



## Multidisciplinary Evaluation and Management of Cavernous Sinus Thrombosis: Integrating Laboratory Diagnostics, Advanced Imaging, Epidemiologic Insights, and Primary Care Approaches

Amani Khamash Hassan Asiri <sup>(1)</sup>, Murdi Ali Naser Aldawsari <sup>(2)</sup>, Abdurhman Majed Ali Aldawsari <sup>(2)</sup>, Bader Fayz Mohammed Aldawsari <sup>(2)</sup>, Misfer Marzooq Mohammed Aldawsari <sup>(2)</sup>, Turki Mohammed Sultan Hakami <sup>(3)</sup>, Abrar Sayer Almutairi <sup>(4)</sup>, Maha Sameer Alanazi <sup>(5)</sup>, Hani Ghazi Abdulmalik <sup>(6)</sup>, Mohammed Abdulrahman Babaseel <sup>(7)</sup>, Abed Abdullah Almetari D <sup>(7)</sup>

(1) Al Harajah General Hospital, Ministry of Health, Saudi Arabia,

(2) Wadi Al-Dawasir General Hospital, Ministry of Health, Saudi Arabia,

(3) Samtah General Hospital – Jazan, Ministry of Health, Saudi Arabia,

(4) Second Health Cluster – Gulf Health Center 2, Ministry of Health, Saudi Arabia,

(5) Public Health Department, Ministry of Health, Saudi Arabia,

(6) Maternity and Children Specialized Hospital – Jeddah, Ministry of Health, Saudi Arabia,

(7) Eastern Health Cluster – Al Khobar Health Network, Ministry of Health, Saudi Arabia

### Abstract

#### Background:

Cavernous sinus thrombosis (CST) is a rare but life-threatening neurovascular condition arising from infectious or aseptic etiologies. Its proximity to critical cranial nerves and the internal carotid artery contributes to rapid neurological and ophthalmologic deterioration when diagnosis and treatment are delayed.

**Aim:** This study aims to synthesize multidisciplinary perspectives on CST—integrating epidemiology, risk factors, clinical features, diagnostic strategies, and management approaches—to support early identification and improve patient outcomes.

**Methods:** A comprehensive review of CST-related anatomy, pathophysiology, clinical presentation, imaging modalities, laboratory evaluation, and current therapeutic practices was conducted. Emphasis was placed on evidence-based antimicrobial therapy, anticoagulation strategies, surgical indications, and interprofessional care models.

**Results:** CST occurs most frequently secondary to facial, sinus, or orbital infections, with *Staphylococcus aureus* being the most common pathogen. Key clinical features include fever, headache, periorbital edema, ophthalmoplegia, and cranial nerve palsies, with bilateral involvement often developing as thrombosis propagates. Contrast-enhanced CT/MRI with venography provides the most reliable diagnostic confirmation. Early initiation of broad-spectrum intravenous antibiotics, combined with anticoagulation when appropriate, significantly reduces mortality from historical levels exceeding 80% to approximately 10–30% today. Multidisciplinary management remains essential due to the high risk of visual loss and persistent cranial neuropathies.

**Conclusion:** Timely, coordinated, and evidence-based intervention markedly improves survival and functional outcomes in CST. Despite advancements, morbidity remains significant, reinforcing the need for early recognition, prompt imaging, and integrated care strategies.

**Keywords:** Cavernous sinus thrombosis, neurovascular infection, ophthalmoplegia, anticoagulation, imaging, multidisciplinary management.

### Introduction

Cavernous sinus thrombosis (CST) represents a rare but potentially fatal condition characterized by the formation of a thrombus within the cavernous sinus. This venous structure, located bilaterally at the base of the skull, is closely associated with critical neurovascular structures, including cranial nerves III, IV, V1, V2, and VI, as well as the internal carotid artery. Thrombosis in this region can therefore rapidly lead to severe neurological and ophthalmologic complications. CST commonly occurs secondary to septic processes originating from

facial infections, sinusitis, orbital cellulitis, pharyngitis, or otitis media. Aseptic causes, such as trauma, surgical interventions, or underlying prothrombotic disorders, may also precipitate thrombosis. The condition is more frequently observed in patients with underlying thrombophilia or immune compromise. Clinically, CST presents with a constellation of symptoms that often progress rapidly. Early signs include fever, headache, and periorbital edema, frequently accompanied by ocular manifestations such as proptosis, chemosis, and cranial nerve palsies leading to ophthalmoplegia.

Diplopia, ptosis, and sensory deficits in the ophthalmic and maxillary distributions of the trigeminal nerve may also occur. Because of the proximity to the brain and risk of intracranial extension, timely identification is essential. Despite advancements in antimicrobial therapy and the use of anticoagulants, CST carries a substantial risk of long-term morbidity. Complications may include permanent visual impairment, persistent cranial nerve deficits, cerebral infarction, or stroke. Mortality rates, although reduced with modern treatment protocols, remain considerable, emphasizing the need for rapid diagnosis, interprofessional collaboration, and comprehensive management strategies involving laboratory confirmation, imaging, and coordinated clinical care.[1][2][3][4][5] Early intervention guided by multidisciplinary assessment is therefore pivotal to mitigating neurological deficits and improving patient outcomes in cavernous sinus thrombosis.

