Complications of Rhinosinusitis

Synopsis of Critical Sequelae

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Grand Rounds Presentation
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Outline

- Anatomy
- Rhinosinusitis
  - Acute
  - Chronic
- Complications
  - Orbital
  - Intracranial
  - Bony
- Conclusion
Anatomy
Maxillary Sinus

- Largest and first sinus to develop
  - At 3 months gestation
  - Volume 6-8cm³ at birth
  - Volume 15cm³ by adulthood
- Biphasic periods of rapid growth
  - First 3 years and between 7-18 years
  - Coincides with dental development
- Natural ostium drains into ethmoidal
  - Accessory ostia in 15-40%
  - Haller cell can impair drainage

Notes: The anterior wall forms the facial surface of the maxilla, the posterior wall borders the infratemporal fossa, the medial wall constitutes the lateral wall of the nasal cavity, the floor of the sinus is the alveolar process, and the superior wall serves as the orbital floor.
Anatomy

Maxillary Sinus

- Innervation via V₂ distribution
  - Infraorbital nerve
  - Dehiscent intraorbital canal in 14%
- Vasculature
  - Maxillary artery and vein
  - Facial artery
- First and second molar roots dehiscent in 2%

NOTES: Haller cell is an ethmoidal cell that pneumatizes between maxillary sinus and orbital floor.
Anatomy
Ethmoid Sinus

- First seen at 5 months gestation
  - Five ethmoid turbinals
    - Agger nasi
    - Uncinate
    - Ethmoid bulla
    - Ground/basal lamella
    - Posterior wall of most posterior ethmoid cell
  - Between 3-4 cells at birth
- Adult size by 12-15 years
  - Between 10-15 cells
  - Volume 2-3cm³ by adulthood

NOTES: The lateral portions form the medial walls of the orbits, the sphenoid establishes the posterior face, the superior surface is formed by the skull base of the anterior cranial fossa, and many of the key structures of the lateral nasal wall, derived from basal lamellas, extend posteroinferiorly from the skull base. The lateral wall of the ethmoid sinus, or lamina papyracea, forms the paper-thin medial wall of the orbit. The midline vertical plate of the ethmoid bone is composed of a superior portion in the anterior cranial fossa called the crista galli and an inferior portion in the nasal cavity called the perpendicular plate of the ethmoid bone that contributes to the nasal septum. The anterior cranial fossa is separated from the ethmoid air cells superiorly by the horizontal plate of the ethmoid bone, which is composed of the thin medial cribiform plate and the thicker, more lateral ethmoid roof. The ethmoid roof articulates with the cribiform plate at the lateral lamella of the cribiform plate, which is the thinnest bone in the entire skull base.

The ethmoid sinuses are separated by a series of recesses demarcated by five bony partitions or lamellae. These lamellae are named from the most anterior to posterior: first (uncinate process), second (bulla ethmoidalis), third (ground or basal lamella), fourth (superior turbinate), and fifth (supreme turbinate).
Anatomy
Ethmoid Sinus

- **Drainage**
  - Anterior cells via ethmoid infundibulum
  - Posterior cells via sphenoid ethmoid recess

- **Innervation via V₁ distribution**
  - Branches from nasociliary nerve
  - Anterior and posterior ethmoids

- **Vasculature**
  - Ophthalmic artery
  - Maxillary and ethmoid veins

Posterior cells drain into superior meatus
Ophthalmic artery provides anterior and posterior ethmoidal arteries
Cavernous sinus gives off maxillary and ethmoidal veins
Anatomy

Frontal Sinus

- Not present at birth
  - Starts developing at 4 years
  - Radiographically visualized at 5-6 years
- Development not complete until 12-20 years
  - Volume 4-7cm³ by adulthood
  - No or poor pneumatization in 5-10%
- Drainage via frontal recess
  - Anterior: posterior agger nasi
  - Lateral: lamina papyracea
  - Medial: middle turbinate

NOTES: The anterior table of the frontal sinus is twice as thick as the posterior table, which separates the sinus from the anterior cranial fossa. The floor of the sinus also functions as the supraorbital roof, and the drainage ostium is located in the posteromedial portion of the sinus floor.

