3 Management of Maxillofacial Infections

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Odontogenic Infections

- Treatment of odontogenic infections is based on medical management, surgical treatment, and antibiotic therapy.
- Odontogenic infections are polymicrobial in nature and are normally composed of more anaerobic bacteria.
- Results from:
  - Dental caries
  - Dentoalveolar infections (infections of the pulp and periapical abscesses)
  - Gingivitis
  - Periodontitis
  - Perimplantitis
  - Pericoronitis

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- Factors that determine the spread include thickness of the cortical plate and the relationship of the adjacent muscle attachment with the apices of the offending teeth.
- Infections spread via hydrostatic pressure along the path of least resistance. These paths tend to be composed of loose connective areolar tissue that is enclosed by fascial layers.
- The cervical fascia is a fibrous connective tissue that envelops and divides the muscles of the neck and creates potential spaces.
- There is a synergistic interdependence between aerobic and anaerobic bacteria thought to be necessary for the development of an abscess.
- Respiration of aerobic bacteria -> depletes the local environment of oxygen -> creates an oxygen-poor and nutrient-rich habitat -> anaerobic bacteria growth increases -> anaerobes proliferate and secrete toxins and enzymes which results in tissue destruction.

Path of Third Molar Infection to Mediastinum

- Periapical abscess erodes through thinnest cortical plate (lingual) into the submandibular space.
- As the submandibular space is filled, the infection travels through the buccopharyngeal gap between the middle and superior pharyngeal constrictors to the lateral pharyngeal space.

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A direct connection to the lateral pharyngeal space is via spread directly around the posterior belly of the digastric muscle.
- There is no barrier between lateral pharyngeal space and retropharyngeal space.
- Retropharyngeal space fuses with alar fascia between C6 and T4 (Figs. 3.1 and 3.2).
- The infection normally enters danger space at the fusion of alar and prevertebral fascia.
- Danger space is continuous with posterior mediastinum.

Principles of Management of Odontogenic Infections

- Determine severity: anatomic location, rate of progression, and airway compromise.
- Evaluate host factors: evaluate immunocompetence and systemic reserve of the patient.
- Decide on setting: inpatient criteria – fever, dehydration, need for general anesthesia, deep space infection, or control of systemic disease.
- Treat surgically.
- Support medically.
- Choose and administer the appropriate antibiotic.

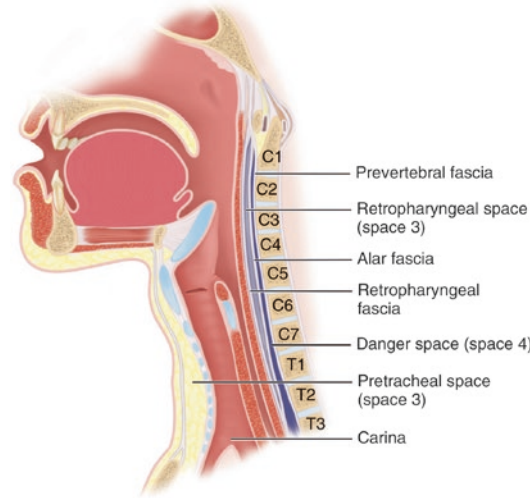

Fig. 3.2 Sagittal section of the neck demonstrating fascial spaces and danger spaces. (Reprinted with permission from Flynn [1])

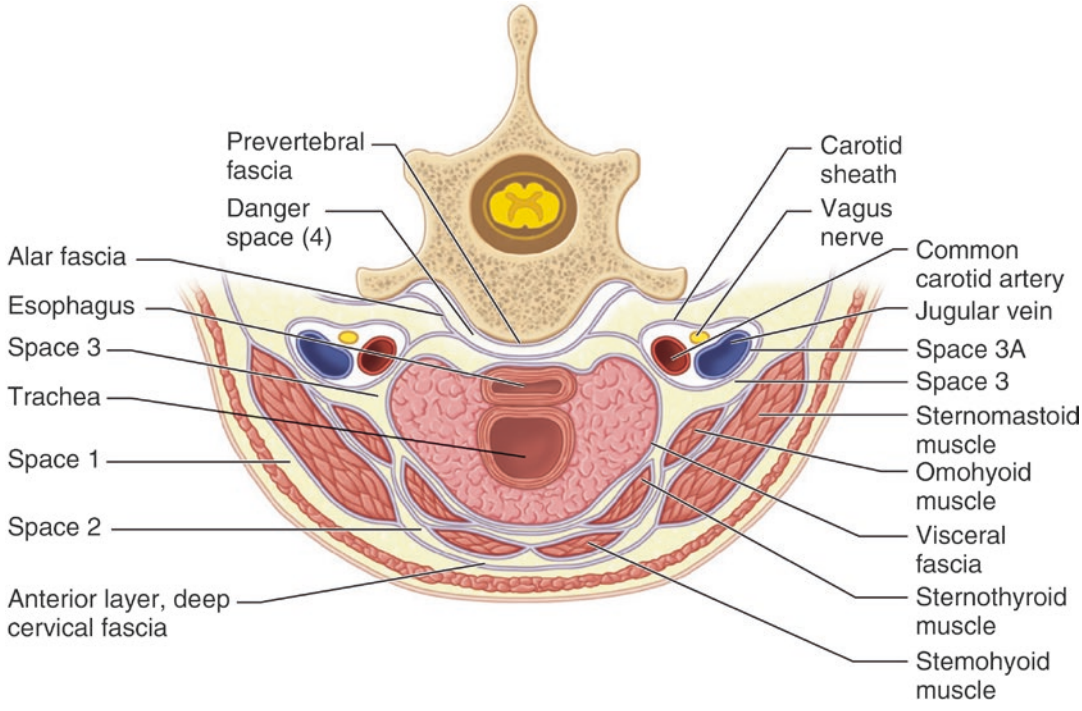

Fig. 3.1 Axial view demonstrating the fascial cervical spaces at the level of the sixth cervical vertebrae. (Reprinted with permission from Flynn [1])

Table 3.1 Characteristics of cellulitis vs. abscess [2]

Cellulitis vs. abscess		
	Cellulitis	Abscess
Duration	3–5 days	5–7 days
Palpation	Hard and very tender	Fluctuant and tender
Skin quality	Thick	Thin, shiny
Bacteria	Mixed	Anaerobic
Tissue fluid	Serosanguineous	Purulent
Size	Diffuse	Localizing

- Evaluate the patient frequently.
- Odontogenic infections pass through three stages: inoculation, cellulitis, and abscess (Table 3.1).
- Cellulitis is more severe than abscess as cellulitis continues to spread.
- Abscess formation is the beginning of localization.

Primary Fascial Spaces (See Table 3.2)
Primary fascial spaces are those that are directly adjacent to the origin of odontogenic infections. Infection spread by direct invasion from the source. These spaces include the following:

- Buccal
- Submandibular
- Canine
- Submental
- Vestibular
- Sublingual

Secondary Fascial Spaces (See Table 3.2)
Secondary Fascial space infections are those that become involved via spread of infection from the primary fascial spaces. These spaces include the following:

- Pterygomandibular
- Infratemporal
- Masseteric
- Masticator (see Fig. 3.3)
- Lateral pharyngeal (see Fig. 3.4)
- Retropharyngeal (see Fig. 3.5)
- Prevertebral

Workup for the Odontogenic Infection Patient

History of Present Illness

- Need to determine onset, duration, symptoms of infection, and any antibiotics previously prescribed.
- NPO (Nil Per Os (nothing by mouth)) status.
- Assessment of concerning signs:
  - Dysphagia – difficulty swallowing
  - Dysphonia – difficulty speaking
  - Dyspnea – difficulty breathing
  - Odynophagia – pain on swallowing
  - Mental status changes
  - Trismus
  - Fevers/chills

Past Medical History

- Important to assess if there are any disease processes that render the patient immunocompromised—e.g., HIV, DM, hepatitis, alcoholism, malignancy, chemotherapy, malnutrition, patients on steroids, or immunosuppressants
- IV drug users have a higher incidence of MRSA infection

Physical Exam

- *Vital Signs*
  - Temperature – elevated temperatures can be indicative of serious infection with systemic involvement. Normal oral adult temperature is on average 98.6 °F/37 °C. Rectal temperature tends to be 1 °F higher and axillary is 1–3 °F lower.
  - Heart rate – tachycardia can be indicative of systemic involvement. Each degree increase in °F tends to correlate with an increase of 10 BPM of heart rate.
  - Respiratory rate (normal 12–20 breaths/min) – elevated rate could suggest respiratory compromise or acid-base imbalance suggestive of SIRS.
  - Blood pressure – hypertension can be present secondary to pain. Hypotension can be seen in septic patients.

Table 3.2 Borders of the deep fascial spaces of the head and neck

Space	Anterior	Posterior	Superior	Inferior	Superficial or Medial*	Deep or Lateral*
Buccal	Corner of mouth	Masseter muscle Pterygomandibular space	Maxilla Infraorbital space	Mandible	Subcutaneous tissue and skin	Buccinator muscle
Infraorbital	Nasal cartilages	Buccal space	Quauratus labii superioris muscle	Oral mucosa	Quadratuc labii superiors muscle	Levator anguli oris muscle Maxilla
Submandibular	Anterior belly digastric muscle	Posterior belly digastric muscle Stylohyoid muscle Stylopharyngeus muscle	Inferior and medial surfaces of mandible	Digastric tendon	Platysma muscle Investing fascia	Mylohyoid muscle Hyoglossus muscle Superior constrictor muscles
Submental	Inferior border of mandible	Hyoid bone	Mylohyoid muscle	Investing fascia	Investing fascia	Anterior bellies of digastric muscles*
Sublingual	Lingual surface of mandible	Submandibular space	Oral mucosa	Mylohyoid muscle	Muscles of tongue*	Lingual surface of mandible*
Pterygomandibular	Buccal space	Parotid gland	Lateral pterygoid muscle	Inferior border of mandible	Medial pterygoid muscle*	Ascending ramus of mandible*
Submasseteric	Bucall space	Parotid gland	Zygomatic arch	Inferior border of mandible	Ascending ramus of mandible*	Masseter muuscle*
Lateral pharyngeal	Superior and middle pharyngeal constrictor muscles	Caroid sheath and scalene fascia	Skull base	Hyoid bone	Pharyngeal constrictors and retropharyngeal Space*	Medial pterygoid muscle*
Retropharyngeal	Superior and middle pharyngeal constrictor muscles	Alar fascia	Skull base	Fusion of alar and prevertebral fasciae at C6-T4		Carotid sheath and lateral pharyngeal space*
Pretracheal	Sternothyroid-thyrohyoid fascia	Retropharyngeal space	Thyroid cartilage	Superior mediastinum	Sternothyroid-thyrohyoid fascia	Visceral fascia over trachea and thyroid gland

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*Medial border

*Lateral border

  - Oxygen saturation – patients unable to maintain an oxygen saturation greater than 96 on room air may have airway compromise (if no underlying pulmonary disease).
- *Inspection (global view of the patient)*
  - Look for facial/cervical swelling and asymmetry.
  - Assess whether or not the patient has a toxic appearance such as pallor, sweat, (diaphoretic), shivering, lethargy, etc.
  - Assess whether the patient can tolerate their secretions (concern for airway swelling). Are they sitting in a tripod position to allow collection of saliva, open a constricted airway, and prevent dirtying clothes?