### **Etiology**

Cavernous sinus thrombosis (CST) most frequently develops in the context of systemic or localized sepsis, though it can also arise from non-infectious, or aseptic, causes. Septic CST commonly originates from infections within the facial region, particularly the nasolabial triangle extending from the corners of the mouth to the nasal bridge. Contributing sources include abscesses, cellulitis, and sinusitis of the sphenoid or ethmoid sinuses, as well as otitis media, mastoiditis, and complications following dental interventions such as tooth extractions, maxillofacial surgery, or posterior superior alveolar nerve blocks that communicate with the pterygoid venous plexus. Aseptic etiologies, while less frequent, include direct trauma, postoperative complications, and physiological states such as pregnancy, which can predispose to thrombotic events through hypercoagulability [6]. The microbial landscape associated with CST is predominantly bacterial, with *Staphylococcus aureus* accounting for approximately two-thirds of cases, including methicillin-resistant strains. *Streptococcus* species contribute to nearly 20% of infections, while pneumococcal organisms are implicated in about 5% of cases. Other bacterial pathogens include gram-negative species such as *Proteus*, *Haemophilus*, *Pseudomonas*, *Fusobacterium*, and *Bacteroides*, alongside gram-positive organisms including *Corynebacterium* and *Actinomyces*. Several of these bacteria, notably *Bacteroides*, *Fusobacterium*, and *Actinomyces*, are anaerobic and capable of establishing deep-seated infections. Fungal pathogens, although less common, are clinically significant in immunocompromised patients, with *Aspergillus*, *Mucor*, and *Coccidioides* species being the most frequently identified. Rarely, CST may result from parasitic infections such as toxoplasmosis, malaria, or trichinosis, and viral pathogens including herpes simplex virus, cytomegalovirus, measles virus, hepatitis viruses, and HIV have also been reported as causative agents [6]. The diversity of potential

infectious and non-infectious triggers underscores the importance of early identification and precise microbiological or etiological investigation. Recognizing the underlying cause is essential for tailoring antimicrobial therapy, initiating anticoagulation when appropriate, and minimizing the risk of morbidity and mortality associated with this life-threatening neurovascular condition.

### **Cavernous Sinus Thrombosis Risk Factors**

Cavernous sinus thrombosis (CST) arises from a combination of infectious, hematologic, and systemic predisposing factors that increase the likelihood of thrombus formation within the cavernous sinus. Immunosuppressed states significantly elevate the risk of CST. Patients with uncontrolled diabetes mellitus, those receiving chronic corticosteroid therapy, individuals with malignancies, and those undergoing chemotherapy are particularly vulnerable. Impaired immune function in these populations diminishes the host's capacity to control local or systemic infections, which can facilitate thrombus propagation and complicate the clinical course [7]. Among all risk factors, localized infections remain the most critical. Facial infections, acute sinusitis, and periorbital infections create direct routes for pathogens to enter the cavernous sinus via venous connections, markedly increasing the risk of septic CST. Thrombophilic states, whether inherited or acquired, further amplify susceptibility. Women who are pregnant, in the postpartum period, or receiving exogenous hormonal therapy such as oral contraceptives or hormone replacement therapy exhibit increased prothrombotic tendencies that predispose them to CST. Genetic thrombophilic disorders, including factor V Leiden mutation, prothrombin G20210A mutation, antithrombin III deficiency, and deficiencies in protein C or protein S, as well as elevated factor VIII levels, are well-documented contributors to thrombus formation within cerebral venous structures [8]. Acquired thrombophilic conditions also increase CST risk. These include antiphospholipid antibody syndrome, hyperhomocysteinemia, heparin-induced thrombocytopenia, and obesity, all of which disrupt normal coagulation balance and promote clot formation. Additional predisposing conditions involve severe dehydration, particularly in hyperosmolar nonketotic states, nephrotic syndrome, and hematologic disorders such as sickle cell disease, which increase blood viscosity and endothelial injury [9][10]. Understanding the multifactorial risk profile of CST is essential for early recognition, risk stratification, and implementation of both preventive and therapeutic strategies, particularly in vulnerable patient populations.

### **Epidemiology**

Cavernous sinus thrombosis (CST) is an exceptionally rare condition, making precise determination of its incidence challenging. CST accounts for approximately 1% to 4% of all cerebral

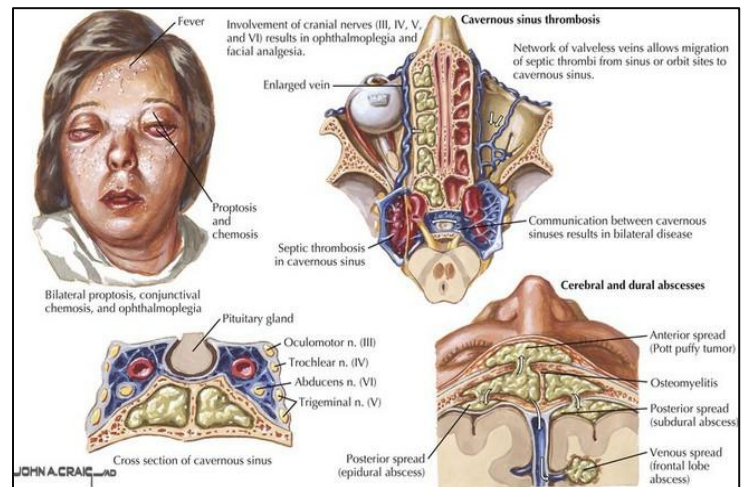
venous and sinus thrombosis (CVST) cases, with CVST itself occurring at an estimated rate of 2 to 4 per million individuals annually. Consequently, the projected incidence of CST ranges from approximately 0.2 to 1.6 per 100,000 individuals per year, with a slightly higher frequency observed in pediatric populations [11]. Unlike cerebral venous thrombosis in general, which often demonstrates a female predominance of 3:1, CST does not consistently show sex-specific trends. Several studies suggest a possible male preponderance in septic cases. For instance, Weerasinghe and Lueck documented a 2:1 male-to-female ratio among 88 adult patients with septic CST. Similarly, Thatai et al. and Smith et al. reported slight male predominance in cohorts of 35 and 12 cases, respectively, indicating that sex differences in CST may be less pronounced than in other forms of venous thrombosis [12]. CST has historically been reported more frequently in children and neonates compared with adults. However, the influence of modern medical interventions, including routine childhood vaccinations and the widespread use of antibiotics, on this trend remains uncertain. These interventions may contribute to reduced incidence by preventing the primary infectious processes that predispose patients to septic CST. Additionally, the mortality and morbidity associated with CST appear to have declined over recent decades, likely due to advances in early recognition, prompt antimicrobial therapy, and improved supportive care. Despite these improvements, CST remains a critical neurological emergency, and continued epidemiological surveillance is essential to monitor trends, identify at-risk populations, and guide preventive strategies.