A markedly pneumatized agger nasi cell or ethmoidal bulla can obstruct frontal sinus drainage by narrowing the frontal recess. Drainage of the frontal sinus also depends on the attachment of the superior portion of the uncinate process.
Anatomy
Frontal Cell Types

- Type 1: single cell superior to agger nasi
- Type 2: ≥ 2 cells superior to agger nasi
- Type 3: single cell from agger nasi into sinus
- Type 4: isolated cell within sinus

NOTES: Type 3 cell attaches to anterior table.

Sold arrow – Frontal cell type
Dashed arrow – Agger nasi cell

Anatomy
Frontal Sinus

- **Vasculature**
  - Supraorbital artery and vein
  - Supratrochlear artery
  - Ophthalmic vein
  - Foramina of Breschet

- **Innervation via V₁ distribution**
  - Supraorbital
  - Supratrochlear

**NOTES:** Foramina of Breschet: small venules that drain the sinus mucosa into the dural veins.
Anatomy
Sphenoid Sinus

- Evagination of nasal mucosa into sphenoid bone
- First seen at 4 months gestation
- Pneumatization begins in middle childhood
  - Minimal volume at birth
  - Volume 0.5-8cm$^3$ by adult
- Reaches adult size by 12-18 years
  - Sellar type (86%)
  - Presellar (11%)
  - Conchal (3%)

NOTES: Approximately 25% of bony capsules separating the internal carotid artery from the sphenoid sinus are partially dehiscent. An optic nerve prominence is present in 40% of individuals with dehiscence in 6%.
In most cases, the posteroinferior end of the superior turbinate was located in the same horizontal plane as the floor of the sphenoid sinus. The ostium was located medial to the superior turbinate in 83% of cases and lateral to it in 17%.
Anatomy

Sphenoid Sinus

- Innervation via sphenopalatine nerve
  - V2 distribution
  - Parasympathetics
- Vasculature via maxillary artery and vein
  - Sphenopalatine artery
  - Pterygoid plexus
Acute Rhinosinusitis (ARS)

- Inflammation of the nasal mucosa and lining of the paranasal sinuses
  - Obstruction of sinus ostia
  - Impaired ciliary transport
- Viral etiology in majority of cases
  - Superimposed bacterial infection in 0.5-2%
  - Symptoms for at least 7-10 days or worsening after 5-7 days
- Symptoms present for ≤ 4 weeks
- “Recurrent ARS” with ≥ 4 episodes, lasting ≥ 7-10 days

NOTES: Most viral upper respiratory tract infections are caused by rhinovirus, but coronavirus, influenza A and B, parainfluenza, respiratory syncytial virus, adenovirus, and enterovirus are also causative agents.
Acute Rhinosinusitis (ARS)

- **Major symptoms**
  - Facial pain/pressure
  - Facial congestion/fullness
  - Nasal obstruction
  - Nasal discharge/purulence
  - Hyposmia/anosmia
  - Purulence on exam
  - Fever (ARS only)
  - Dental pain
  - Cough
  - Ear pain/pressure/fullness

- **Minor symptoms**
  - Headache
  - Fever (non-ARS)
  - Halitosis
  - Fatigue
  - Dental pain
  - Cough
  - Ear pain/pressure/fullness

- **Diagnosis with two major or one major and two minor factors**
# Acute Rhinosinusitis (ARS)

**Microbiology**

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<thead>
<tr>
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<th>Adults</th>
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<tr>
<td><em>Streptococcus pneumoniae</em> (30-43%)</td>
<td><em>Streptococcus pneumoniae</em> (20-45%)</td>
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<td><em>Haemophilus influenzae</em> (20-28%)</td>
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Chronic Rhinosinusitis (CRS)

- Symptoms present for >12 consecutive weeks
- “Subacute” for symptoms between 4-12 weeks
- Chronic inflammation
  - Bacterial, fungal, and viral
  - Allergic and immunologic
  - Anatomic
  - Genetic predisposition
- No clear consensus on pathophysiology

NOTES: One of the major problems with identifying the pathogenesis of CRS is that neither symptoms, findings, nor radiographs, taken independently, are sufficient basis for the diagnosis. One study showed that current symptom-based criteria had only a 47% correlation with a positive CT scan result.