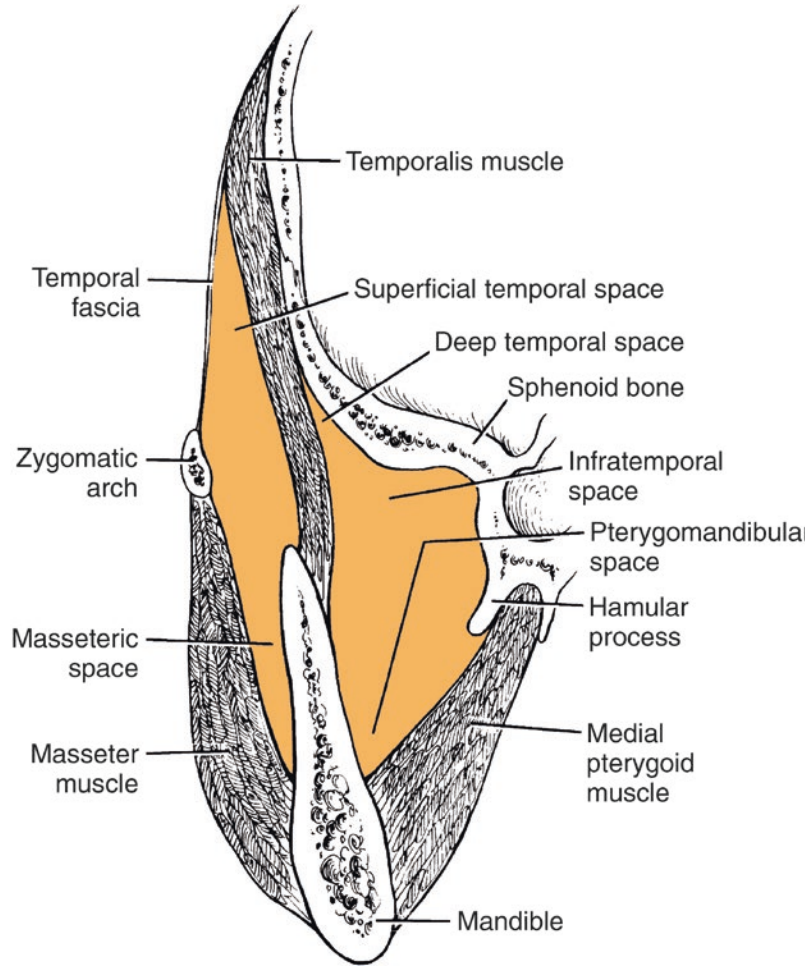

Fig. 3.3 The masticator space is made up of the temporal space, pterygomandibular space, and masseteric space. The pterygomandibular space lies between the medial aspect of the mandible and the medial pterygoid muscle. The masseteric space lies between the lateral body of the mandible and the masseter muscle. The temporal space is posterior and superior to the masseteric space and pterygomandibular space. It is bound by the temporalis fascia laterally and the skull medially. (Reprinted with permission from Flint et al. [4])

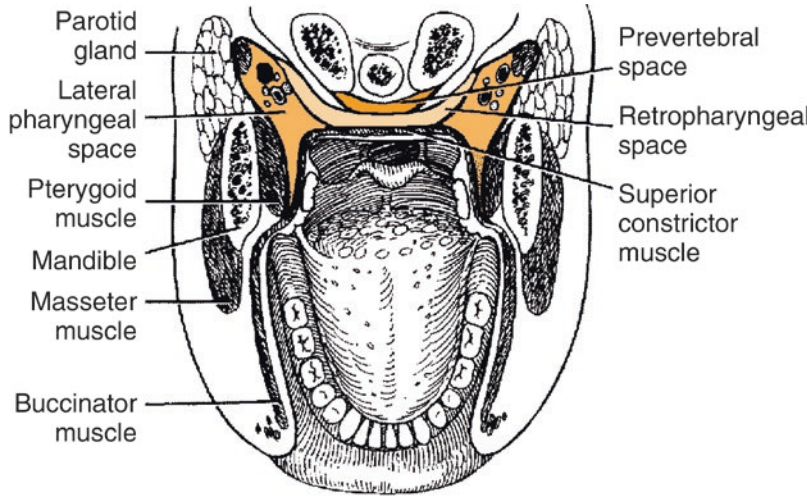

Fig. 3.4 The lateral pharyngeal space is shaped like an inverted cone with its base as the skull base and the apex at the hyoid bone. It is located between the medial pterygoid muscle laterally, the superior pharyngeal constrictor superiorly, the pterygomandibular raphe anteriorly, and the retropharyngeal space posteriorly. The styloid processes and its attachments divide the space into anterior compartments (containing muscles) and posterior compartments (containing the carotid sheath and cranial nerves). (Reprinted with permission from Flint et al. [4])

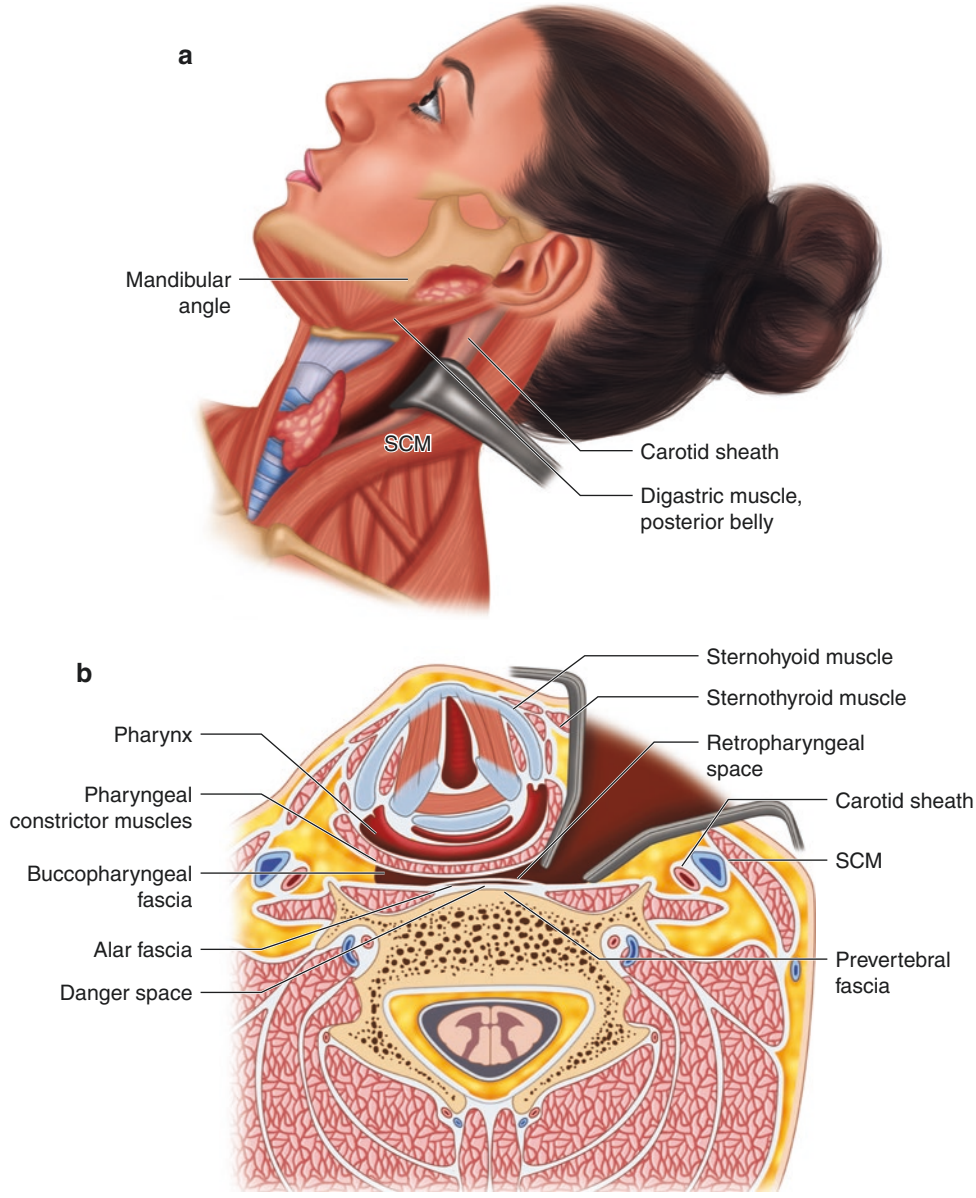

Fig. 3.5 (**a**) Retropharyngeal space is located posterior and medial to the lateral pharyngeal space. It is bounded superiorly by the base of skull, anteriorly by the superior pharyngeal muscle, posteriorly by the alar fascia, and extends inferiorly to the level of C7 or T1 (fusion of alar and buccopharyngeal fascia at the level of the posterior mediastinum). Involvement of the prevertebral space (danger space no. 4) may communicate to the region of the diaphragm. (**b**) Access to the retropharyngeal space. Incision is made parallel to the anterior border of the sternocleidomastoid (SCM) muscle inferior to the hyoid bone. The SCM and carotid sheath are retracted laterally. The loose connective tissue is bluntly dissected between the carotid sheath and the esophagus to gain access to the retrophrangyeal space. (Reprinted with permission from Kademani and Tiwana [5])

  - Signs of respiratory distress such as labored breathing (dyspnea) or noisy breathing (stridor) or inability to tolerate being in a supine position. Does the patient have hoarseness to their voice (dysphonia)? If outpatient setting, activate emergency response system for transfer. Does the airway need to be secured prior to imaging? Look for patient posturing to improve airway patency by aligning upper and lower airways (e.g., sniffing position).
- *Head and Neck Exam Assessment*
  - Measure maximal incisal opening. A concerning sign is opening less than 30 mm.
  - Palpate for tenderness, warmth, induration (firm), crepitus (sensation of crackling suggestive of gas), or fluctuance (fluid wave on bidigital palpation suggestive of pus). Note any parulis or fistula of skin.
  - Lymphadenopathy can aid in determination of origin.
  - Decreased mobility of neck. Normal flexion 70–90°, extension 55°, and rotation 70°. Nuchal rigidity may be a sign of retropharyngeal space infection.
  - Attempt to palpate if trachea is midline; in severe infection there can be deflection and markings for emergency cricothyrotomy/tracheostomy may be off-center.
  - Inability to palpate inferior border of mandible (indicative of submandibular space involvement).
  - Floor of the mouth and tongue elevation (indicative of sublingual space involvement). If the patient is able to extend tongue past vermillion border of the upper lip, there is less of a chance that the sublingual space is involved.
  - Deviation of uvula to the opposite side (indicative of the lateral pharyngeal/pterygomandibular/peritonsillar space involvement; also may be indicative of an oropharyngeal malignancy). Swelling of lateral neck between the sternocleidomastoid and mandibular angles, just above hyoid, is suggestive of lateral pharyngeal space involvement.
  - Look for carious, periodontally involved or abscessed teeth and their relation to the region of involvement.
  - Look for erythema and crepitus spreading to chest and neck for spread of infection/mediastinitis/necrotizing fasciitis. Consider serial markings of skin in area of erythema to monitor spread.
  - Look for use of accessory muscles of respiration.
  - Dimpling over zygomatic arch can be seen with temporal space involvement due to adherence of temporal fascia to periosteum.
  - Cranial exam to examine for intracranial extension.
- *Cardiopulmonary Exam*
  - Tachycardia may be appreciated in the setting of an infection due to an increase in sympathetic tone.
  - Pulmonary rales may be appreciated in the setting of acute respiratory distress syndrome secondary to sepsis.
  - Distant heart sounds, murmurs, and pericardial friction rub may be indicative of mediastinal spread.

