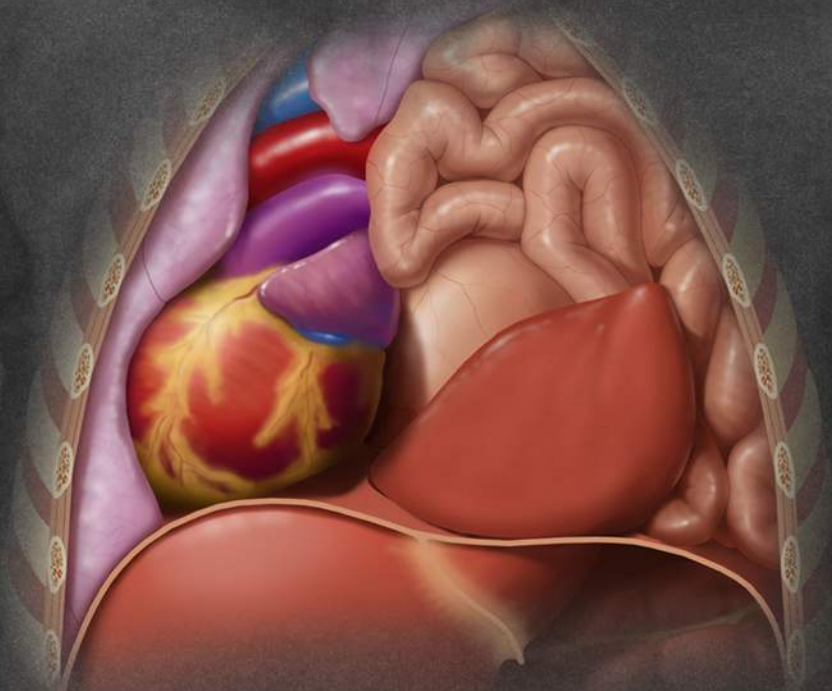
Diagnostic Imaging
Pediatrics

THIRD EDITION



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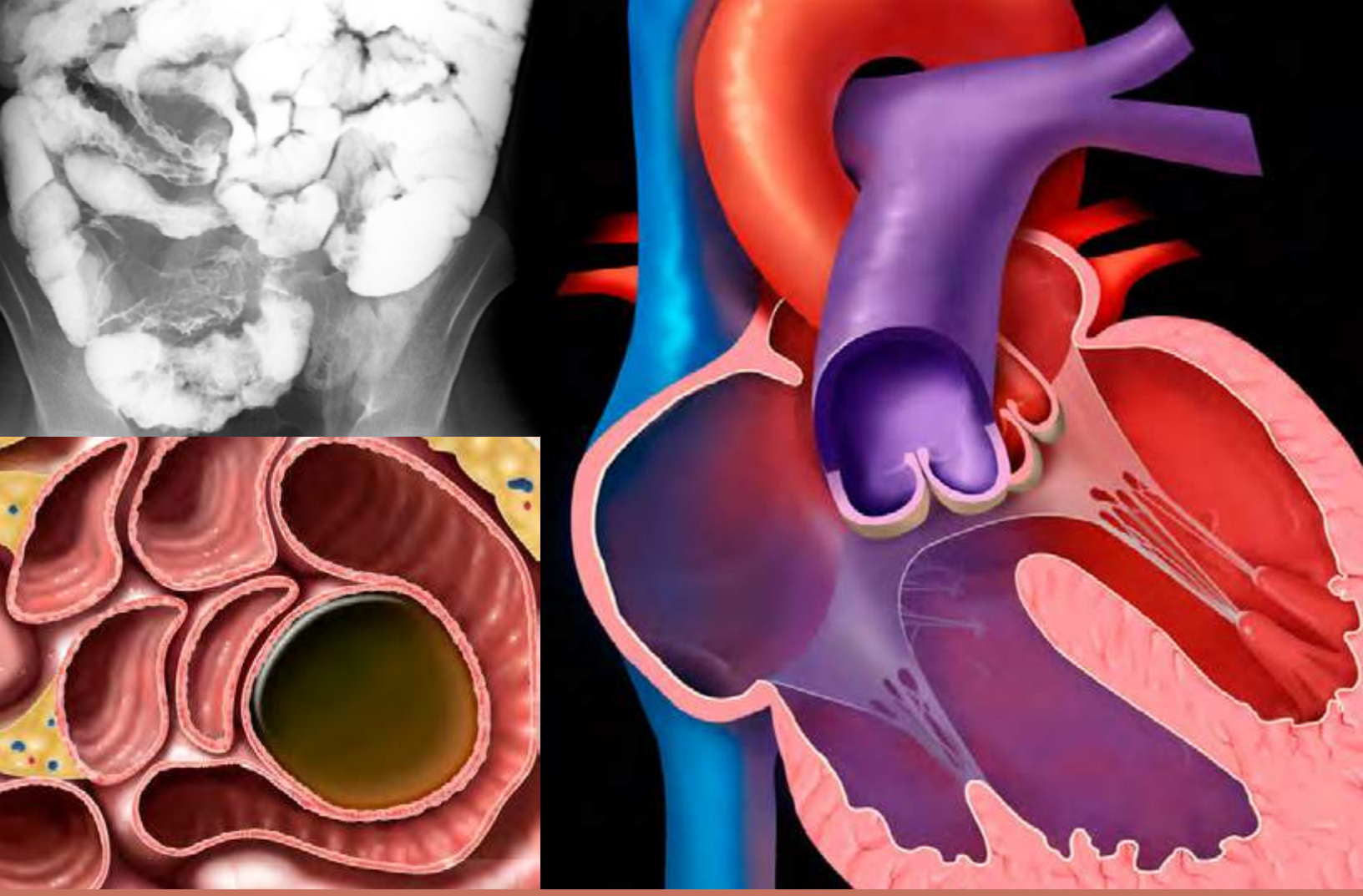