### Pathophysiology

#### Anatomic Structures

The cavernous sinuses are paired dural venous structures situated on either side of the sella turcica, superior and lateral to the sphenoid sinus. These sinuses are anatomically delineated anteriorly by the superior orbital fissure and posteriorly by the petrous apex of the temporal bone. Internally, the cavernous sinuses consist of trabeculated venous channels formed by layers of dura mater, which are filled with slow-flowing venous blood. Venous inflow arises from multiple sources, including the superior and inferior ophthalmic veins, as well as superficial cortical veins. Posteriorly, blood drains from the cavernous sinus into the basilar plexus via the superior and inferior petrosal sinuses, maintaining a bidirectional flow due to the valveless venous system. The cavernous sinus has been described as an "anatomic jewel box" due to its complex contents and relationships with vital neurovascular structures. The internal carotid artery passes horizontally through the sinus lumen, accompanied medially by the sympathetic plexus and cranial nerve VI (abducens). Cranial nerves III (oculomotor), IV (trochlear), and the ophthalmic (V1) and maxillary (V2) branches of the

trigeminal nerve traverse the lateral wall of the sinus. This anatomical proximity underlies the characteristic cranial neuropathies seen in cavernous sinus pathology.



**Fig. 1:** Cavernous Sinus Thrombosis.

#### Pathophysiologic Mechanisms of Thrombosis

Cavernous sinus thrombosis (CST) can be classified into septic and aseptic forms, with septic CST predominating. Septic thrombosis frequently originates from local spread through valveless facial and ophthalmic veins or from contiguous infections, including acute sinusitis (particularly sphenoid and ethmoid), periorbital or orbital cellulitis, facial abscesses within the nasolabial triangle, pharyngitis, tonsillitis, otitis media, mastoiditis, and odontogenic infections [13]. Embolization of bacteria or other pathogens into the cavernous sinus promotes local thrombus formation, which traps organisms within the venous lumen, perpetuating infection and inflammation. Impaired venous drainage contributes to venous congestion, resulting in characteristic clinical findings such as facial and periorbital edema, ptosis, proptosis, chemosis, pain with ocular movement, and visual disturbances including papilledema and retinal venous distension. The valveless nature of the dural venous system permits bidirectional flow, allowing thrombus propagation into interconnected dural sinuses. Communication between the right and left cavernous sinuses via anterior and posterior intercavernous sinuses facilitates contralateral spread of infection and thrombosis. Local inflammation and compression within the sinus lumen frequently affect cranial nerves, leading to partial or complete cranial neuropathies. The sixth cranial nerve (abducens) is often the earliest affected, producing limited lateral eye movement, while involvement of cranial nerves III and IV can result in total ophthalmoplegia and diplopia. Sympathetic or parasympathetic fiber involvement may cause pupillary abnormalities, including miosis or mydriasis. Ophthalmic and maxillary branches of the trigeminal nerve can be

affected, producing hypoesthesia, paresthesia, or loss of corneal reflex.

Septic CST carries the risk of systemic and central nervous system complications. Infection may extend into the dural sinuses, cerebral veins, or emissary veins, resulting in meningitis, subdural empyema, or brain abscess. Hematogenous spread via the jugular system can lead to pulmonary complications, including septic emboli, pneumonia, pulmonary abscess, or pleural empyema. Cerebrovascular events may occur secondary to carotid artery narrowing, local vasculitis, or hemorrhagic infarction from cortical vein thrombosis. Rarely, hypopituitarism develops due to ischemia or direct infectious involvement of the pituitary gland. The pathophysiology of CST underscores the interplay between venous anatomy, infectious spread, and neurovascular compromise. The combination of valveless venous communication, proximity to critical cranial nerves, and susceptibility to septic or aseptic insults explains the high morbidity associated with this disorder, emphasizing the need for rapid recognition and targeted multidisciplinary management [13].

### **History and Physical**

#### **Clinical History**

Patients diagnosed with cavernous sinus thrombosis (CST) frequently present with a constellation of systemic and ocular symptoms reflecting both infectious and neurovascular involvement. Fever is one of the most common presenting features, accompanied by headache in 50% to 90% of cases. Headache may be localized or diffuse, often severe, and may precede ocular findings. Patients frequently report periorbital swelling, ocular pain, and visual disturbances such as diplopia, photophobia, or partial loss of vision. Symptoms often develop initially in one eye, typically corresponding to the side of the primary infectious focus, and progress to the contralateral eye as thrombosis propagates through the intercavernous sinus connections. The onset can be abrupt in acute septic cases or subacute, evolving over several days. Less frequent manifestations include rigors, neck stiffness, facial numbness, altered mental status, confusion, seizures, or even stroke-like deficits and coma in severe cases. Patients may also describe a sensation of eye pressure, photophobia, or pulsatile discomfort reflecting orbital venous congestion [12][13].

#### **Physical Examination Findings**

Vital signs often demonstrate systemic inflammatory response, with fever, tachycardia, and occasionally hypotension. A "picket fence" fever pattern, characterized by abrupt elevations in temperature followed by rapid normalization, may be noted, particularly in cases involving the lateral wall of the cavernous sinus. Neurologic examination can reveal altered mental status, ranging from lethargy to obtundation, though seizures and focal stroke-like signs are less common. Ocular abnormalities are present in approximately 90% of patients. These