Labs

- *Complete Blood Count*
  - Look for leukocytosis with a left shift. Leukopenia can also be seen in a serious infection. WBC count can also be trended to assess for resolution of an infection. A thrombocytosis can also be appreciated in the setting of infection (acute phase reactant).
  - Left shift/bandemia refers to the presence of immature white blood cells released into bloodstream denoting an acute infection.
- *Basic Metabolic Panel*
  - BUN/creatinine ratio can be used to assess the volume status of the patient. Patients may display prerenal (denoted by a BUN/CR ratio of greater than 20) or renal azotemia.
  - Renal baseline function is important to know as certain antibiotics are nephrotoxic

which may have implications on dosing. Creatinine levels are also necessary prior to obtaining CT with contrast due to the risk of contrast-associated nephropathy.
  - Hyperglycemia or hypoglycemia (if no oral intake) may be present in diabetics which may need to be treated. Blood sugar below 200 mg/dL is imperative for good infection control.
  - Electrolyte disturbances may also be present with long-term malnutrition.
- *C-Reactive Protein*
  - Marker of inflammation that rises in response to inflammation (acute phase reactant). Can be trended to assess for resolution of an infection.
- *Blood Cultures*
  - Routine culturing is not practiced. Should be reserved for those with signs of septicemia to prevent false-negative results.

Systemic Inflammatory Response Syndrome (SIRS)

SIRS is defined by having two or more of the following:

1. Fever >38 °C or <36 °C
2. Heart rate >90 beats per minute
3. Respiratory rate >20 breaths per minute or $PaCO_2$ <32 mm Hg
4. Abnormal WBC count (>12,000/mm^3 or <4000/mm^3 or >10% bands)

Sepsis

Sepsis – life-threatening organ dysfunction caused by a dysregulated host response to infection

- Organ dysfunction – based on sequential organ failure assessment (SOFA) scores. Points are given to abnormalities in cardiovascular, coagulation, pulmonary, liver, renal, and brain panels. A score of two or more denotes organ dysfunction.
- Infection – based on clinical signs (e.g., SIRS) and supportive microbiologic and radiological data.
- *Imaging*
  - *CT with contrast* – image must extend from the skull base to the thoracic inlet. 3 mm cuts in the neck and 5 mm below the hyoid. Contrast used to delineate collections manifested as ring-enhancing collections noted on CT. Fat stranding can also be appreciated. Also can assess for radiographic evidence of airway embarrassment and lymphadenopathy.
  - *Panorex* – plain scout film used to assess for causative teeth of the odontogenic infection. Can also see resorptive changes that could be indicative of apical periodontitis or osteomyelitis.
  - *Plain Neck Films* – screening for retropharyngeal and pretracheal spaces. Normal retropharyngeal tissue 7 mm at C-2; 14 mm for children and 22 mm for adults at C-6. Largely supplanted by CT.

Medical/Surgical Management

- Prompt medical management:
  - Intravenous fluids to address dehydration.
  - Initiate empiric antibiotic therapy. Change to specific antibiotic therapy once culture and sensitivity becomes available. The spread of an infection that is still in the cellulitis stage is aborted by prompt incision and drainage of all anatomic spaces affected by cellulitis or abscess. Cultures taken from cellulitis yield viable specimens for culture and sensitivity testing.
  - Analgesics
- Determine what spaces are involved.
- Admit to hospital for serious infection.
- Criteria for hospital admission:
  - Temperature >101 °F
  - Dehydration
  - Signs of airway embarrassment
  - Infection involving secondary fascial spaces
  - Need to control systemic disease that has implications on the infected patient
  - Need for general anesthesia

- Nursing orders:
  - Suction at the bedside
  - NPO
  - Monitor ins and outs
  - Q4 vital signs
  - Head of bed elevated to 30 degrees

Surgical Management

- Discuss securing a definitive airway with the anesthesia team before proceeding to the operating room. An awake fiberoptic intubation or an awake tracheotomy may be indicated.
- Consider needle decompression prior to intubation to prevent rupture of abscess upon intubation.
- Be prepared for emergency tracheotomy in the "cannot ventilate, cannot intubate" situation.
- Mark out emergency cricothyrotomy prior to intubation attempt. This may be deviated in serious infection.
- Attempt aspiration for sterile sample for culture and sensitivity.
- Make incision in healthy skin versus height of fluctuance to prevent scar contracture.
- Place an incision in a natural fold of skin in a gravity-dependent position.
- Bluntly dissect into the involved spaces to establish drainage. Attempt to follow lingual border of mandible to prevent damage to facial vessels.
- A through and through drain, passing from one skin or mucosal incision through the infected space to a separate incision, can be used to allow unidirectional flow of irrigation fluid, to provide two routes for drainage, and to keep the incisions away from the site of abscess formation.
- Irrigate copiously.
- Extract the offending teeth.
- Reassess the patient frequently after incision and drainage.
- Consider infectious diseases consultation.

Management of Orbital Infections

- Orbital infections can include different anatomic sites with varying clinical manifestations. A thorough clinical exam to evaluate visual acuity, pupillary reflexes, extraocular movement, and ophthalmoscopy is indicated to evaluate and distinguish the extent of infection.
- Orbital infections are rare sequelae of sinusitis, odontogenic infections, or orbital trauma and may have devastating consequences if they are not treated aggressively.

Classification of Orbital Infections (See Fig. 3.6) [3]

- Group 1: inflammatory edema (preseptal cellulitis)
- Group 2: orbital cellulitis
- Group 3: subperiosteal abscess
- Group 4: orbital abscess
- Group 5: cavernous sinus thrombosis

Review of Pertinent Anatomy

- The orbit is a cone-shaped structure.
- Surrounded by paranasal sinuses (frontal, ethmoid, and maxillary).
- Orbital septum (see Fig. 3.7): membranous sheet that extends from the periosteum of the infraorbital region to the tarsal plate and forms the anterior boundary of the orbital compartment.
- Lamina papyracea: separates ethmoid sinuses from the orbit. Nerves and vasculature within natural fenestrations are named Zuckerkandl's dehiscences.
- Most common route of infection to the orbit is by extension from the ethmoid sinuses.
- Superior and inferior ophthalmic veins drain blood directly into the cavernous sinus.
- Inferior orbital veins are valveless, and infections can pass readily from the orbit to intracranial structures.

Workup

- Usual review of medical history, systems, and duration/onset. Emphasis on symptoms of decreased vision and decreased color perception.
- Labs tests: complete blood cell count and blood cultures.
- Visual acuity (e.g., Snellen chart).

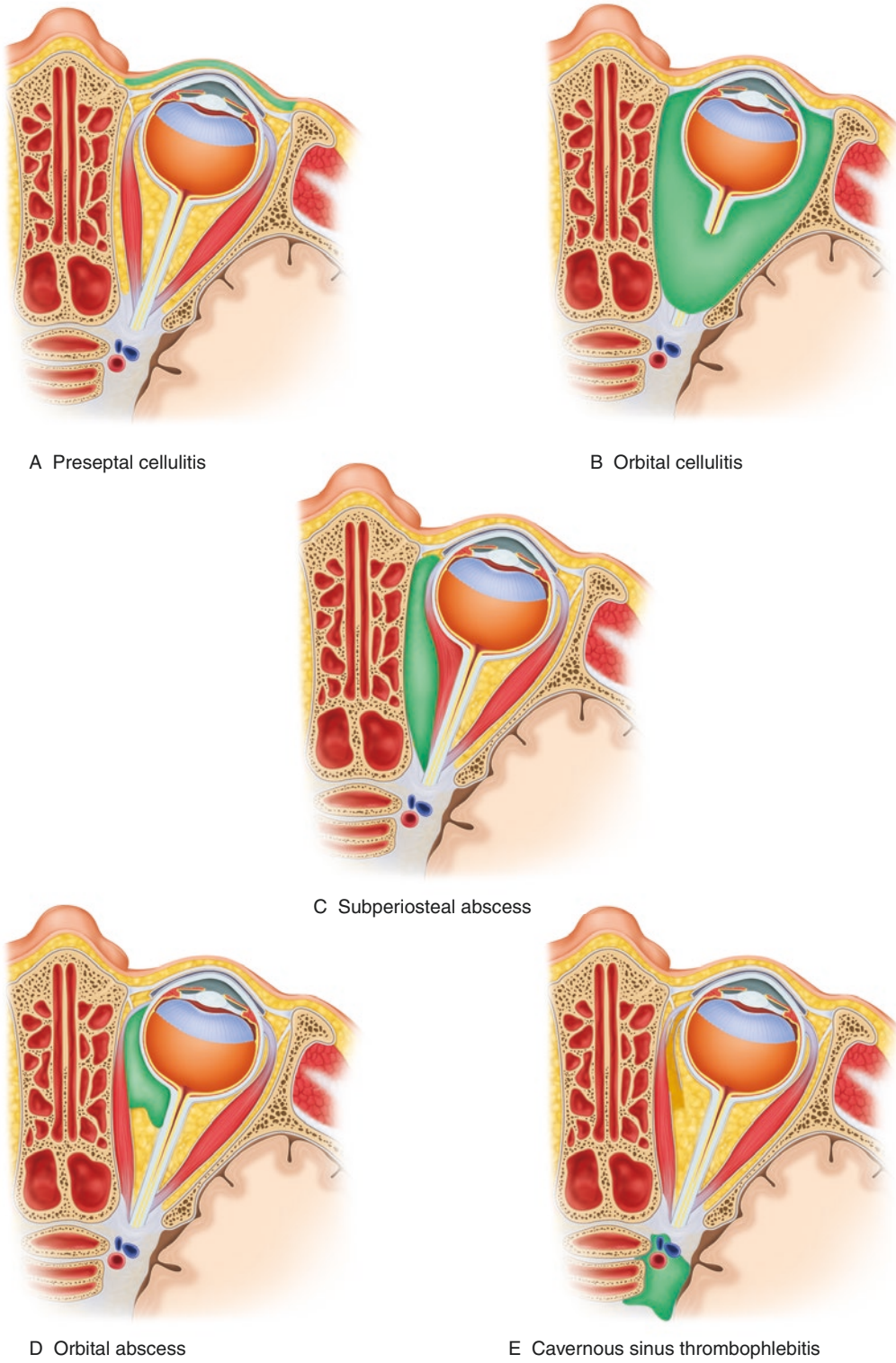

Fig. 3.6 Classification of orbital infections. (Reprinted with Permission from Chander J., Lagenbrunner D, Stevens E [3])