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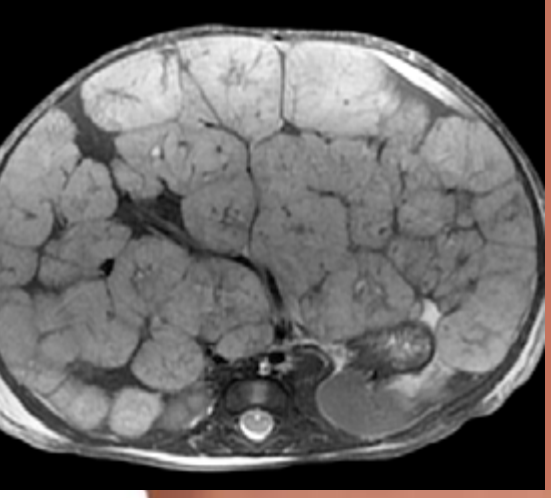

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Dedications

To Nan—the love of my life—I am bound to you through and through. Thank you so much for your support. This would not have been possible without you.

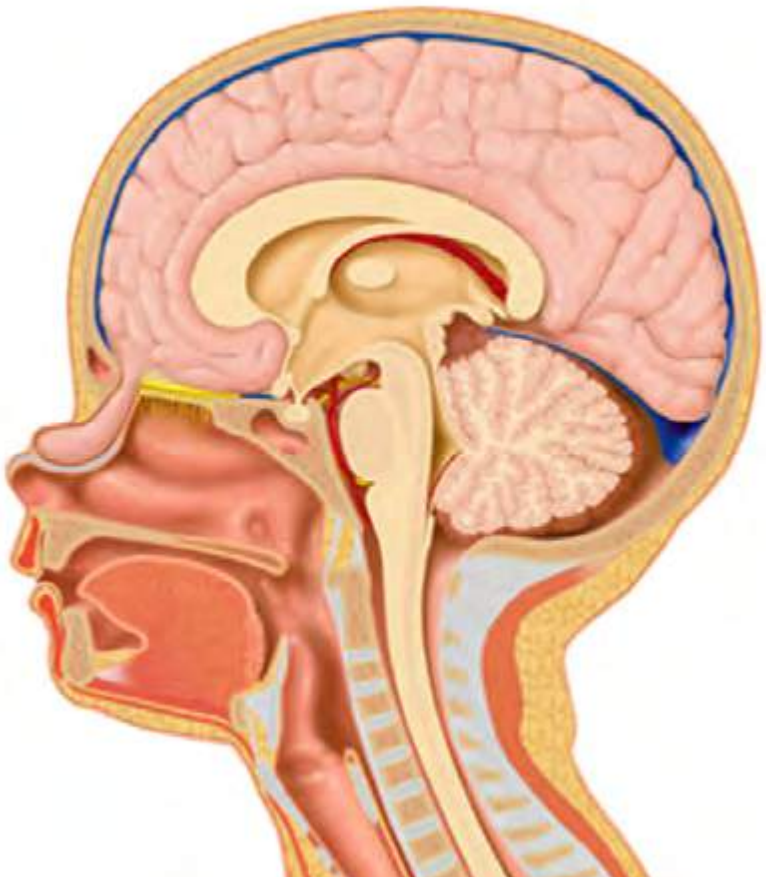
To Cora and Nate—I am so grateful to be your father. May I have taught you at least a fraction of the things you have taught me.