### Chronic Rhinosinusitis (CRS)
#### Microbiology

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Complications of Sinusitis

- Incidence has decreased with antibiotic use
- Three main categories
  - Orbital (60-75%)
  - Intracranial (15-20%)
  - Bony (5-10%)
- Radiography
  - Computed tomography (CT) best for orbit
  - Magnetic resonance imaging (MRI) best for intracranium

Siedek et al, 2010
Complications of Sinusitis

Orbital

- Most commonly involved complication site
  - Proximity to ethmoid sinuses
  - Periorbita/orbital septum is the only soft-tissue barrier
  - Valveless superior and inferior ophthalmic veins

- Continuum of inflammatory/infectious changes
  - Direct extension through lamina papyracea
  - Impaired venous drainage from thrombophlebitis
  - Progression within 2 days

- Children more susceptible
  - < 7 years – isolated orbital (subperiosteal abscess)
  - ≥ 7 years – orbital and intracranial complications

NOTES:
-- close proximity of the orbit to the paranasal sinuses, particularly the ethmoids, make it the most commonly involved structure in sinusitis complications; rarely from frontal or maxillary sinuses
-- pediatric population difference likely related to age-related sinus development
  * pain and deterioration is not necessarily always present
  * increase in WBC only found in 50%
Orbital Complications

Microbiology

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Staphylococcus epidermidis
Orbital Complications

Chandler Criteria

- Five classifications
  - Preseptal cellulitis
  - Orbital cellulitis
  - Subperiosteal abscess
  - Orbital abscess
  - Cavernous sinus thrombosis

- Not exclusive, can occur concurrently

Orbital Complications

Preseptal Cellulitis

- Symptomatology
  - Eyelid edema and erythema
  - Extraocular movement intact
  - Normal vision
  - May have eyelid abscess

- CT reveals diffuse thickening of lid and conjunctiva

Orbital Complications

Preseptal Cellulitis

- Medical therapy typically sufficient
  - Intravenous antibiotics
  - Head of bed elevation
  - Warm compresses

- Facilitate sinus drainage
  - Nasal decongestants
  - Mucolytics
  - Saline irrigations

Ramadan et al, 2009
Orbital Complications

Orbital Cellulitis

- Symptomatology
  - Post-septal infection
  - Eyelid edema and erythema
  - Proptosis and chemosis
  - Limited or no extraocular movement limitation
  - No visual impairment
  - No discrete abscess

- Low-attenuation adjacent to lamina papyracea on CT

NOTES: Patients may complain of pain and diplopia and a history of recent orbital trauma or dental surgery.
Orbital Complications
Orbital Cellulitis

- Facilitate sinus drainage
  - Nasal decongestants
  - Mucolytics
  - Saline irrigations

- Medical therapy typically sufficient
  - Intravenous antibiotics
  - Head of bed elevation
  - Warm compresses

- May need surgical drainage
  - Visual acuity 20/60 or worse
  - No improvement or progression within 48 hours
Orbital Complications

Subperiosteal Abscess

- Symptomatology
  - Pus formation between periorbita and lamina papyracea
  - Displace orbital contents downward and laterally
  - Proptosis, chemosis, ophthalmoplegia
  - Risk for residual visual sequelae
  - May rupture through septum and present in eyelids

- Rim-enhancing hypodensity with mass effect
  - Adjacent to lamina papyracea
  - Superior location with sinusitis etiology
  - Diagnostically accurate 91%