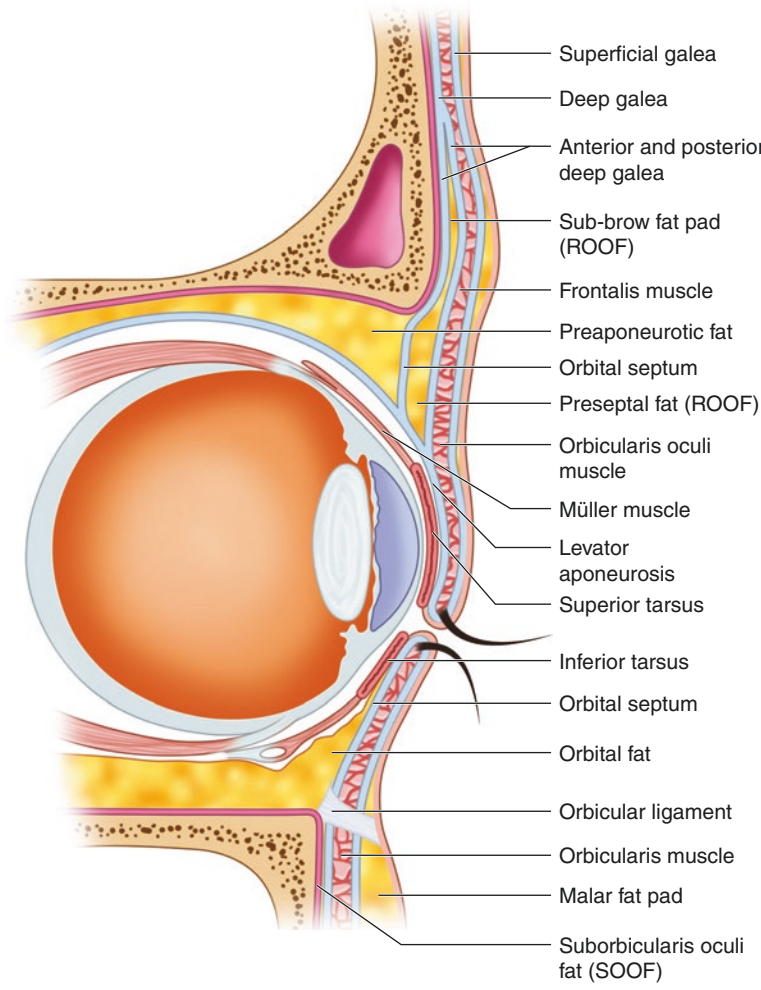

Fig. 3.7 Orbital septum. (Reprinted with permission from Tyers and Collin [6])

- Extra-ocular muscles movement, cardinal position of gaze.
- Pupillary examination, check afferent pupillary reflexes.
- Check ocular pressures.
- Fundoscopic exam to assess optic nerve involvement (papilledema – optic nerve swelling).
- Consider ophthalmology consultation.
- Posterior orbital involvement around the superior orbital fissure and optic foramen may result in orbital apex syndrome.

Radiography

- CT of orbits and/or sinuses with contrast, 3 mm cuts to help distinguish between preseptal and orbital cellulitis.
- Preseptal cellulitis radiographic features: diffuse soft tissue edema will be seen anterior to the septum on CT.
- Postseptal cellulitis radiographic features: intraconal fat stranding and edema of the extra-ocular muscles are seen. All these radiographic signs are posterior to the septum on CT.

- Postseptal abscess radiographic features: collection of purulent material (ring-enhancing lesion) between the bony walls of the orbit and the periorbita. Displacement of the globe away from the site of the abscess.

Preseptal Cellulitis

- Infection confined to the lids and periocular soft tissues anterior to the orbital septum.
- More common in children than in adults.
- Three primary sources: (1) paranasal sinusitis, (2) upper respiratory tract infection, (3) direct inoculation (e.g., chalazion or trauma to area).
- Bacteria implicated: *Staphylococcus aureus, Streptococcus pneumoniae, Haemophilus influenzae,* other streptococci, and anaerobes [3].
- Clinical manifestations – ocular pain, eyelid swelling, erythema. Chemosis can occur in severe cases.

Treatment

- Antibiotic treatment should be tailored to cover community-acquired MRSA, such as clindamycin or TMP/SMX.
- Serial ocular exams looking for deteriorating or improving symptoms.
- Keep head of bed elevated to prevent worsening edema due to gravity, which may confound exam findings.
- If abscess is defined, drainage via transcutaneous, transconjunctival, or transnasal endoscopic approach through ethmoid sinus.

Postseptal/Orbital Cellulitis/Abscess

- Reflects true involvement of the orbital contents (retroseptal).
  - Fat and ocular muscle involvement.
- More common in young children.
- Blood cultures can be positive in children. Rarely positive in adults.
- Most common cause is rhinosinusitis.
  - Ethmoid sinusitis and pansinusitis can also lead to subperiosteal orbital abscess or orbital cellulitis.
- Other potential causes:
  - Ophthalmic surgery: strabismus surgery, blepharoplasty, retinal surgery.
  - Orbital trauma.
  - Dacryocystitis.
  - Odontogenic infection.
  - Fungal rhinosinusitis.
- Clinical features that distinguish from preseptal cellulitis include ophthalmoplegia, decreased visual acuity, proptosis, eye pain (ophthalmalgia), changes in visual acuity, superior orbital fissure syndrome, orbital apex syndrome.
- Usually abscess located medially or superomedially causing the eye to be fixed looking "down and out."
- Most common bacteria involved are *Staphylococcus aureus* and *Streptococci*. Mucor and Aspergillus (fungi) can cause life-threatening invasive infections and are more common in poorly controlled diabetics [3].

Treatment

- Uncomplicated orbital cellulitis– may attempt conservative treatment with antibiotics. All patients with orbital abscesses should have immediate surgical drainage.
- Broad-spectrum regimen aimed at *S. aureus, S. pneumoniae,* and other streptococci and gram-negative bacilli.
- Initial treatment includes a combined antibiotic therapy; may narrow and tailor antibiotic treatment with culture results.
- When intracranial extension is suspected, include coverage for anaerobes and request neurosurgical consultation.
- Contrast-enhanced CT or magnetic resonance venogram (MRV) may be diagnostic.
- Common antibiotics regimens include vancomycin, ampicillin–sulbactam, metronidazole, ceftriaxone, piperacillin–tazobactam, or levofloxacin.
- Indications for surgical intervention:
  - Poor response to antibiotic treatment (24–28 hours).
  - Worsening visual acuity or pupillary changes.
  - Large abscess (>10 mm).
- Surgical approaches:
  - Common approach is transconjunctival which may include transcaruncular or lateral canthotomy extensions.

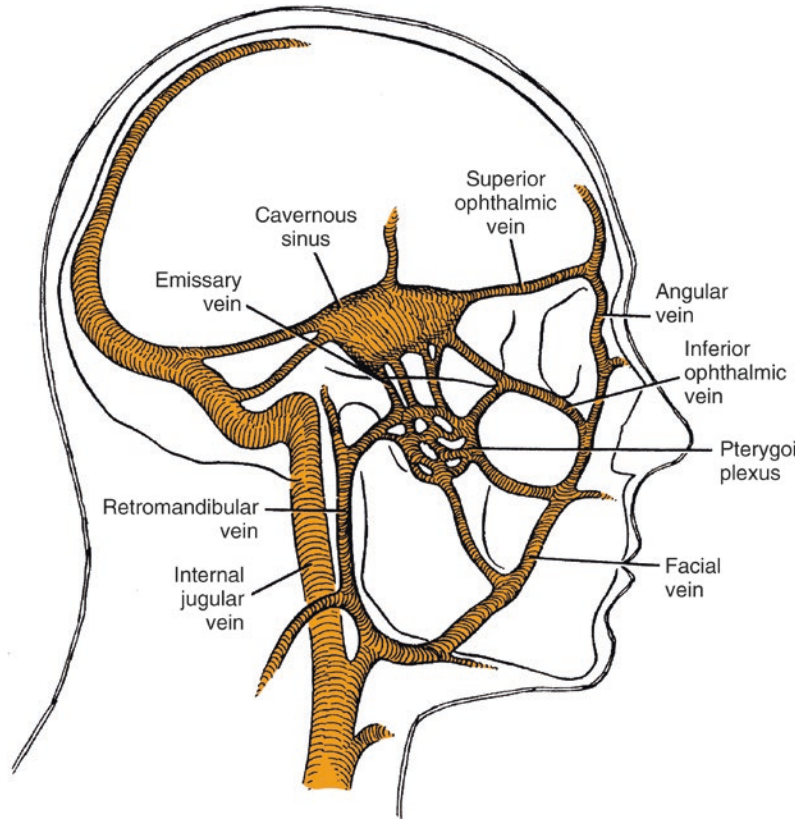

Fig. 3.8 Spread to cavernous sinus from an odontogenic source may travel via the inferior or superior ophthalmic vein or via the emissary veins to the pterygoid plexus. (Reprinted with permission from Flint et al. [4])

  - Endoscopic sinus surgery is indicated in patients with severe destructive rhinosinusitis.
- Some clinicians initiate high-dose steroid 24 hours after antibiotic therapy has begun. Steroid therapy is used to prevent ocular complications due to increased intraorbital pressure.
- Emergency lateral canthotomy and cantholysis may be required if signs of optic nerve involvement.