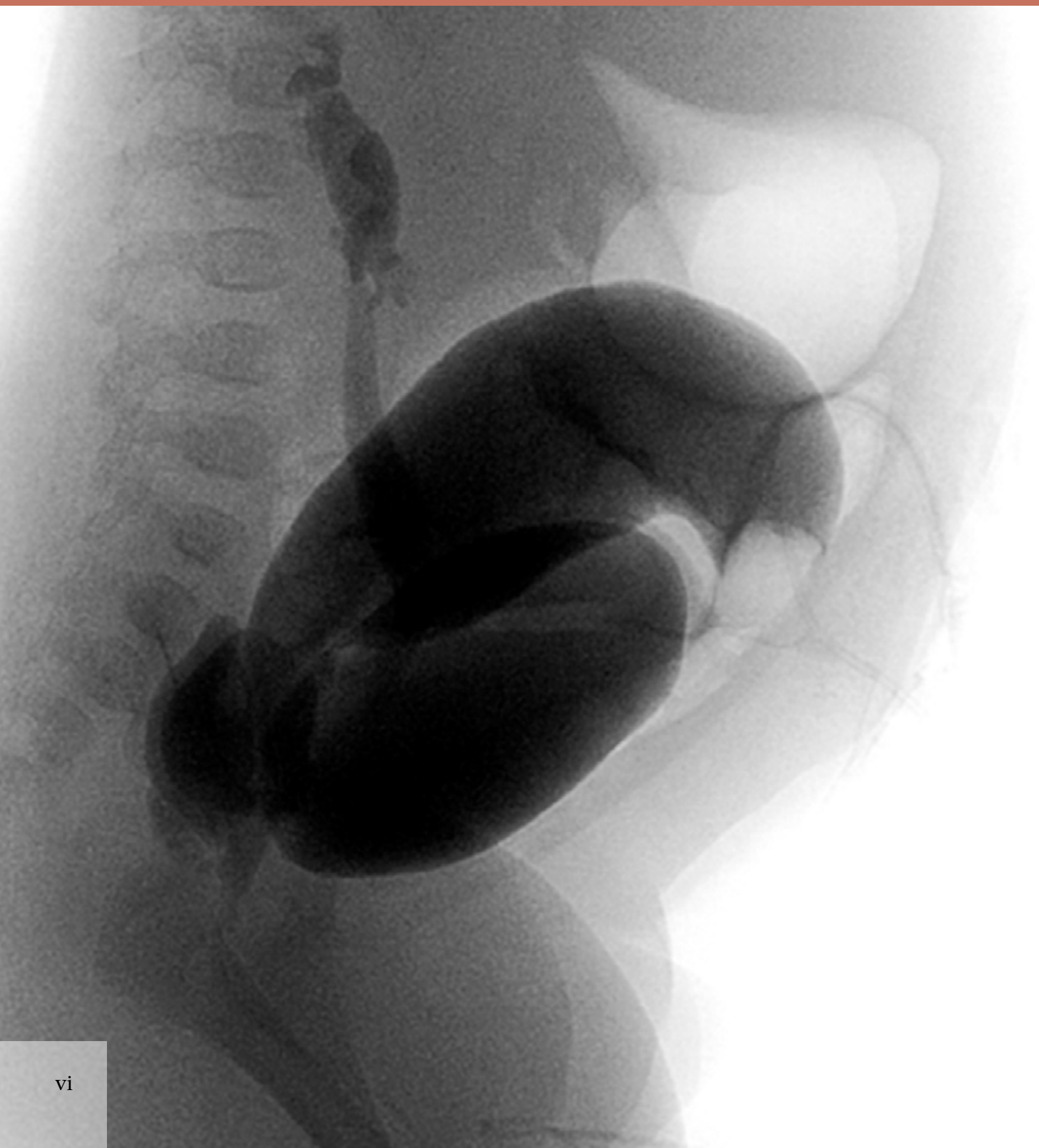
To my parents—thank you for your lifelong sacrifices and encouragement.