NOTES: Patients will complain of diplopia, ophthalmoplegia, exophthalmos, or reduced visual acuity. The patient has limited ocular motility or pain on globe movement toward the abscess.; may have normal movement early on. Orbital signs include proptosis, chemosis, and visual impairment.
Orbital Complications

Subperiosteal Abscess

- **Surgical drainage**
  - Worsening visual acuity or extraocular movement
  - Lack of improvement after 48 hours

- **May be treated medically in 50-67%**
  - Meta-analysis cure rate 26-93% (Coenraad 2009)
  - Combined treatment 95-100%
Orbital Complications

Subperiosteal Abscess

- Open ethmoids and remove lamina papyracea

**Approaches**
- External ethmoidectomy (Lynch incision) is most preferred
- Endoscopic ideal for medial abscesses
- Transcaruncular approach
  - Transconjunctival incision
  - Extend medially around lacrimal caruncle

Orbital Complications

Orbital Abscess

■ Symptomatology
  ○ Pus formation within orbital tissues
  ○ Severe exophthalmos and chemosis
  ○ Ophthalmoplegia
  ○ Visual impairment
  ○ Risk for irreversible blindness
  ○ Can spontaneously drain through eyelid

■ Drain abscess and sinuses
Orbital Complications

Orbital Abscess

- Incise periorbita and drain intraconal abscess
- Similar approaches as with subperiosteal abscess
  - Lynch incision
  - Endoscopic

NOTES: Transcaruncular approach allegedly does not utilize a facial incision.
Orbital Complications
Cavernous Sinus Thrombosis

- Symptomatology
  - Orbital pain
  - Proptosis and chemosis
  - Ophthalmoplegia
  - Symptoms in contralateral eye
  - Associated with sepsis and meningismus

- Radiology
  - Poor venous enhancement on CT
  - Better visualized on MRI

**Contralateral involvement** is distinguishing feature of cavernous sinus thrombosis

MRI findings of heterogeneity and increased size suggest the diagnosis
Orbital Complications

Cavernous Sinus Thrombosis

- Mortality rate up to 30%
- Surgical drainage
- Intravenous antibiotics
  - High-dose
  - Cross blood-brain barrier
- Anticoagulant use is controversial
  - Prevent thrombus propagation
  - Risk intracranial or intraorbital bleeding


MRI better especially if suspecting intracranial involvement, too.
Cavernous Sinus Thrombosis

Anticoagulation

**Beneficial**
- Southwick *et al* (1986)
  - Reduction in mortality
  - Not recommended for other dural sinus thrombosis
  - No change in mortality
  - Mortality reduction with added early
  - PTT ratio 1.5-2.5
  - INR 2-3
  - Anticoagulate for 3 months

**Harmful**
  - Fatal hemorrhagic cerebral infarction
  - Subarachnoid hemorrhage reversed with protamine

NOTES: 1980s were retrospective reviews
Bhatia was a literature review
Complications of Sinusitis

Intracranial

- Occurs more commonly in CRS
  - Mucosal scarring, polypoid changes
  - Hidden infectious foci with poor antibiotic penetration
- Male teenagers affected more than children
- Direct extension
  - Sinus wall erosion
  - Traumatic fracture lines
  - Neurovascular foramina (optic and olfactory nerves)
- Hematogenous spread
  - Diploic skull veins
  - Ethmoid bone

NOTES: Teenagers affected more because of developed frontal and sphenoid sinuses, and because they are more prone to URI’s than adults.