Cavernous Sinus Thrombosis (CST)

- Cavernous sinus thrombosis is a vascular thrombosis in the cavernous sinus with inflammation of its anatomic structures.
- Most common etiology is from contiguous spread of infection from the sinuses and very uncommon from dental abscesses (see Fig. 3.8).
- *Staphylococcus aureus* is the most common pathogen.

Anatomy of the Cavernous Sinus (See Fig. 3.9)

- Bilateral venous drainage for middle cranial fossa.
- Anteriorly bordered by the superior orbital fissure, receiving tributaries of the ophthalmic vein.
- Posterior border is the trigeminal ganglion.
- Superior and inferior ophthalmic veins, central retinal vein, and the middle meningeal vein drain into cavernous sinus.
- The cavernous sinus drains into the superior and inferior petrosal sinuses.
- Emissary veins drain from the sinus into the pterygoid plexus to the retromandibular vein.
- Nerves in sinus:

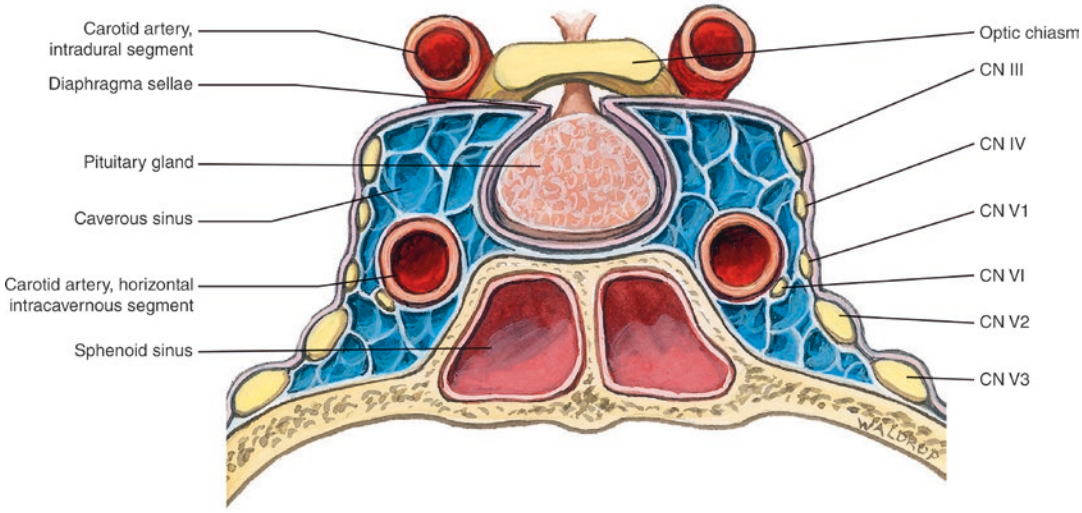

Fig. 3.9 Anatomy of the cavernous sinus. (Reprinted with permission from Dutton [7])

- Oculomotor (CN III)
- Trochlear (CN IV)
- Abducens (CN VI)
- Ophthalmic (CN V-1)
- Maxillary (CN V-2)

Presentation of Cavernous Sinus Thrombosis

- Aseptic causes – after surgery or after trauma.
- Infectious causes:
  - Sinusitis
  - Otitis
  - Facial furuncles
  - Erysipelas – superficial cellulitis of skin that is caused by β-hemolytic streptococci and group B streptococci.
- Symptoms: fever, headache, and diplopia common symptoms.
- Earliest neurological sign is lateral gaze palsy (CN 6). First easily assessed sign of CST, as it is the only cranial nerve traversing the interior of the sinus.
- Clinical signs include photophobia, proptosis, sepsis, lid edema, chemosis, dilated pupils, cranial nerve 3, 4, 6 palsies (ophthalmoplegia), and paresthesia of V1, V2. Dilatation of the retinal veins of the opposite eye may precede lateral gaze palsy CN 6 on the affected side. This is due to venous congestion in the cavernous sinus obstructing the venous outflow of the retinal veins on the unaffected side.
  - Pyrexia is seen with a "picket fence" pattern of high temperature spikes, suggestive of thrombophlebitis.
  - On fundoscopic exam, congested retinal veins on the opposite side are the earliest signs of cavernous sinus thrombosis.
- Clinical evidence of intracranial extension:
  - Nausea/vomiting
  - Altered mental status
  - Generalized sepsis
- Intracranial extension of infection may result in meningitis, encephalitis, blindness, brain abscess, pituitary infection, epidural and subdural empyemas, possible coma, and death.

Danger Triangle on Face leading to CST

- Triangular region formed by the corners of the mouth, medial cheeks, and bridge of the nose.
- Pathway is via retrograde flow through veins that are valveless.
  - Facial veins>angular vein>ophthalmic veins>cavernous sinus
  - Emissary veins connected to the pterygoid plexus (slower spread)
  - Internal jugular vein connecting to inferior petrosal sinus (complication of Lemierre's syndrome)

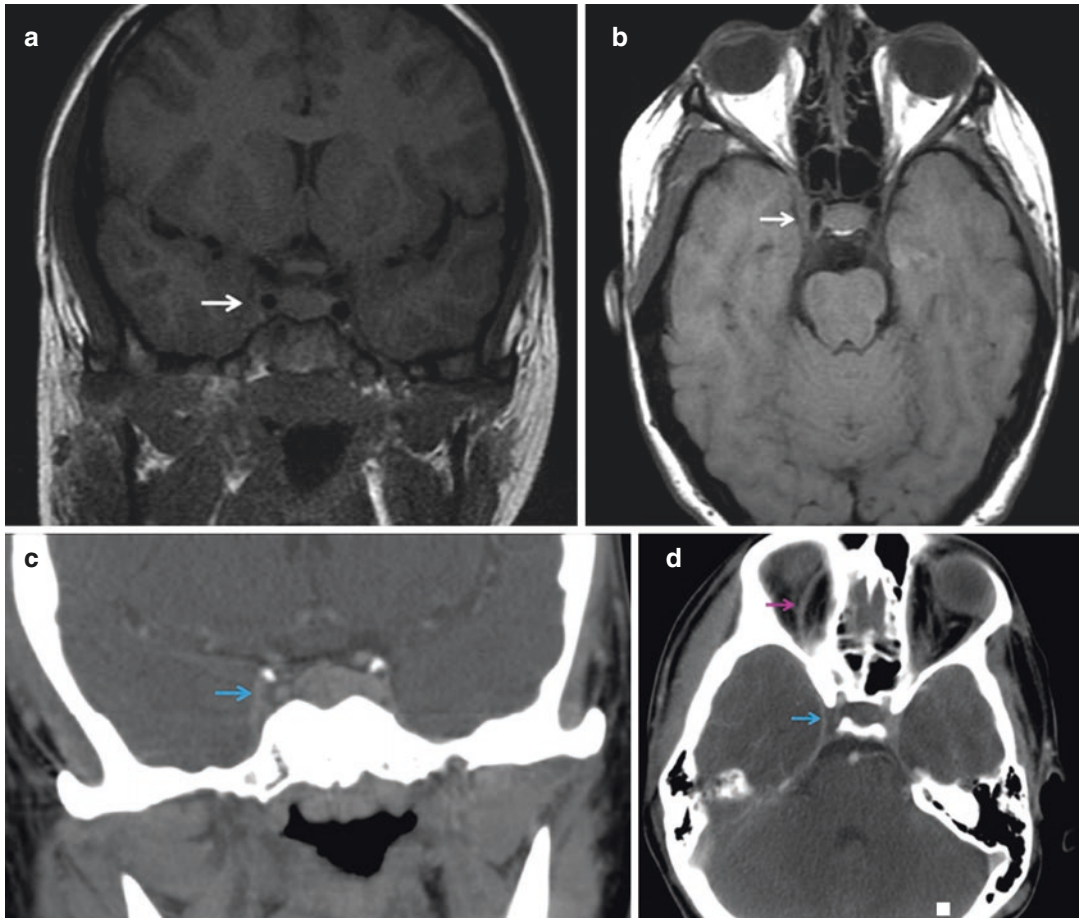

Fig. 3.10 Cavernous sinus thrombosis. (**a**) T1-weighted MRI at level of the cavernous sinus, thickening of the right cavernous sinus (arrow). (**b**) T1-weighted MRI at the level of orbits, thickening of the right cavernous sinus (arrow). (**c**) Soft tissue window coronal CT with areas of low attenuation within cavernous sinus representing thrombus (arrow). (**d**) Soft tissue window axial CT at level of orbits with mild enlargement of superior ophthalmic vein (superior arrow) and low attenuation region in the right cavernous sinus representing thrombus (inferior arrow). (Images courtesy of Dr. Gillian Lieberman and Dr. Christopher Aderman)

Radiographic Features of CST (see Fig. 3.10)

- Magnetic resonance venography (MRV):
  - Imaging modality of choice to examine venous anatomy and demonstration of decreased or absence of signal in area of thrombus
  - Venous wall thickening
  - Filling defect in cavernous sinus
  - Lateral bulging of cavernous sinus wall
  - Narrowing of the internal carotid artery within the cavernous sinus
- CT with and without IV contrast:
  - Expansion of cavernous sinus
  - Convexity of the normally concave lateral wall
  - Indirect signs: venous obstruction, dilation of the superior ophthalmic vein

Treatment of Cavernous Sinus Thrombosis

- Surgery
  - Directed at the primary source of infection and obtaining culture.
- Antibiotics:
  - Start with empiric antibiotic regimens with combination of (1) third- or fourth-generation cephalosporin that crosses the blood–brain barrier, such as ceftriaxone (third generation) or ceftazidime (fourth generation), (2) metronidazole, and (3) vancomycin (high likelihood of *S. aureus*) until culture results.

  - 6–8 weeks of therapy.
- Steroids (controversial):
  - May have benefits of decreasing orbital inflammation and cranial nerve edema.
- Anticoagulants (controversial):
  - Proposed benefit: cessation of the progression of the thrombus to other dural venous sinus and cerebral veins.
  - Early anticoagulation decreased morbidity (blindness, stroke, ophthalmoplegia, focal seizures, vascular steal syndrome).
  - Risk: intracranial and systemic hemorrhage. Many postmortem evaluations have shown venous hemorrhagic infarcts.

Mucormycosis (Zygomycosis)

- Mucormycosis is an opportunistic fungal infection (caused by fungi in the Mucorales family) that occurs in immunocompromised patients.
- Head and neck manifest as two forms: rhinocerebral and rhinomaxillary.
- Disease involves thrombosis, vascular invasion, ischemia, and infarctions.
- Black necrotic eschars in the oral cavity, palate, or face can be the early diagnostic signs.
- Fungi will enter the body through the nasal mucosa, lungs, or skin.
  - Cutaneous mucormycosis: injured tissue in the oral cavity can be a suitable port of entry.
  - Fungal hyphae preferentially invade the walls of blood vessels, producing thrombi and infarctions.
  - Progressive tissue ischemia and necrosis are the inevitable result.
- Rhizopus organisms have an enzyme, ketone reductase, which allows them to thrive in high glucose and acidic conditions.
  - Serum from individuals in diabetic ketoacidosis stimulates growth.
- Rhino-orbital cerebral and pulmonary mucormycosis are acquired by the inhalation of spores.
- The agents of mucormycosis are angioinvasive; infarction of tissues is a hallmark of invasive disease.