To my teachers—your enthusiasm and engagement with your patients and trainees have touched so many. May this text be another conduit of your passion and mercy.

To my patients and their families—let the physician not forget that none of this work matters apart from you. Your fight inspires daily.

ACM





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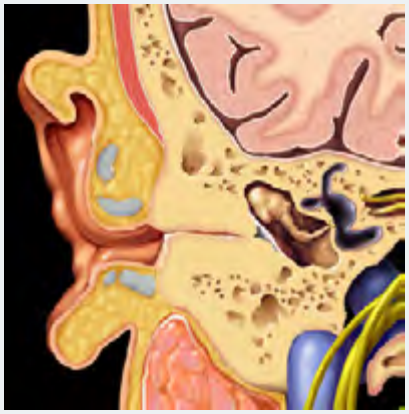

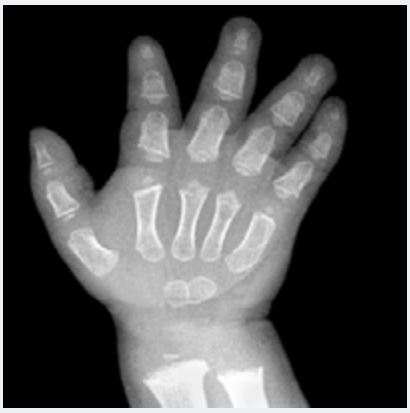

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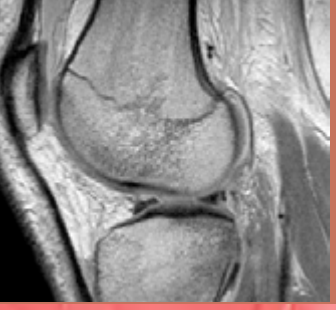

Preface

Welcome to the third edition of *Diagnostic Imaging: Pediatrics*. As in all of medicine, there has been substantial evolution in the understanding of pediatric disorders in the last five years, particularly with regards to molecular genetics, therapeutic options, clinical outcomes, & imaging manifestations of various diseases. In some cases, this has resulted in revised classifications & treatment pathways. Technical advances & refined research have also led to modified diagnostic algorithms. Our pediatrics team has been excited to update this text accordingly, meticulously revising the previous edition and adding over 70 new topics and more than 2,000 new print & online images.

It has been my goal, however, not just to update the text with the latest research available, but also to maximize the teaching impact of this work. I have desired to create a text from which anyone can learn. That is, one that is simultaneously rich with relevant details and accessible to all levels of training, from the medical student to the experienced attending physician. We have specifically sought to optimize the Key Facts sections for the quick review of information critical to each diagnosis. Additionally, we have enhanced the "Imaging Recommendations" and "Diagnostic Checklist" segments of most chapters to enrich the "viewbox teaching" for each topic (with the author imparting to you a few supplementary or summary pearls of wisdom by which to make the correct diagnosis).