Thrombophlebitis originating in the mucosal veins progressively involves the emissary veins of the skull, the dural venous sinuses, the subdural veins, and, finally, the cerebral veins. By this mode, the subdural space may be selectively infected without contamination of the intermediary structure; a subdural empyema can exist without evidence of extradural infection or osteomyelitis.
Intracranial Complications

Types

- Five types (not exclusive)
  - Meningitis
  - Epidural abscess
  - Subdural abscess
  - Intracerebral abscess
  - Cavernous sinus, venous sinus thrombosis

- Common signs and symptoms
  - Fever (92%)
  - Headache (85%)
  - Nausea, vomiting (62%)
  - Altered consciousness (31%)
  - Seizure (31%)
  - Hemiparesis (23%)
  - Visual disturbance (23%)
  - Meningismus (23%)

NOTES: Not exclusive, can occur concurrently. Percentages in children (Hicks et al, 2011)
**Intracranial Complications**

**Meningitis**

- Most common intracranial complication of sinusitis
- Symptomatology
  - Headache
  - Meningismus
  - Fever, septic
  - Cranial nerve palsies
- Sinusitis is unusual cause of meningitis
  - Sphenoiditis
  - Ethmoiditis
- Usually amenable with medical treatment
- Drain sinuses if no improvement after 48 hours
- Hearing loss and seizure sequelae

*NOTES: Also incidence of neurologic sequelae such as hearing loss and seizure disorder.*
## Meningitis Microbiology

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<td><em>Fusobacterium</em> species)</td>
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<td>Gram-negative rods</td>
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Intracranial Complications

Epidural Abscess

- Second-most common intracranial complication
- Generally a complication of frontal sinusitis
- Symptomatology
  - Fever (>50%)
  - Headache (50-73%)
  - Nausea, vomiting
  - Papilledema
  - Hemiparesis
  - Seizure (4-63%)
- Crescent-shaped hypodensity on CT

Intracranial Complications
Epidural Abscess

- Lumbar puncture contraindicated
- Prophylactic seizure therapy not necessary
- Antibiotics
  - Good intracerebral penetration
  - Typically for 4-8 weeks
- Drain sinuses and abscess
  - Frontal sinus trephination
  - Frontal sinus cranialization
  - Stereotactic-guided drainage

NOTES: Will likely need antibiotics for 4-8 weeks; usually vancomycin and 3rd or 4th generation cephalosporin
Prophylactic seizure therapy not necessary unless there’s an associated subdural abscess.
Intracranial Complications

Subdural Abscess

- Generally from frontal or ethmoid sinusitis
- Symptomatology
  - Headaches
  - Fever
  - Nausea, vomiting
  - Hemiparesis
  - Lethargy, coma
- Third-most common intracranial complication, rapid deterioration
  - Mortality in 25-35%
  - Residual neurologic sequelae in 35-55%
- Accompanies 10% of epidural abscesses
Intracranial Complications
Subdural Abscess

- Lumbar puncture potentially fatal
- Aggressive medical therapy
  - Antibiotics
  - Anticonvulsants
  - Hyperventilation, mannitol
  - Steroids
- Drain sinuses and abscess
  - Medical therapy possible if < 1.5cm
  - Craniotomy or stereotactic burr hole
  - Endoscopic or external sinus drainage

NOTES:
Need antibiotics with good intracerebral penetration, typically 3-6 weeks
Craniotomy is favored over burr hole placement due to better exposure
Intracranial Complications

Intracerebral Abscess

- Uncommon, frontal and frontoparietal lobes
- Generally from frontal sinusitis
  - Sphenoid
  - Ethmoids

Symptomatology
- Headache (70%)
- Mental status change (65%)
- Focal neurological deficit (65%)
- Fever (50%)
- Nausea, vomiting (40%)
- Seizure (25-35%)
- Meningismus (25%)
- Papilledema (25%)

Mortality 20-30%
Neurologic sequelae 60%

NOTES: May have mood swings and behavioral changes with frontal lobe involvement
Worsening headache with meningismus suggests possible rupture of the abscess.
Intracranial Complications

Intracerebral Abscess

- Lumbar puncture potentially fatal
- Aggressive medical therapy
  - Antibiotics
  - Anticonvulsants
  - Hyperventilation, mannitol
  - Steroids
- Drain sinuses and abscess
  - Medical therapy possible if abscess < 2.5cm
  - Excision or aspiration
    - Diagnostic aspiration if < 2.5cm or cerebritis
    - Stereotactic-guided aspiration
  - Endoscopic or external sinus drainage