Oral Mucormycosis

- Most frequently seen as palatal ulcers – almost always necrotic, well-defined borders.
- May result from rapid lysis of the maxilla or other adjacent structures.
- Has been reported in the alveolar ridge, lips, cheeks, tongue, mandible (rare), and maxillary sinuses.
- Diagnosis by biopsy with histopathological evidence of fungal invasion showing broad non-septate hyphae with right angle branching.
- Fungal cultures may not reveal mucor, so biopsy is important for diagnosis.

Management/Treatment

- Surviving this condition largely depends on early identification and treatment.
- Elimination of predisposing factors for infection (e.g., hyperglycemia, metabolic acidosis, immunosuppressive drugs, and neutropenia).
- Several simultaneous approaches: surgical intervention and antifungal therapy.
- Antifungal treatment: systemic (IV), high-dose amphotericin B (5 mg/kg with the liposomal formulation).
  - Side effects: renal toxicity and high fevers and chills (shake and bake).
  - Monitor serum urea nitrogen, creatinine, and creatinine clearance.
  - Amphotericin mechanism of action – binds with the ergosterol of fungal membrane causing disruption and ion permeability.
- Posaconazole or isavuconazole can also be used for salvage therapy for patients who don't respond or cannot tolerate amphotericin B.
- Surgical debridement to limit aggressive spread of infection. Aggressive surgical debridement of involved tissues should be undertaken as soon as the diagnosis of any form of mucormycosis is suspected.
- Therapy should continue until there is a clinical resolution of signs/symptoms as well as resolution of radiographic signs of active disease.

Cervicofacial Necrotizing Fasciitis

- Aggressive bacterial infection leading to necrosis of the superficial fascial planes with concurrent systemic toxicity.
- High mortality rate due to sepsis.
- More common in diabetic, alcoholics, malnourished, malignancy, obese, and immunocompromised patients.
- Five distinct bacterial patterns are seen in necrotizing fasciitis:
  - Type I – mixed aerobic and anaerobic, most commonly seen.
  - Type II – *Streptococcus pyogenes* (group A beta-hemolytic streptococci), seen more often in otherwise healthy children.
  - Type III – *Staphylococcus aureus* (MRSA).
  - Type IV – clostridial, gas-producing bacterium.
  - Type V – *Klebsiella pneumonia* – may be highly resistant to antibiotics.
- Clinical signs:
  - Erythematous skin without demarcation that is tense, smooth, shiny, and painful.
  - Will have signs of sepsis including tachycardia, pyrexia, apathy, weakness, hypotension, etc.
  - Progression leads to vesicle and blister formation early, followed by dusky purple discoloration.
  - Skin may become anesthetic due to compression and destruction of the underlying sensory nerves.
  - Crepitus may be present due to gas production.
  - Drainage is described as "dishwater" due to the foul smell, low viscosity, and gray color. Product of colliquative necrosis.
- Radiographic signs:
  - CT scan would identify soft tissue emphysema and edema, possible gas bubbles.
- Laboratory studies:
  - Complete blood counts. Extreme leukocytosis and anemia secondary to bacterial hemolysis and bone marrow suppression.
  - Comprehensive metabolic panel. Hypocalcemia due to sequestration of calcium into regions of fat necrosis, elevated blood glucose, elevated blood urea nitrogen, and elevated creatinine.
  - Lactate levels will be increased.
- Treatment:
  - Secure a definitive airway.
  - Early recognition leading to surgical intervention via fasciotomy and necrotic tissue debridement (requires serial debridement). Muscle layers can be preserved, but all necrotic tissues and overlying skin must be removed.
  - Biopsies of the involved fascia to identify toxin-producing invasive streptococcal infection should be taken.
  - Gram-positive cocci invading fascia, without leukocytic infiltrate, indicates streptococcal toxin production.
  - Frozen sections show dense polymorphonuclear infiltrates in the dermal layers of skin; these may guide the removal of devitalized tissue.
  - Biopsies should be taken of adjacent normal looking tissue, not necrotic tissue.
  - Broad-spectrum empiric antibiotics (e.g., carbapenem plus vancomycin to cover all five types) with de-escalation according to culture and sensitivity results.
  - The wounds should be washed (consider hydrogen peroxide to aid in tissue debridement) and packed with antimicrobial-soaked gauze (e.g., povidone iodine) regularly.
  - Hyperbaric oxygen. Must start early in treatment. Must weigh against cost and risk, availability in hospital, and risk of transport. Some protocols for acute infection require two three dives per day.
  - Fluid, electrolyte, and blood replacement for volume repletion and hemolysis.
  - Secondary reconstruction may require locoregional flaps and skin grafts.

Mediastinitis

Life-threatening infection involving the mediastinum.

- Spread from an odontogenic source is via the danger space (also called Space 4) that is found between the alar and prevertebral fascia. This space extends from the base of the skull, through posterior mediastinum, to the level of the diaphragm. Its loose areolar tissue allows for rapid spread of infection. The infection normally enters this plane through the fusion of alar and prevertebral fascial layers between C6 and T4.
- Clinical signs:
  - Chest pain
  - Dyspnea
  - High fever
  - Tachypnea
  - Hypotension due to decreased venous return
- Radiographic signs:
  - Mediastinal widening and pulmonary congestion/effusions can be appreciated on chest radiographs.
  - CT may show location of collections, tissue emphysema, pericardial effusions, and decreased airway patency.
- Treatment:
  - Establish definitive airway.
  - Aggressive surgical source control including drainage of spaces (repeat drainage and debridement often required).
  - Cardiothoracic surgery consultation for open mediastinal drainage.
  - Broad-spectrum antibiotics.
  - HBO therapy may be indicated.

Osteomyelitis

In its strict definition, it is an inflammation of the medullary portion of bone. It frequently involves the cortical bone and periosteum, however.

- Bone marrow offers a path of lower resistance that allows for the spread along the medullary bone.
- Most often seen in the mandible, as the thin cortical bone of the maxillae does not easily confine the infectious process. The mandible is also not as well vascularized as the maxillae and, therefore, is more susceptible to osteomyelitis.
- Odontogenic mixed flora (primarily alpha-hemolytic *Streptococci* vs. *Staphylococcus aureus* seen in the axial skeleton.
- In general, grouped as (1) acute or chronic (1 month or greater), (2) suppurative (pus forming), or (3) non-suppurative.
- Symptoms: pain, trismus, paresthesia/anesthesia, anorexia, swelling over affected area, loose teeth, adenopathy, and malaise. Chronic disease may form a fistula or sinus tract.
- Imaging:
  - A scouting film like an orthopantogram may show odontogenic infection with or without sequestra.
  - CT scan can show the extent of lytic bone, keeping in mind 30% demineralization is required to appreciate changes.
  - Radionuclide imaging:

    Allows for earlier identification of osteomyelitic activity, as early as 3 days. Technetium-99, although non-specific, will aid in identifying areas of higher blood flow and osteoblastic activity. It is used in a three-phase scan and is typically ordered if osteomyelitis is suspected.

    Although technetium-99 scan alone is normally sufficient, a gallium-67 aids in ruling out osteomyelitis from malignancy and trauma. Gallium-67 identifies inflammatory changes, as it binds to granulocytes.
  - White blood cell tagging can be useful in detecting early infection when lytic processes are not appreciated on imaging.
  - PET CT scan with fluoride isotope is sensitive to areas of bone turnover with much greater resolution.
- Treatment
  - Patient should be treated with corticotomies (bur fenestration) or removal of the buccal bone (decortications) for decompression, plus removal of infected teeth or repair of a mobile fracture segment.
  - Infected bone marrow should be debrided until it bleeds. It is useful to send multiple culture and histopathological samples along the length of involved bone to see the extent of infection or changes in flora.

- Cultures of affected bone for microbiology and bone biopsies sent to pathology (to rule out neoplasia and identify fungi or actinomycosis in samples).
- Infectious diseases service should be consulted due to the need for long-term IV antibiotics with PICC line.
- Hyperbaric oxygen should be considered to aid in revascularization and for antimicrobial utility.

Case (Fig. 3.11)

- *You have been paged to the ED to evaluate a 40-year old male with dental pain and extensive left facial swelling. What would you like to know?*
  - HPI (history onset, duration, symptoms etc.)
  - Past medical history
  - Presence of dysphagia, dysphonia, odynophagia, fevers etc.
  - Vital signs
  - NPO status
- *The patient has a history of hypertension and takes lisinopril. He has no previous history of surgery. He smokes 1 pack per day for 15 years. Social use of alcohol. He has no known drug allergies. He has not had anything to eat or drink for 2 days as he says he cannot swallow. What would you like to do next*?
  - Physical exam:
  - Inspection

    Look for facial swelling

    Assess whether the patient can tolerate his secretions.

    Look for posturing to improve airway patency (e.g., sniffing position or tripod position)
  - Head and neck exam:

    Record temperature.

    Measure maximal incisal opening.

    Assess for lymphadenopathy.

    Look for spreading erythema, using marking pen to delineate extent.

    Is the inferior border palpable (indicative of submandibular space involvement)?

    Is the floor of the mouth elevated (indicative of sublingual space involvement)?

    Is there uvular deviation from the midline (indicative of lateral pharyngeal/pterygomandibular space involvement)?

    Look for carious or periodontally involved teeth and their relation to the region of involvement.

    Palpate the area of involvement to determine the character of the swelling (firm versus fluctuant).
  - Cardiopulmonary Exam

    Are the accessory muscles of respiration being used?

    Auscultate heart and lungs

    Tachycardia may be appreciated in the setting of an infection

    Are the heart sounds distant or muffled?

    Is there any heart murmur?

    Rales?