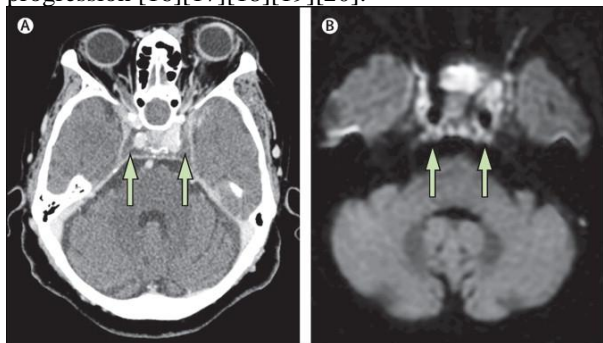
include periorbital edema, which is initially unilateral but usually progresses bilaterally, lid erythema, chemosis, ptosis, and proptosis resulting from impaired orbital venous drainage. Eye movements are typically restricted and painful due to cranial nerve involvement. Papilledema, retinal hemorrhages, decreased visual acuity, photophobia, impaired pupillary reflexes, and conjunctival pulsation may also be observed. Blindness develops in approximately 8% to 15% of patients if diagnosis and treatment are delayed. Cranial nerve examination frequently demonstrates sixth cranial nerve involvement as the earliest neuropathy, producing partial ophthalmoplegia and limitation of lateral eye movement. Disease progression often results in complete external ophthalmoplegia due to sequential involvement of cranial nerves III, IV, and VI. Internal ophthalmoplegia may occur, causing pupillary abnormalities; miosis results from sympathetic fiber paralysis via the short ciliary nerves, whereas parasympathetic fiber impairment from cranial nerve III may cause mydriasis. Associated Horner syndrome, characterized by ptosis, miosis, and anhidrosis, may also be evident. Sensory deficits typically involve diminished facial sensation due to compression of the ophthalmic (V1) and maxillary (V2) divisions of the trigeminal nerve, with reduced corneal reflex as an additional indicator of trigeminal nerve involvement [14]. The combination of systemic signs, ocular findings, cranial neuropathies, and sensory deficits provides critical diagnostic clues for early recognition of CST, which is essential for timely intervention and prevention of permanent sequelae.

### **Evaluation**

#### **Imaging Studies**

The definitive diagnosis of cavernous sinus thrombosis (CST) relies heavily on neuroimaging, with contrast-enhanced computed tomography (CT) and magnetic resonance imaging (MRI) considered the primary modalities for evaluation. CT venography (CTV) and contrast-enhanced MR venography (MRV) demonstrate the highest sensitivity in detecting thrombus formation within the cavernous sinus. Noncontrast CT or time-of-flight MRV, while sometimes performed initially, may fail to reveal the pathology due to subtle or nonspecific changes, making them insufficient as standalone diagnostic tools. Noncontrast CT of the head may reveal indirect indicators such as dilation or engorgement of the superior and inferior ophthalmic veins, bulging of the lateral margins of the cavernous sinus, or orbital proptosis. Additionally, evidence of adjacent infections, including sphenoid or ethmoid sinusitis, or mass lesions near the sphenoid sinus or pituitary gland, may be detected, aiding in identifying potential sources of septic CST. Contrast-enhanced MRI offers superior visualization of the cavernous sinus anatomy. Findings may include widening of the sinus, asymmetric or heterogeneous filling defects, increased dural enhancement, and the absence of normal flow

voids on T2-weighted sequences. CTV and enhanced MRV can provide detailed evaluation of the venous structures, revealing convexity of the lateral wall—normally concave in healthy individuals—thrombosis of tributary veins, superior ophthalmic vein involvement, and increased orbital fat density indicative of venous congestion. These modalities also allow assessment of carotid artery involvement, including arterial narrowing and enhancement of the carotid wall. Associated intracranial complications such as cerebral infarction, intraparenchymal hemorrhage, subdural empyema, meningitis, cerebritis, or brain abscess may also be identified, highlighting the systemic and potentially multifocal nature of the condition. Since CST frequently involves multiple thromboses, careful evaluation of the dural venous sinuses and cerebral veins is essential to guide therapeutic interventions and monitor disease progression [16][17][18][19][20].



**Fig. 2:** CT Scan of Cavernous Sinus thrombosis.

### Laboratory Studies

Laboratory evaluation complements imaging in confirming the diagnosis and guiding management. Blood tests often reveal leukocytosis, elevated C-reactive protein (CRP), increased erythrocyte sedimentation rate (ESR), and elevated D-dimer levels, reflecting systemic inflammation and coagulation activation. Blood cultures are critical and should be obtained prior to initiating antibiotic therapy, as they are frequently positive in septic CST. Screening for inherited or acquired thrombophilias may assist in identifying underlying risk factors; however, testing should be deferred until after anticoagulation therapy is completed to avoid false-negative or inconclusive results. Lumbar puncture may be indicated to exclude coexisting meningitis, particularly in patients presenting with fever, neck stiffness, or altered mental status. Findings may include elevated opening pressure and pleocytosis, even in the absence of positive cultures. Prior imaging to exclude mass lesions or intracranial hypertension is essential before performing lumbar puncture to minimize the risk of herniation. Additional laboratory assessments may include coagulation profiles, renal and hepatic function tests, and monitoring of electrolytes, particularly in patients receiving anticoagulation, broad-spectrum antibiotics, or supportive care measures. Together, neuroimaging

and targeted laboratory studies provide a comprehensive evaluation framework for CST, allowing clinicians to confirm the diagnosis, identify the etiology, detect complications, and guide urgent therapeutic interventions. Prompt, coordinated use of these diagnostic tools significantly improves clinical outcomes and reduces the risk of long-term morbidity.

### Treatment / Management

The management of cavernous sinus thrombosis (CST) requires a multimodal approach that combines antimicrobial therapy, anticoagulation, supportive care, and selective surgical interventions. Due to the rarity of the condition, robust randomized controlled trials are lacking, and treatment decisions are guided by observational studies, retrospective analyses, and expert consensus [21]. Prompt recognition and early initiation of therapy are critical to reduce morbidity and mortality, given the high risk of visual loss, neurological deficits, and systemic complications associated with CST.