NOTES: Antibiotic regimen is typically 6-8 weeks; typically ceftriaxone, vancomycin or nafcillin, and metronidazole

Corticosteroid use is controversial. Steroids can retard the encapsulation process, increase necrosis, reduce antibiotic penetration into the abscess, increase the risk of ventricular rupture, and alter the appearance on CT scans. Steroid therapy can also produce a rebound effect when discontinued. If used to reduce cerebral edema, therapy should be of short duration. The appropriate dosage, the proper timing, and any effect of steroid therapy on the course of the disease are unknown. The procedures used are aspiration through a bur hole and complete excision after craniotomy. Aspiration is the most common procedure and is often performed using a stereotactic procedure with the guidance of CT scanning or MRI.
### Intracranial Abscesses

#### Microbiology

<table>
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**NOTES:** Incidence of anaerobes in suppurative intracranial complications range from 60-100%
Intracranial Complications

Venous Sinus Thrombosis

- Sagittal sinus most common
- Retrograde thrombophlebitis from frontal sinusitis
- Extremely ill
  - Subdural abscess
  - Epidural abscess
  - Intracerebral abscess
- Decreased cavernous carotid artery flow void on MRI
- Elevated mortality rate
Intracranial Complications

Venous Sinus Thrombosis

- **Aggressive medical therapy**
  - Antibiotics
  - Steroids
  - Anticonvulsants

- **Anticoagulation controversial**
  - Heparin inpatient, warfarin outpatient
  - Thrombus resolution by 6 weeks (Gallagher 1998)
  - Increased intracranial pressure outweighs bleeding risk (Gallagher 1998)

- **Drain sinuses**
  - External
  - Endoscopic
Complications of Sinusitis

Bony

- Pott’s puffy tumor
  - Frontal sinusitis with acute osteomyelitis
  - Subperiosteal pus collection leads to “puffy” fluctuance
- Rare complication
  - Only 20-25 cases reported in post-antibiotic era (Raja 2007)
  - Less than 50 pediatric cases in past 10 years (Blumfield 2010)
- Symptomatology
  - Headache
  - Fever
  - Neurologic findings
  - Periorbital or frontal swelling
  - Nasal congestion, rhinorrhea

NOTES: Sir Percivall Pott described Pott’s Puffy tumor in 1768 as a local subperiosteal abscess due to frontal bone suppuration resulting from trauma. Pott reported another case due to frontal sinusitis.
Complications of Sinusitis

Bony

- Associated with other abscesses in 60%
  - Pericranial
  - Periorbital
  - Epidural
  - Subdural
  - Intracranial
- Cortical vein thrombosis
- Frontocutaneous fistula

**NOTES:** Sir Percivall Pott described Pott’s Puffy tumor in 1768 as a local subperiosteal abscess due to frontal bone suppuration resulting from trauma. Pott reported another case due to frontal sinusitis.
## Pott’s Puffy Tumor

### Microbiology

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Complications of Sinusitis

Bony

- Cooperative effort
  - Otolaryngology
  - Neurosurgery
  - Infectious disease

- Surgical and medical therapy
  - Drain abscess and remove infected bone
  - Intravenous antibiotics for six weeks
  - May obliterate frontal sinus to prevent recurrence
Conclusions

- Complications are less common with antibiotics
  - Orbital
  - Intracranial
  - Bony
- Can result in drastic sequelae
- Drain abscess and open involved sinuses
- Surgical involvement
  - Ophthalmology
  - Neurosurgery
References


Blumfield E, Misra M. Pott's puffy tumor, intracranial, and orbital complications as the initial presentation of sinusitis in healthy adolescents, a case series. Emerg Radiol 2011 Mar 5 [Epub ahead of print].


References