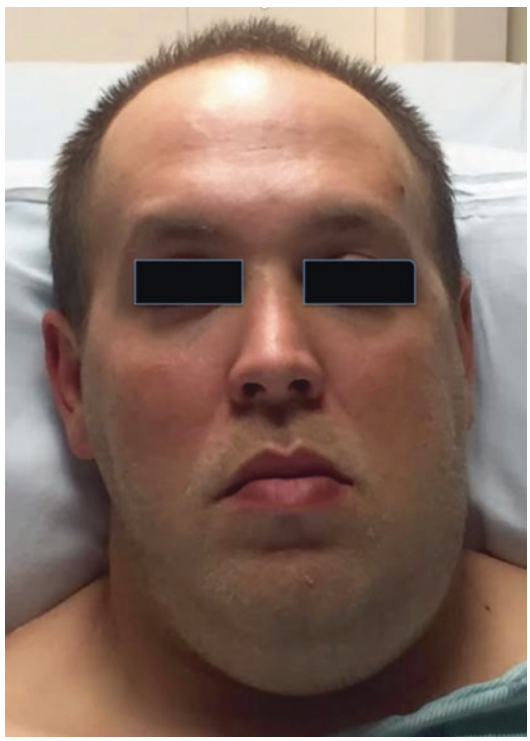

Fig. 3.11 Infection case photo. (Image courtesy of Dr. Damian Findlay)

- *What laboratory studies would you like to see?*
  - CBC, CRP, BMP, and obtain a blood culture.
- *Your patient is febrile to 104 degrees Fahrenheit (40 degrees Celsius) with a heart rate of 105 bpm. His maximum incisal opening is 25 mm. On exam, he has a toxic appearance. The inferior border is not palpable. Intraoral exam reveals fullness in the floor of the mouth and left palatoglossal arch. Extensive caries noted on #17 and #18 with tenderness to percussion. He has a WBC count of 17,000 with a left shift and he has BUN/creatinine ratio of 20:1. What imaging would you like to order?*
- CT with contrast-image must extend from the orbits to the clavicles. Contrast used to delineate encapsulated abscesses manifested as ring-enhancing collections noted on CT.

Your patient returns from CT. Below are his images (Figs. 3.12 and 3.13)*:*

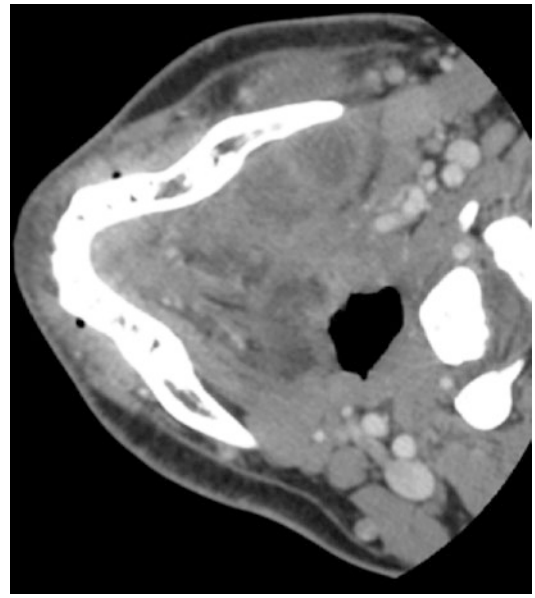

Fig. 3.12 CT scan with contrast at the level of the mandible. (Image courtesy of Dr. Damian Findlay)

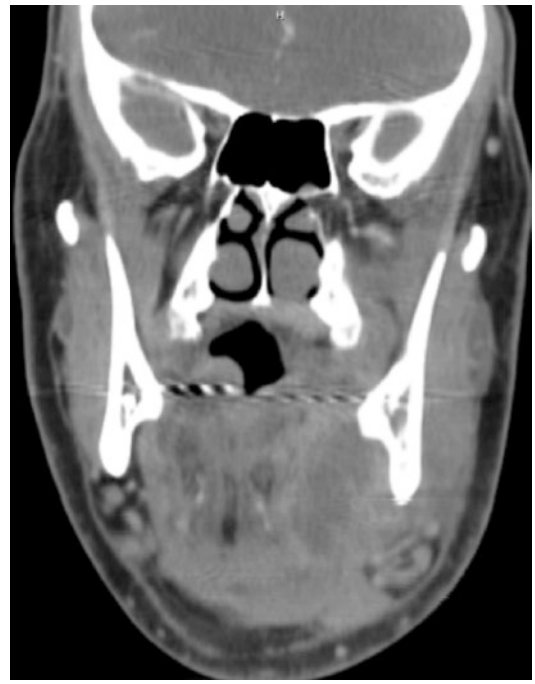

Fig. 3.13 CT scan with contrast at the level of the pterygoid plate. (Image courtesy of Dr. Damian Findlay)

- *What spaces are involved?*
  The left sublingual, submental, submandibular, and pterygomandibular spaces are involved (note the ring-enhancing areas in the aforementioned spaces).

- *How do you want to proceed?*
  - Admit to hospital
  - Intravenous fluids to address dehydration
  - Start empiric antibiotic therapy
  - Analgesics
  - Nursing orders
    - Suction at the bedside
    - NPO
    - Monitor ins and outs
    - Q 4 vital signs
  - Plan for prompt incision and drainage
- *How would you proceed with your drainage?*
  Mark out landmarks for cricothyrotomy and have surgical airway kit open and ready in case of emergent airway concerns. After securing a definitive airway, I would scrub and drape the patient in a normal sterile surgical fashion. I would then place a throat pack. At this time, I would attempt needle aspiration of the abscess to have a sterile sample for culture. I would palpate and mark a 3 cm incision in healthy skin under the area of the fluctuance, ensuring I was 2 cm below the inferior border of the mandible. I would

make a sharp incision using a 15 blade down to platysma. I would bluntly dissect with a hemostat toward the lingual border of the mandible. I would continue to dissect superiorly in a subperiosteal plane along the lingual border of the mandible traversing the sublingual and submandibular spaces. My other hand would be inside the mouth along the floor of the mouth for the purpose of appreciating the tip of the hemostat. I would then continue my dissection posteriorly along the lingual mandible to enter the pterygomandibular space. I would then redirect the hemostat along the lingual border deep to the lingual gingiva into the oral cavity adjacent to the involved teeth. This bimanual manipulation also would ensure entry to the correct spaces and also aid in placement of through and through drains. I would use penrose drains (another option is a perforated red rubber catheter or a Jackson-Pratt drain) and place them in the involved spaces in a through and through fashion. The drains would then be irrigated to ensure patency of drains and communication with drains in other spaces. The drains would then be secured with a non-resorbable suture. I would remove the offending dentition. I would then irrigate the oral cavity. I would remove the throat pack and place drain sponges/dressings.

- *What is the function of the drain?*
  They facilitate gravity-dependent drainage of fluids or purulence from the wound. They allow for also cleansing of the infected site via irrigation. Prevent closure of the mucosa which can result in reformation of abscess.
- *When would you remove the drains?*
  I would remove the drains when the drainage is nearly complete (without signs of gross purulence/mainly serosanguineous drainage). This would be typically between 3 and 7 days. Leaving the drain for an extended period of time may lead to secondary infection as drains are antigenic and allow for ingress of skin flora.
- *How does incision and drainage treat the patients?*
  Reduction in tissue tension improves local blood flow and increase host defenses to area. Decreases bacterial load and removes necrotic tissue.
- *What cultures would you order?*
  Aerobic, anaerobic, and fungal cultures with antibiotic sensitivities in addition to a gram stain.
- *What is gram stain?*
  A gram stain is a rapid test to aid in categorizing involved microorganisms into four broad groups: gram positive cocci, gram positive rods, gram negative cocci, or gram negative rods. This aids in tailoring early antibiotic therapy. It involves process of staining, decolorizing, and counterstaining the microorganism to detect a peptidoglycan in the cell wall found in gram positive bacteria.
- *What is Ludwig angina?*
  Rapidly progressing cellulitis that may not have yet formed abscesses. This infection involves the bilateral submental, sublingual, and submandibular spaces. Angina refers to the respiratory distress associated with airway obstruction.
- *The patient is 3 days s/p incision and drainage. On exam your patient appears toxic and is not tolerating his secretions. He spiked a fever this morning of 103 degrees Fahrenheit. On exam the uvula is deviated to the right. How do you proceed?*
  Rescan the patient. He may have developed a new collection in the previously drained spaces, inadequate drain placement, inadequate surgery/missed space or may have had extension into additional spaces.
- *What is going on?* (*see* Fig. 3.14)
  The patient's CT now shows a ring-enhancing abscess with the involvement of the lateral pharyngeal space with deviation of the airway. The patient should be taken back to the OR for incision and drainage. I would consider changing my antibiotic therapy based on culture results if not already tailored. (It may be wise in this instance to keep the patient intubated.)
- *You get a call from the ICU nurse that the patient is complaining of frequent nose bleeds. What might be going on?*

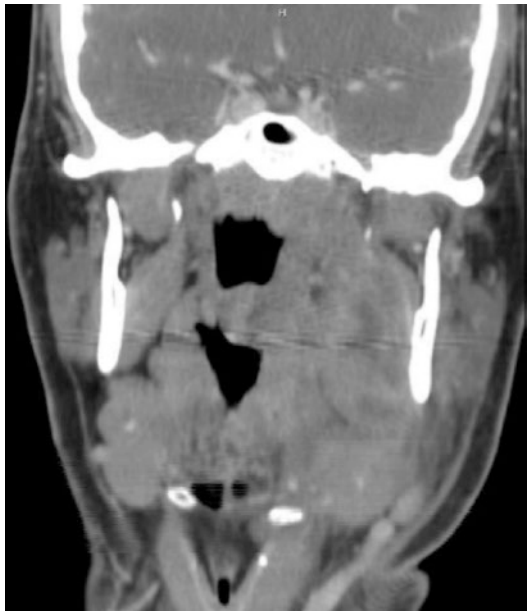

Fig. 3.14 Coronal CT scan with contrast at the level of mandibular ramus. (Image courtesy of Dr. Damian Findlay)

Possible carotid sheath involvement. Herald bleeds are intermittent bleeding episodes of the nose or the pharynx caused by erosion of the carotid artery or internal jugular vein. The erosion can be caused by placement of a rigid drain in the lateral pharyngeal space. Other signs can include palsies of nerves IX, X, or XII, Horner's syndrome, or an enlarging hematoma. If carotid sheath involvement is suspected, then order CTA of the head and neck and request vascular surgery consultation.