### Antimicrobial Therapy

Antimicrobial therapy constitutes the cornerstone of treatment in septic cavernous sinus thrombosis. Empirical therapy should target the most common pathogens, including *Staphylococcus aureus* (including methicillin-resistant strains), *Streptococcus* species, gram-negative bacilli, and anaerobes such as *Fusobacterium* and *Bacteroides*. Standard regimens often include an anti-staphylococcal agent such as vancomycin in cases of suspected methicillin resistance, combined with a third-generation cephalosporin to cover streptococcal and gram-negative organisms. Metronidazole may be added to provide anaerobic coverage. In immunocompromised patients or those with fungal risk factors, amphotericin B or other antifungal agents should be considered, particularly in cases of mucormycosis or *Aspergillus* infection. The duration of antimicrobial therapy is prolonged, typically lasting three to four weeks or extending at least two weeks beyond clinical resolution. Parenteral administration is preferred in the acute phase due to enhanced bioavailability and reliable therapeutic concentrations. Continuous monitoring during therapy is essential, including clinical assessment, laboratory markers of infection (e.g., white blood cell count, C-reactive protein, erythrocyte sedimentation rate), and follow-up imaging when indicated to ensure resolution of thrombosis and associated complications. Even after cessation of antibiotics, patients require close follow-up due to the potential for relapse or late sequelae, such as persistent cranial neuropathies or cavernous sinus fibrosis [21].

### Anticoagulation Therapy

Anticoagulation in CST remains controversial but is generally recommended in the absence of absolute contraindications. The primary rationale is to prevent thrombus propagation, reduce venous congestion, and potentially enhance the

delivery of antibiotics to the affected area. Unfractionated heparin (UFH) or low molecular weight heparin (LMWH) is typically administered for several weeks to months, with therapy duration tailored to patient response, underlying risk factors, and the presence of thrombophilic disorders. Retrospective studies suggest that anticoagulation, when combined with antibiotics, may reduce mortality from approximately 40% to 14% and decrease neurological morbidity from 61% to 31% in septic CST. Despite the apparent benefits, anticoagulation carries risks, including systemic or intracranial hemorrhage and, theoretically, dissemination of septic emboli. Insights from cerebral venous sinus thrombosis indicate that anticoagulation is safe even in the presence of intracranial hemorrhage and may reduce mortality, although the statistical significance remains uncertain. Current recommendations from the European Federation of Neurological Societies (EFNS) suggest three months of anticoagulation for secondary cerebral venous thrombosis with transient risk factors, six to twelve months for idiopathic cases or mild thrombophilia, and indefinite therapy for recurrent thrombosis or severe thrombophilia. Although thrombolysis has been explored for cerebral venous thrombosis, insufficient evidence exists to support its routine use in CST [21].

#### **Corticosteroids**

Corticosteroid therapy in CST is frequently employed to reduce inflammation and vasogenic edema affecting cranial nerves and orbital structures. Despite their theoretical benefits, evidence supporting improved outcomes is lacking. The International Study on Cerebral Veins and Dural Sinus Thrombosis (ISCVT) reported steroid use in approximately 24% of cerebral venous thrombosis cases, without demonstrating significant clinical improvement. Corticosteroids are primarily indicated in cases complicated by hypopituitarism or significant orbital edema threatening optic nerve function, and their use should be carefully weighed against the potential for immunosuppression, which could exacerbate infection.

#### **Surgical Interventions**

Direct surgical intervention within the cavernous sinus itself is generally avoided due to the high risk of morbidity and technical complexity. However, surgical procedures may be required to address the underlying source of infection or associated complications. These may include endoscopic sinus surgery such as sphenoidectomy, ethmoidectomy, or maxillary antrostomy to remove purulent collections and improve drainage in cases of sinusitis. Mastoidectomy may be indicated for infections extending from the middle ear, and abscess drainage is necessary for orbital or facial abscesses contributing to septic propagation. Craniotomy may be warranted for subdural empyema or brain abscess, while orbital decompression may be indicated to relieve proptosis or optic nerve compression. In rare

cases, ventricular shunt placement may be necessary for secondary hydrocephalus. Extensive debridement is often required for fungal CST, particularly mucormycosis, to remove necrotic tissue and limit fungal invasion.

#### **Supportive Care and Monitoring**

Supportive care is essential in the management of CST. Patients require intensive monitoring in a hospital or intensive care setting due to the risk of rapid clinical deterioration. Vital signs, neurological status, and visual function should be frequently assessed. Intravenous fluids, electrolyte management, and nutritional support are critical components, particularly in patients with sepsis or prolonged hospitalization. Pain control and management of ocular complications, such as chemosis, proptosis, and ophthalmoplegia, may necessitate adjunctive ophthalmologic consultation. Multidisciplinary collaboration is key to optimizing outcomes. Radiologists provide essential imaging interpretation for diagnosis and monitoring, infectious disease specialists guide antimicrobial selection, hematologists manage anticoagulation, neurosurgeons and otolaryngologists address surgical indications, and ophthalmologists monitor and treat ocular sequelae. Family physicians and primary care providers play a critical role in early recognition and coordination of follow-up care. Epidemiologists and public health specialists may contribute to outbreak investigation in cases of community-associated septic CST or to guide preventive measures in populations at risk [21].

#### **Prognosis**

Early recognition and aggressive management have significantly improved outcomes for patients with CST compared to historical reports. Mortality rates, previously as high as 80%, have declined to approximately 10% to 30% in modern series with combined antimicrobial and anticoagulation therapy. Neurological and ophthalmologic sequelae, however, remain common, emphasizing the importance of ongoing monitoring, rehabilitation, and long-term follow-up. Timely intervention, appropriate antimicrobial therapy, and multidisciplinary collaboration remain the cornerstones of management, aiming to prevent irreversible vision loss, cranial neuropathies, and systemic complications. In conclusion, the management of cavernous sinus thrombosis requires an integrative approach combining prolonged parenteral antimicrobial therapy, judicious anticoagulation, selective corticosteroid use, and targeted surgical interventions. Continuous monitoring, supportive care, and close collaboration across multiple specialties—including radiology, infectious disease, neurology, ophthalmology, otolaryngology, and primary care—are essential to improve survival and reduce long-term morbidity. Despite the lack of high-level evidence, clinical experience and retrospective data support early, aggressive treatment to optimize patient outcomes and

prevent the potentially devastating complications associated with CST [21][22].