I offer many thanks to the authors of this text—I am honored to have led such a distinguished group of colleagues on this journey. Many of the contributors are well-established experts in their pediatric subspecialties. Others have an intense interest and impressive awareness of their fields given an earlier career stage. But each author was hand-selected for his or her distinct knowledge base, clinical and academic experience, and passion for teaching.

I would also like to thank the fantastic staff at Elsevier (especially Nina!) for their guidance, support, and seemingly tireless efforts that have helped bring to life my vision for this book.

I must also give special thanks to my family, whose patience, encouragement, and love enabled the creation of this text.

And thank you, reader, for choosing this product—may it daily enhance your care of children no matter the location or type of your practice.

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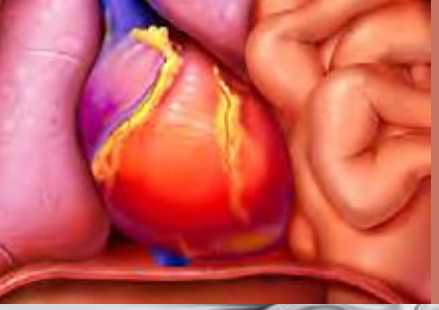

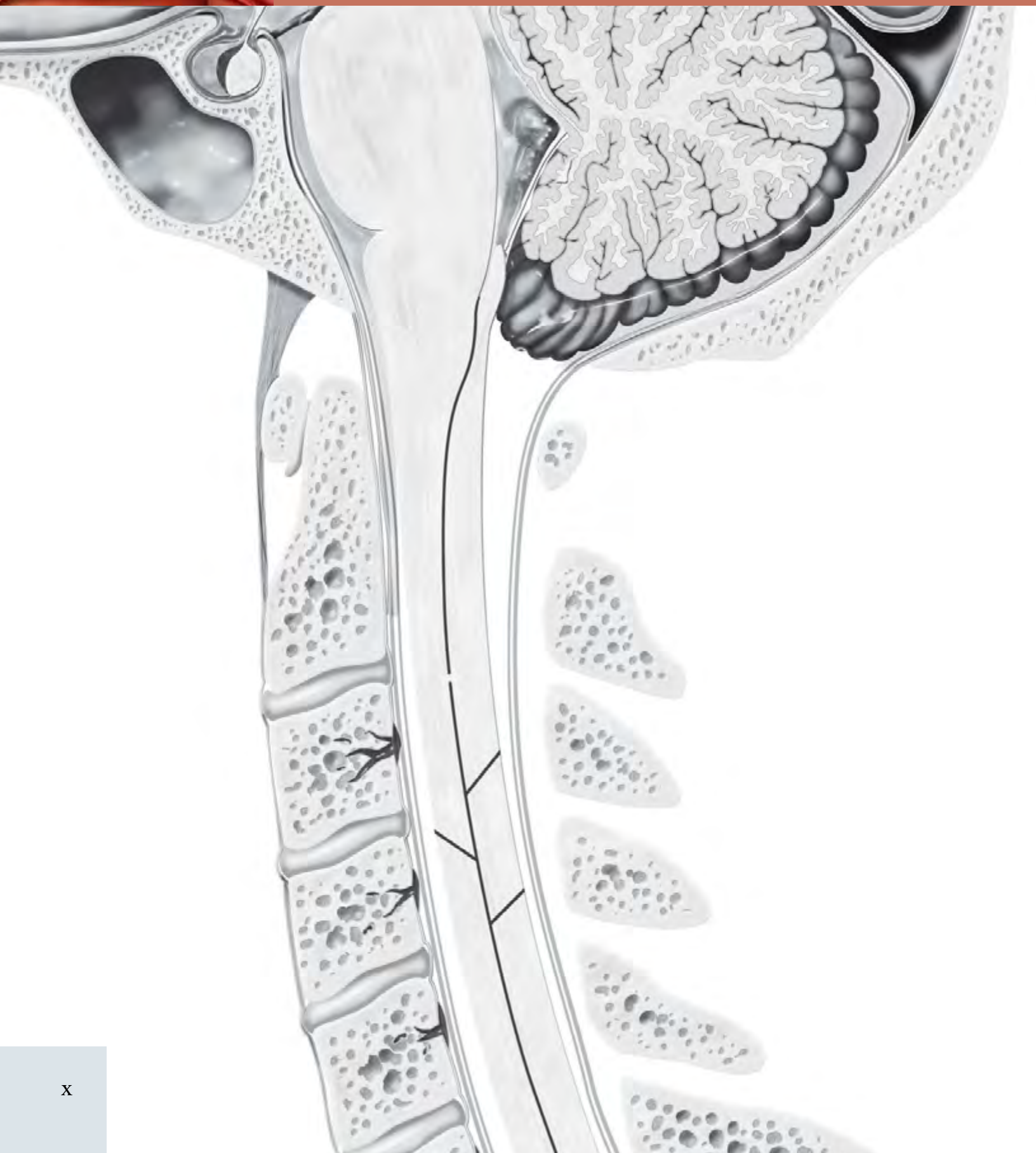

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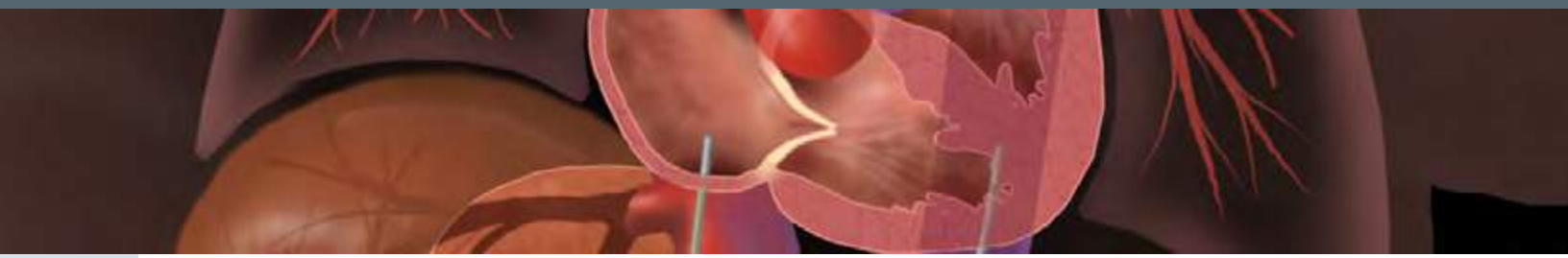