- *You order a CT scan, describe what you see?* (*see* Fig. 3.15)
  A ring-enhancing multilocular collection in the lateral pharyngeal space proximal to the bifurcation of the common carotid artery. Numerous intra-arterial calcifications are seen within the carotid vasculature.
- *What is the potential sequalae of this collection expanding?*
  Expansion of this infection collection could cause airway compromise and erosion of the carotid arteries. Extension into the internal carotid artery could result in a cerebrovascular accident.
- *What is your criteria for extubation?*

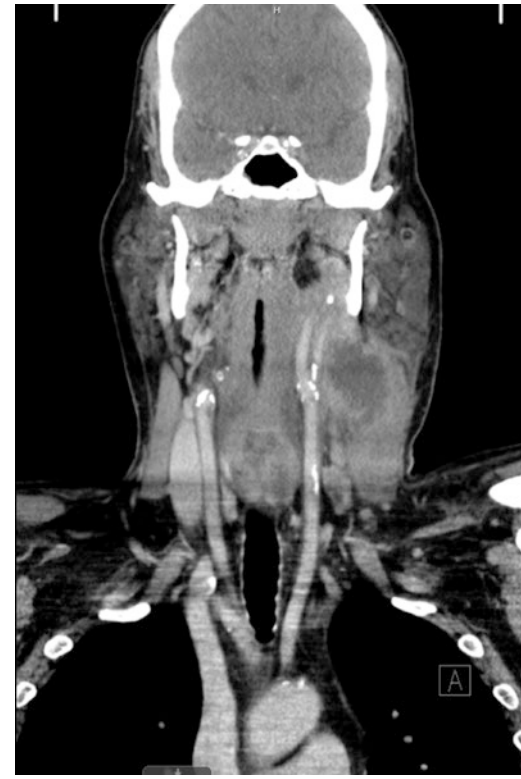

Fig. 3.15 Coronal CT with contrast level of carotid bifurcation. (Image courtesy of Dr. Damian Findlay)

Stable vital signs
Positive air leak test
Acceptable ventilatory readings (vital capacity >15 mg/kg, minute ventilation of 6–10 L/min, inspiratory pressures of >25 cm H_2O)
Normal arterial blood gases

Appendix 1. Bacteria Involved in Odontogenic Infections

Cell wall characteristics – gram negative vs. gram positive

Oxygen consumption: aerobic, anaerobic facultative

Aerobic: bacteria that utilize oxygen to generate ATP

- *Bacillus*
- *Pseudomonas*
- *Nocardia*
- *Mycobacteria*

Anaerobic: bacteria that can proliferate in low oxygen tension

- *Peptostreptococci* (also called *Anaerococcus* or *Parvimonas*)
- *Bacteroides*
- *Fusobacteria*
- *Prevotella*
- *Porphyromonas*
- *Actinomyces*
- *Actinobacillus*
- *Eikenella*
- *Veillonella*
- *Capnocytophaga*
- *Neisseria*

Facultative: bacteria that make ATP by aerobic respiration if oxygen is present but are capable of switching to fermentation or anaerobic respiration if oxygen is absent.

- *Staphylococcus*
- *Streptococcus*
- *Escherichia*
- *Listeria*
- *Lactobacillus*

Major Pathogens:

- *Viridans* group (facultative alpha-hemolytic streptococci)
- *Streptococcus milleri* group (subset of *Viridans* group)
  - *S. anginosus*
  - *S. intermedius*
  - *S. constellatus*
- *Peptostreptococcus* (anaerobic)
- *Prevotella* and *Porphyromonas* (anaerobic)
- *Fusobacteria* (anaerobic)

Appendix 2: Antibiotics

Beta-lactams

- Mechanism of action – beta-lactam antibiotics inhibit penicillin-binding proteins, which disrupt cell wall synthesis.
- Bactericidal.
- Penicillin G is no longer recommended for serious odontogenic infections due to the high number of bacteria involved in these infections that liberate beta lactamases.
- Penicillins (examples include penicillin, amoxicillin, dicloxacillin, oxacillin, nafcillin, piperacillin, ampicillin).
- Cephalosporins (examples include cephalexin, cefazolin, cefuroxime, ceftriaxone).
- Cephamycins (examples include cefoxitin and cefotetan).
- Carbapenems (examples include imipenem, meropenem, doripenem, ertapenem).
- Monobactams (e.g., aztreonam): treatment of gram negative, aerobic bacilli. Synergistic with aminoglycosides. No activity for anaerobic and gram positive bacteria.
- Beta-lactamase inhibitors – bind to the catalytic site of beta-lactamases to prevent hydrolysis of the beta-lactam (e.g., tazobactam, sulbactam, and clavulanate). Used in combination with a penicillin to cover bacteria that confer their resistance through liberation of beta lactamases. Examples include Unasyn® (ampicillin and sulbactam), Zosyn® (piperacillin and tazobactam), and Augmentin® (amoxicillin and clavulanate).

Macrolides

- Binds to the 50S ribosomal subunit and inhibits its bacterial protein synthesis. Examples include erythromycin, clarithromycin, and azithromycin.
- Bacteriostatic.
- Side effects – prolongation of the QT interval is of concern, especially when combined with other drugs that are metabolized by CYP3A4 in the liver microsomal system. Gastrointestinal side effects such as nausea and diarrhea are common.

Clindamycin (Cleocin®)

- Binds to the 50S ribosomal subunit and inhibits its bacterial protein synthesis. Its action is bacteriostatic or bactericidal depending on drug concentration, infection site, and organism.

- Part of the Lincosamides family.
- Good anaerobic coverage and excellent abscess and bone penetration.
- Does not cover *Eikenella corrodens*.
- *Pseudomembranous colitis* – common side effect
  - Treatment with cleocin and other antibacterial agents alters the normal flora of the large intestine that can lead to overgrowth of *C. difficile.*
  - *C. difficile* produces toxins A and B that cause disorganization of actin microfilaments leading to enterocyte cytoskeleton destruction and leaks between the tight junctions between enterocytes. Additionally, toxin A leads to proinflammatory cytokines that cause further intestinal mucosal damage.
  - Major side effect is antibiotic-associated colitis (AAC), which manifests itself as fever, abdominal pain, and foamy diarrhea that may be bloody.
  - First step is to discontinue use.
  - Stop any opiates or antidiarrheal medications.
  - Administration of fluids and correction of electrolytes.
  - Management includes discontinuing the offending antibiotic, fluid and electrolyte management, antibiotic treatment for *C. difficile*, and surgical evaluation as clinically indicated.
  - Antibiotic treatment is 10–14 days of metronidazole (500 mg three times daily) or oral vancomycin (125 mg four times daily). Fidaxomicin (200 mg PO BID) is now available, with decreased recurrence rates.
  - Antibiotic-associated colitis/fulminant colitis/toxic megacolon

    Usually occurs in elderly, extended hospital stay (greater than 2 weeks), exposure to IV antibiotics, and occurs in patients who underwent surgical procedures.

    See rapid spike in WBC to >20 cell/μL.

    Toxic megacolon manifests as abdominal pain, abdominal distension, fever, and extreme leukocytosis. The goal is to decompress the bowel within 24 hours or total colectomy is indicated.
  - Diagnosis of pseudomemnranous colitis is by assessing the presence of the *C. difficile* via. toxin assay from a stool sample via the cell cytotoxicity neutralization assay. Nucleic acid amplification tests and enzyme immunoassays to detect toxins A and B area also available.

Fluoroquinolones

- Bactericidal agents that inhibit bacterial enzymes (DNA gyrase and topoisomerase IV), which are involved in DNA replication. This inhibition results in damage to bacterial DNA and bacterial cell death.
- Fourth-generation fluoroquinolones have gram-positive and anaerobic coverage. Oral and IV bioavailability are equal. Examples include ofloxacin, ciprofloxacin, levofloxacin, moxifloxacin, and gemifloxacin.
- Side effects – chondrotoxicity, especially to growing cartilage. Avoid in children <18 years of age. Tendinitis/tendon rupture has been reported in patients over 60 years of age also. Many drug interactions via CYP3A4 which can worsen prolonged QT syndrome can lead to torsades des pointes and sudden cardiac death, fatigue, dizziness, skin rash, and diarrhea.

Dosages of Common Antibiotics

BETA-LACTAMS

- Pen VK
- 500 mg P.O. q6h
- Amoxicillin
- 500 mg P.O. q8h
- Amoxicillin–clavulanate (Augmentin®)
- 875 mg/125 mg P.O. q12h
- Pen G
- 4 million units IV q4h

- Ampicillin–sulbactam (Unasyn®)
- Dosage 1.5 or 3 g IV q6-8h

- Nafcillin (Unipen®)
- 500 mg IV q4h

- Dicloxacillin
- 250–500 mg P.O. q6h

- Piperacillin–tazobactam (Zosyn®)
- Dosage 1.5 or 3 g IV q6-8h

- Ertapenem (Invanz®)
- Dosage 1 g IV daily

- Cephalexin (Keflex®)
- 500 mg P.O. q6h
- Cefazolin (Ancef®)
- 1–2 g IV q8h

LINCOSAMIDES

- Clindamycin
- 600–900 mg IV q8h
- 300–450 mg P.O. q6h

MACROLIDES

- Erythromycin
- 250–500 mg P.O. q6h

- Clarithromycin (Biaxin®)
- 500 mg P.O. bid
- Azithromycin (Zmax®, Zithromycin®)
- Z-pack: 250 mg P.O. bid first day, 250 mg P.O. qday x 4 days
- May be prescribed as directed by doctor for a longer or shorter course.

FLUOROQUINOLONES

- Moxifloxacin (Avelox®)
- Oral 400 mg P.O. q24 hours
- IV: 400 mg P.O. q24 hours
- Levofloxacin (Levaquin®)
- 500 mg P.O. q24 hours

Antibiotic Prophylaxis

2007 American Heart Association now only recommends antibiotic prophylaxis in (Table 3.3) the following conditions:

1. Patients with prosthetic heart valves or who have had a heart valve repaired with prosthetic material.
2. A history of endocarditis.
3. A heart transplant with abnormal heart valve function.

Table 3.3 AHA guidelines for antibiotic prophylaxis for prevention of subacute bacterial endocarditis

Antibiotic regimen for dental procedures (30–60 minutes prior to procedure)			
Clinical scenario	Antibiotic	Adult	Pediatric
Not allergic to PCN and able to take oral fluids	Amoxicillin	2 g	50 mg/kg
Not allergic to PCN and unable to take PO	Ampicillin	2 g IM/IV	50 mg/kg IV/IM
PCN Allergic	Clindamycin Cephalexin Azithromycin Clarithromycin	600 mg 2 g 500 mg 500 mg	20 mg/kg 50 mg/kg 15 mg/kg 15 mg/kg
PCN allergic and unable to take PO	Clindamycin Cefazolin Cetriaxone	600 mg IV/IM 1 g IV/IM 1 g IV/IM	20 mg/kg IV/IM 50 mg/kg IV/IM 50 mg/kg IV/IM

4. Certain congenital heart defects including:
   - Cyanotic congenital heart disease (birth defects with oxygen levels lower than normal) that has not been fully repaired, including children who have had a surgical shunts and conduits.
   - A congenital heart defect that has been completely repaired with prosthetic material or a device for the first six months after the repair procedure.
   - Repaired congenital heart disease with residual defects, such as persisting leaks or abnormal flow at or adjacent to a prosthetic patch or prosthetic device.

2015 ADA guidelines for prosthetic joints: No association between dental procedures and prosthetic joint infections. No longer recommended, but clinicians may use their judgment after patient input in decision-making.

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