### Differential Diagnosis

The differential diagnosis of cavernous sinus thrombosis (CST) encompasses a broad spectrum of conditions that may mimic its clinical presentation, particularly other causes of cavernous sinus syndrome and painful ophthalmoplegia. Distinguishing CST from these conditions is critical, as management strategies differ significantly, and delayed recognition may result in severe neurological and ophthalmologic sequelae. Cavernous sinus syndrome can result from local compression or infiltration of the cavernous sinus by noninfectious and nonthrombotic lesions. Tumors account for approximately 30% of such cases and include both primary and secondary lesions. Common etiologies are pituitary adenomas, meningiomas, schwannomas, plexiform neurofibromas, chordomas, chondrosarcomas, and melanocytomas. Metastatic lesions, particularly from breast, lung, or prostate cancers, may also involve the cavernous sinus. Nasopharyngeal carcinoma represents the most frequent primary malignant tumor affecting this region. Imaging findings, such as lytic bone lesions near the sphenoid sinus or sella turcica, enlargement of the cavernous sinus, and mass effect on adjacent structures, help differentiate these lesions from thrombotic processes. Cavernous hemangiomas, though benign, may also compress cavernous sinus structures and mimic CST symptoms. Carotid-cavernous fistulas present another critical consideration, characterized radiographically by proptosis, dilation of the superior orbital vein, retro-orbital fat stranding, and enlargement of extraocular muscles on contrast-enhanced CT or MRI. Inflammatory and granulomatous conditions can also produce cavernous sinus syndrome. Tolosa-Hunt syndrome, for example, involves a retro-orbital granulomatous pseudotumor extending into the cavernous sinus. Clinically, it manifests retro-orbital pain, ophthalmoplegia, and cranial nerve palsies, and it typically responds to systemic corticosteroids. Similarly, sino-orbital aspergillosis may invade the cavernous sinus in immunocompromised individuals, leading to ophthalmoplegia and orbital pain. Superior orbital fissure syndrome, which involves cranial nerves III, IV, V1, V2, and VI, may present symptoms similar to CST but often lacks systemic features of infection such as fever or leukocytosis [22].

Painful ophthalmoplegia may also arise from orbital apex syndrome, characterized by inflammation at the posterior orbit affecting the superior orbital fissure and optic canal. This condition often results in more severe visual loss and less prominent orbital edema or proptosis compared to CST. Infectious etiologies affecting the orbit, such as orbital cellulitis, must be considered, particularly when associated with periorbital swelling, erythema, and systemic signs of infection. Systemic infectious and inflammatory

diseases, including sarcoidosis, syphilis, and tuberculosis, may involve the orbit or cavernous sinus and produce overlapping clinical features, further complicating diagnosis. In summary, differentiating CST from other causes of cavernous sinus syndrome or painful ophthalmoplegia requires careful integration of clinical history, examination, and targeted imaging. Key distinguishing features include the presence of systemic infection, progression from unilateral to bilateral ocular involvement, and laboratory evidence of sepsis or thrombosis. Radiologic studies, especially contrast-enhanced CT or MRI with venography, are essential in confirming CST and excluding structural, inflammatory, or neoplastic mimics. Early recognition and accurate differentiation directly influence management, optimizing patient outcomes while preventing unnecessary interventions or complications [22].

### Prognosis

The prognosis of cavernous sinus thrombosis (CST) has improved considerably with the advent of early recognition, prompt imaging, and aggressive treatment strategies. Historically, CST carried an extremely poor prognosis, with reported mortality rates ranging between 80% and 100% prior to the availability of effective antibiotics and supportive care. The high mortality was primarily due to the rapid spread of infection through the valveless venous system, leading to sepsis, meningitis, cerebral infarction, or multiple organ dysfunction. Contemporary management with intravenous broad-spectrum antibiotics, anticoagulation when indicated, and close monitoring has reduced the mortality rate to approximately 8% to 13%. [22][23][24] Early identification of hallmark signs, including fever, headache, periorbital edema, and ophthalmoplegia involving cranial nerves III, IV, and VI, is crucial in achieving these outcomes. Despite the improvement in survival, significant morbidity persists. Visual impairment remains a frequent complication, with fewer than 20% of patients experiencing permanent deficits, ranging from partial loss of visual acuity to complete blindness in severe cases. Cranial neuropathies are common, particularly involving cranial nerves III and VI, leading to persistent ophthalmoplegia and diplopia in up to 50% of patients. Other neurologic sequelae include trigeminal nerve dysfunction, ptosis, and abnormal pupillary responses. Recovery of cranial nerve function may be incomplete even with optimal treatment, emphasizing the importance of long-term ophthalmologic and neurologic follow-up. Functional limitations may also arise from residual motor deficits, headaches, or ocular discomfort. Factors influencing prognosis include the timing of diagnosis, the extent of thrombotic involvement, the underlying infectious pathogen, the presence of comorbidities such as immunosuppression or thrombophilia, and the promptness of antimicrobial and anticoagulation therapy. Early initiation of

treatment has been associated with a reduced risk of systemic complications, shorter hospital stays, and improved neurologic recovery. Multidisciplinary coordination, including neurology, infectious disease, ophthalmology, and critical care teams, is vital in optimizing outcomes. In summary, while mortality has decreased markedly with modern management, CST continues to carry significant morbidity, and early recognition, aggressive treatment, and multidisciplinary follow-up remain essential for improving both survival and quality of life [23][24].

