174 Steroids are used to reduce edema and inflammatory process.149,170 Prompt surgical intervention is essential in cases with CST.174

Adjunctive use of corticosteroids is considered favorable together with the appropriate antibiotics, in the management of OC particularly after clinical improvement is noted. Intravenous corticosteroids moderate the inflammatory process and decrease the levels of inflammatory cytokines.66,197 Steroids, however, are contraindicated in cases of fungal OC or in immunocompromised individuals because of their immunosuppressive effects and the potential risk of delaying or preventing the resolution of the primary infection. Steroid use for the control of cerebral edema can present disadvantages. Steroids retard the encapsulation of the abscess, reduce the antibiotic potency, and influence CT scans. Hence, their use in these cases should be cautious.23 and each case must be carefully evaluated before steroids are administered.108

Antifungals should be considered in cases that do not respond to first-line therapy, especially at high-risk populations. In cases of fungal infection, treatment focuses on fixing the underlying metabolic abnormalities, along with intravenous antifungal therapy and surgical debridement of the affected tissues. Orbital exenteration may be necessary in nonresolving cases of fungal infections in order to avoid fatal complications.50,91,181

Finally, it is important that simultaneous sinusitis is treated, along with medical treatment of OC, with aggressive nasal hygiene, decongestants, saline nasal irrigation, and intranasal corticosteroids.26,108

10.2. Surgical management

Surgical management in cases of OC includes drainage of orbital abscesses, sinus surgery and treatment of intracranial complications.

Orbital abscesses, apart from aggressive antibiotic treatment, often require prompt drainage; however, the necessity of surgical treatment of a subperiosteal or orbital abscess is not clearly defined.86,173 Delayed drainage is likely to lead to serious complications and poor visual outcomes. On the other hand, an abscess may resolve with medical therapy alone, avoiding the likelihood of complications from surgery such as infection seeding.79,86,152

There are reports that propose surgery in high-risk cases such as children over the age of 10 years in whom complex infections are more common, the presence of anaerobes is more frequent, and extension of the abscesses more likely.75,79,108 Patients younger than 10 years with OC are more likely to respond to medical therapy without surgical drainage.26,72 Harris and colleagues consider that, with this approach, the formation of an orbital abscess or the intracranial extension of the infection can be prevented.79 Additionally, medial or inferior abscesses are more likely to respond to medical treatment,26,67,79,86,152 whereas cases of a superior abscess or an abscess at the orbital apex may require surgical drainage.108 Other factors considered for surgical treatment include the presence of severe signs such as compromised vision, papillary changes, raised intraocular pressure, proptosis of over 5 mm, and failure to respond to medical therapy.108 Patients with optic nerve or retinal compromise from compression by the abscess also require emergent drainage.72

The presence of a retained foreign body, a concurrent paranasal or frontal sinus infection, an identified dental source of the infection, the presence of intracranial complications, and the large abscesses also constitute high-risk factors that may require surgical treatment.34,67,72,86,89,108,171 Iatrogenic foreign bodies that lead to orbital infection, such as scleral buckles and glaucoma drainage devices, require urgent removal.108 Organic foreign bodies must be immediately surgically removed, as they carry a high risk of severe infections and complications. The treatment approach is empiric antibiotic therapy, immediate removal of the foreign body, simultaneous removal of the necrotic tissue, acquisition of cultures during surgery, and change of antibiotic therapy according to culture results.178 Usually, the entrance of the surgical incision for the foreign body removal is the original wound, as less injury is caused. If the wound has healed, the surgical approach depends on the location of the injury and the size of the foreign body. Finally, caution is required during removal of wooden foreign bodies because they tend to break into multiple pieces.110

An individualized treatment scheme is generally recommended.32 Jain and Rubin suggested the following categorization to guide the choice of the treatment modality in cases with orbital abscesses: patients requiring emergent drainage, patients who may need urgent drainage, and patients subjected to expectant observation.72,89 Close clinical monitoring is indicated, including careful evaluation of the optic nerve function, the pupillary reflexes, visual acuity and the level of consciousness, along with repeated orbital CT scans, so that surgical intervention can be offered when needed.32

There are different techniques for surgical removal of subperiosteal and orbital abscesses.178 The traditional external method for medial abscesses is performed through Lynch incision, which offers adequate visibility and effective drainage but leaves a visible scar, unpleasant in the pediatric
population. This indicates why transnasal endoscopic surgery represents a great advance. Factors that guide the surgical approach of choice include location of the abscess and radiographic findings. Successful transnasal endoscopic surgery is reported in patients with medial-based subperiosteal orbital abscesses, whereas superolateral extension requires an external approach. Migirov and colleagues have suggested endoscopic sinus surgery in the treatment of medial orbital abscesses. Another report from the United States suggests a combined endoscopic and transcaruncular surgical approach to medial orbital subperiosteal abscesses for an effective and cosmetically superior outcome.

In cases with intracranial complications, surgical treatment is indicated and should be planned promptly after diagnosis, given that a delay in surgical drainage and decompression of brain abscesses is related to high morbidity and mortality. Cases of OC with concurrent frontal sinusitis and complex infections with anaerobes are candidates for surgical management because of the increased risk of intracranial extension. Surgical drainage of the concomitant sinus infection and any orbital or other adjacent abscesses, such as a periodontal abscess, should also be performed concomitantly. A study from New York that reviewed pediatric cases of intracranial infections associated with sinusitis and OC concluded that all patients with intracranial extension of the infection require surgical intervention. Over 90% of patients were subjected to a combination of 2 or more surgical procedures such as craniotomy, orbital surgery, and sinus surgery. In cases with CST, surgery should be performed promptly after diagnosis. Surgical intervention is also indicated in the treatment of the bacterial sinusitis that precipitates CST, such as endoscopic sinus surgery.

11. Conclusion

Morbidity and mortality from OC have decreased over the past decades; however, OC still may lead to serious ophthalmic, neurologic, and even fatal complications. Early diagnosis and management are crucial for the preservation of vision and diminution of complications. Ongoing research into new antibiotic agents may further benefit the care of patients presenting with the disease. Future studies may also help better define prognostic criteria based on imaging to stratify risk and identify cases that require early intervention. Comprehension of clinical manifestations, predisposing factors, microbiology, and management of the disease is necessary. A multidisciplinary approach is indispensable for responsible monitoring and management of the disease.

11.1. Literature search

An extensive literature research has been performed in the MEDLINE database (PubMed) and included surveys published until 2016. The below key words were used: Orbital cellulitis AND predisposing factors, age, sinusitis, epidemiology, microbiology, classification, differential diagnosis, imaging and management. Articles that reported the possible causative organisms, and their correlation to geographic distribution were thoroughly studied. There was no language restriction. References cited in the articles were also studied.

In the present review, 197 studies were evaluated, which were published from the year 1948 to 2017. The included studies comprise data of OC coming from various geographic locations (North and South America, Europe, Africa, Australia, and Asia), and regarding different age groups (childhood, young adults, patients over 60 years), etiologic factors, clinical manifestations, complications, and treatment modalities of cellulitis.

12. Disclosure

There was no funding for this study. The authors report no proprietary or commercial interest in any product mentioned or concept discussed in this article.

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