### Complications

Cavernous sinus thrombosis carries the risk of severe and potentially life-threatening complications, even when prompt antimicrobial and anticoagulation therapy is administered. Neurologic complications may include seizures, which can arise from cortical irritation secondary to venous congestion or ischemic injury. Meningitis may develop either from direct extension of infection into the meninges or through hematogenous spread, increasing the risk of long-term neurologic deficits. Subdural empyema and brain abscess are other critical intracranial complications, often necessitating neurosurgical intervention in addition to antimicrobial therapy. Cortical vein thrombosis, carotid artery narrowing, and vasospasm may result in ischemic or hemorrhagic strokes, further contributing to morbidity and mortality. Ophthalmologic complications are frequent and severe due to the anatomical proximity of the cavernous sinus to the orbital structures. Blindness may occur in 8% to 15% of cases, often from prolonged venous congestion, optic nerve ischemia, or secondary retinal involvement. Persistent cranial nerve deficits, particularly affecting the oculomotor and abducens nerves, can result in permanent diplopia and ophthalmoplegia. Internal ophthalmoplegia with pupillary abnormalities may also develop. Periorbital edema, ptosis, and chemosis can persist even after infection resolution, impacting the patient's quality of life. Endocrinologic complications may include panhypopituitarism due to ischemic injury or infectious extension to the pituitary gland. Intracranial hypertension is another concern, often necessitating medical or surgical management to prevent optic nerve damage. Infectious arteritis or mycotic aneurysm formation may further complicate the clinical course, potentially resulting in hemorrhagic events. Septic emboli may disseminate to the pulmonary vasculature, causing pneumonia, empyema, or pulmonary abscesses. Severe systemic infection can lead to sepsis and multi-organ dysfunction, which remain significant causes of mortality despite advanced therapy. Coma and death may still occur in cases of extensive thrombus propagation, delayed diagnosis, or multidrug-resistant infections. Overall, the potential complications of CST underscore the importance of early recognition, aggressive multidisciplinary management, and careful follow-up to mitigate long-term sequelae [23].

### Patient Education

Patient education is a cornerstone of preventing complications associated with cavernous sinus thrombosis. CST, while rare, is a life-threatening disorder that frequently arises secondary to facial infection, sinusitis, orbital cellulitis, pharyngitis, otitis media, trauma, or surgery, especially in patients with underlying thrombophilic disorders. Raising awareness among patients and caregivers regarding early warning signs—such as fever, headache, periorbital swelling, ocular pain, diplopia, and visual disturbances—can facilitate prompt medical evaluation and diagnosis, directly improving clinical outcomes. Patients who are well-informed are more likely to seek care early, reducing delays that may contribute to irreversible neurologic or ophthalmologic sequelae. Education strategies should be tailored to the patient's level of understanding. For patients with advanced health literacy, detailed explanations regarding pathophysiology, risk factors, and potential complications can be provided. For those with limited health literacy, simplified, clear, and visually supported instructions are essential to ensure comprehension. Patients should understand the importance of adhering to prescribed treatments, including antibiotics, anticoagulants, and follow-up evaluations. Counseling should also address potential adverse effects and the signs of disease progression or recurrence, emphasizing the urgency of returning for care if symptoms worsen. In addition to individual education, patients should be informed of their right to participate in decisions regarding investigations and interventions. Shared decision-making promotes adherence, patient satisfaction, and trust in the healthcare team. This approach involves discussing the benefits, limitations, and potential risks associated with imaging studies, surgical procedures, or therapeutic interventions. Preventive strategies, including prompt management of sinus or facial infections and avoidance of high-risk behaviors or medications that may increase thrombotic risk, should also be communicated. By ensuring that patients are knowledgeable and engaged, healthcare providers can reduce the risk of delayed diagnosis, enhance treatment adherence, and ultimately improve both short-term and long-term outcomes in patients with CST [23].

### Enhancing Healthcare Team Outcomes

Effective management of cavernous sinus thrombosis relies on a coordinated, interprofessional healthcare team capable of rapid assessment, early intervention, and sustained follow-up. Physicians and advanced practitioners must recognize the hallmark signs of CST, including fever, headache, periorbital edema, and ophthalmoplegia, and promptly initiate diagnostic imaging such as contrast-enhanced CT or MRI with venography. Emergency physicians and neurologists are pivotal in stabilizing patients, excluding alternative neurologic etiologies, and ensuring urgent supportive care. Infectious disease

specialists provide guidance on empiric and targeted antimicrobial therapy, tailoring regimens based on culture results, pathogen resistance patterns, and clinical response. Hematologists play a critical role in identifying and managing underlying thrombophilic disorders, guiding the initiation and duration of anticoagulation therapy. Ophthalmologists evaluate and monitor visual function, manage cranial nerve deficits, and intervene to prevent vision-threatening complications. Nurses are integral in ongoing patient assessment, monitoring for progression of ocular or neurologic symptoms, and educating patients and families on disease trajectory, warning signs, and treatment adherence. Pharmacists ensure appropriate dosing of antibiotics and anticoagulants, manage potential drug-drug interactions, and provide patient counseling to enhance compliance and reduce adverse effects. Interprofessional communication is essential, with daily rounds, structured handoffs, and shared documentation ensuring continuity of care. This approach minimizes delays in diagnosis and treatment, reduces preventable complications, and improves overall patient safety. Coordination across transitions of care—from emergency departments to inpatient units, intensive care settings, and eventual outpatient follow-up—ensures comprehensive management. By integrating expertise across disciplines, teams can optimize patient-centered care, mitigate long-term morbidity, and improve functional recovery. Ultimately, an interprofessional, collaborative approach enhances clinical outcomes, strengthens healthcare team performance, and reinforces the timely and effective management of this life-threatening condition [24].

#### Conclusion:

Cavernous sinus thrombosis continues to pose a major clinical challenge due to its rapid progression, complex anatomy, and potentially devastating neurologic and ophthalmologic consequences. Although modern diagnostics and therapeutics have significantly reduced mortality from historical rates as high as 80% to contemporary figures near 10–30%, CST remains associated with substantial long-term morbidity, including visual impairment and persistent cranial nerve deficits. Early recognition of hallmark symptoms—particularly fever, headache, periorbital edema, and ophthalmoplegia—is crucial to preventing irreversible complications. Effective management depends on rapid deployment of broad-spectrum intravenous antimicrobial therapy, judicious anticoagulation, and careful supportive care. Imaging with contrast-enhanced CT or MRI venography is essential to confirming diagnosis, identifying complications, and guiding treatment decisions. Surgical intervention, while not typically directed at the cavernous sinus itself, plays a vital role in eradicating primary infectious sources such as sinusitis, mastoiditis, or orbital abscesses when indicated. Ultimately, optimal outcomes rely on robust

interprofessional collaboration involving neurology, infectious disease, radiology, ophthalmology, otolaryngology, and critical care teams. Such multidisciplinary coordination ensures timely diagnosis, minimizes complications, and enhances long-term functional recovery. Continued emphasis on clinician awareness, patient education, and early intervention remains essential in improving prognosis and reducing the burden of this rare but serious condition.

#### References:

1. Matthew TJH, Hussein A. Atypical Cavernous Sinus Thrombosis: A Diagnosis Challenge and Dilemma. *Cureus*. 2018 Dec 04;10(12):e3685.
2. Eltayeb AS, Karrar MA, Elbeshir EI. Orbital Subperiosteal Abscess Associated with Mandibular Wisdom Tooth Infection: A Case Report. *J Maxillofac Oral Surg*. 2019 Mar;18(1):30-33.
3. Dolapsakis C, Kranidioti E, Katsila S, Samarkos M. Cavernous sinus thrombosis due to ipsilateral sphenoid sinusitis. *BMJ Case Rep*. 2019 Jan 29;12(1)
4. Chen MC, Ho YH, Chong PN, Chen JH. A rare case of septic cavernous sinus thrombosis as a complication of sphenoid sinusitis. *Tzu Chi Med J*. 2019 Jan-Mar;31(1):63-65.
5. Kasha S, Bandari G. Bilateral Posterior Fracture-Dislocation of Shoulder Following Seizures Secondary to Cavernous Sinus Venous Thrombosis - A Rare Association. *J Orthop Case Rep*. 2018 Jul-Aug;8(4):49-52.
6. DiNubile MJ. Septic thrombosis of the cavernous sinuses. *Arch Neurol*. 1988 May;45(5):567-72.
7. Dinkin M, Patsalides A, Ertel M. Diagnosis and Management of Cerebral Venous Diseases in Neuro-Ophthalmology: Ongoing Controversies. *Asia Pac J Ophthalmol (Phila)*. 2019 Jan-Feb;8(1):73-85.
8. Torretta S, Guastella C, Marchisio P, Marom T, Bosis S, Ibba T, Drago L, Pignataro L. Sinonasal-Related Orbital Infections in Children: A Clinical and Therapeutic Overview. *J Clin Med*. 2019 Jan 16;8(1)
9. Darmawan G, Hamijoyo L, Oehadian A, Bandiara R, Amalia L. Cerebral Venous Sinus Thrombosis in Systemic Lupus Erythematosus. *Acta Med Indones*. 2018 Oct;50(4):343-345.
10. Mulvey CL, Kiell EP, Rizzi MD, Buzi A. The Microbiology of Complicated Acute Sinusitis among Pediatric Patients: A Case Series. *Otolaryngol Head Neck Surg*. 2019 Apr;160(4):712-719.
11. Housley SB, McPheeters MJ, Raygor KP, Bouslama M, Scullen T, Davies JM. Cavernous Sinus Thrombosis. *Neurosurg Clin N Am*. 2024 Jul;35(3):305-310.
12. Weerasinghe D, Lueck CJ. Septic Cavernous Sinus Thrombosis: Case Report and Review of the

- Literature. *Neuroophthalmology*. 2016 Dec;40(6):263-276.
13. Neal TW, Schlieve T. Complications of Severe Odontogenic Infections: A Review. *Biology (Basel)*. 2022 Dec 08;11(12)
  14. Alam MS, Backiavathy V, Noronha V, Mukherjee B. Orbital abscess: 20 years' experience at a tertiary eye care center. *Orbit*. 2022 Dec;41(6):751-758.
  15. Berge J, Louail C, Caillé JM. Cavernous sinus thrombosis diagnostic approach. *J Neuroradiol*. 1994 Apr;21(2):101-17.
  16. Branson SV, McClintic E, Yeatts RP. Septic Cavernous Sinus Thrombosis Associated With Orbital Cellulitis: A Report of 6 Cases and Review of Literature. *Ophthalmic Plast Reconstr Surg*. 2019 May/Jun;35(3):272-280.
  17. Deliran SS, Sondag L, Leijten QH, Tuladhar AM, Meijer FJA. [Headache: consider cavernous sinus thrombophlebitis]. *Ned Tijdschr Geneeskd*. 2018 Aug 16;162
  18. Fujikawa T, Sogabe Y. Septic cavernous sinus thrombosis: potentially fatal conjunctival hyperemia. *Intensive Care Med*. 2019 May;45(5):692-693.
  19. van der Poel NA, de Witt KD, van den Berg R, de Win MM, Mourits MP. Impact of superior ophthalmic vein thrombosis: a case series and literature review. *Orbit*. 2019 Jun;38(3):226-232.
  20. Leach JL, Fortuna RB, Jones BV, Gaskill-Shipley MF. Imaging of cerebral venous thrombosis: current techniques, spectrum of findings, and diagnostic pitfalls. *Radiographics*. 2006 Oct;26 Suppl 1:S19-41; discussion S42-3.
  21. Akarapas C, Wiwatkunupakarn N, Sithirungson S, Chaiyasate S. Anticoagulation for cavernous sinus thrombosis: a systematic review and individual patient data meta-analysis. *Eur Arch Otorhinolaryngol*. 2025 Mar;282(3):1127-1134.
  22. Wang YH, Chen PY, Ting PJ, Huang FL. A review of eight cases of cavernous sinus thrombosis secondary to sphenoid sinusitis, including a 12-year-old girl at the present department. *Infect Dis (Lond)*. 2017 Sep;49(9):641-646.
  23. Frank GS, Smith JM, Davies BW, Mirsky DM, Hink EM, Durairaj VD. Ophthalmic manifestations and outcomes after cavernous sinus thrombosis in children. *J AAPOS*. 2015 Aug;19(4):358-62.
- Caranfa JT, Yoon MK. Septic cavernous sinus thrombosis: A review. *Surv Ophthalmol*. 2021 Nov-Dec;66(6):1021-1030.