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SYNDROMES WITH CRANIOFACIAL INVOLVEMENT

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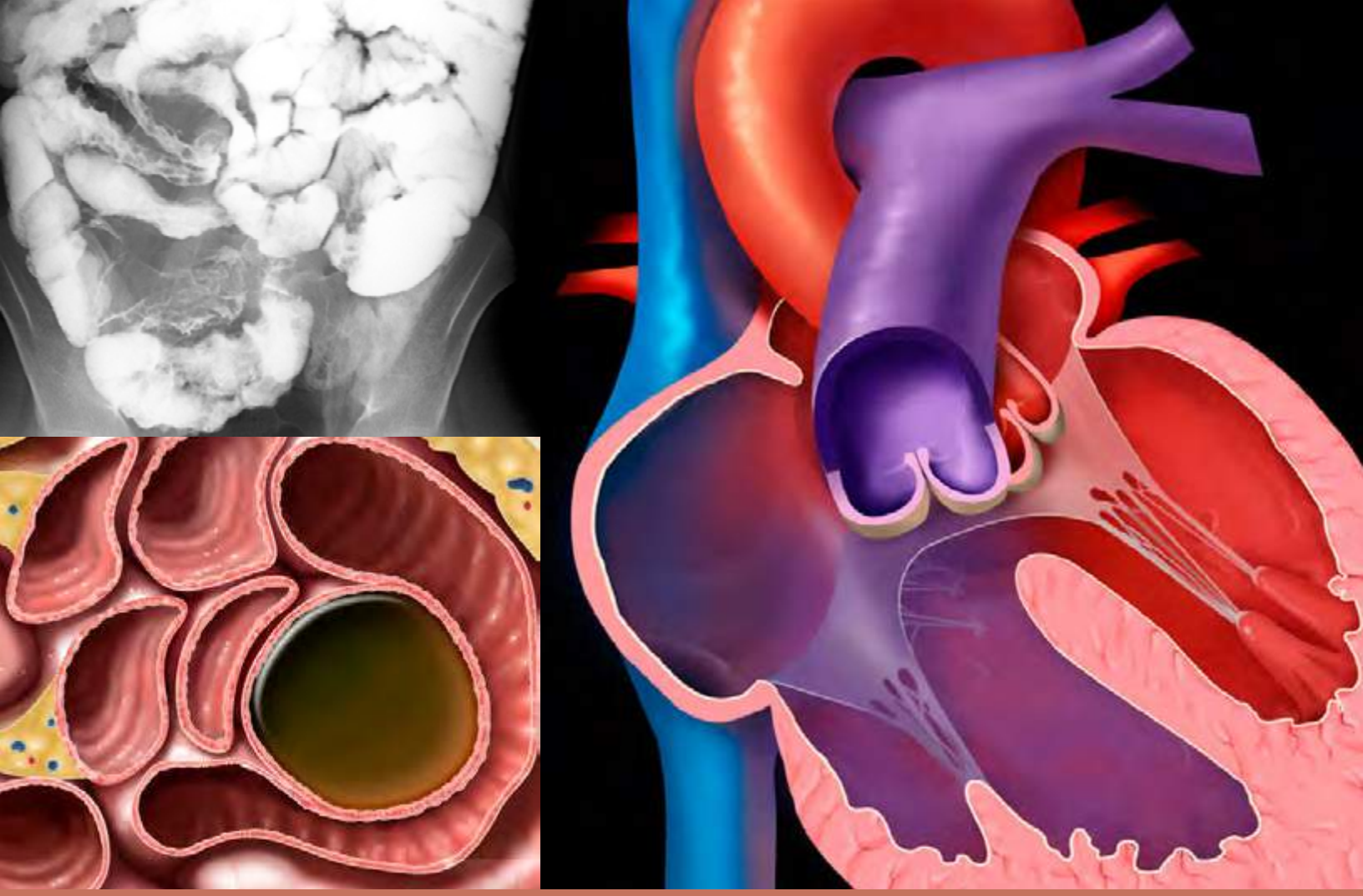

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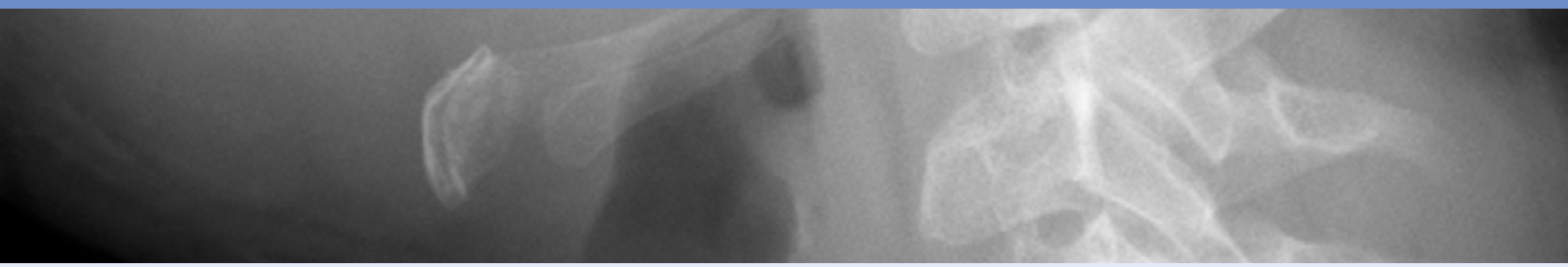
SECTION 1

Airway



Introduction

Anatomically & functionally, the pediatric airway can be divided into upper & lower segments at the glottis (larynx) or large & small airways at the transition from the cartilage-containing bronchi proximally to the distal airways that lack supporting cartilage. The superimposed disease processes may be extrinsic or intrinsic, & they may manifest as acute or chronic airway compromise at a variety of ages. The general categories of diseases listed below are not always distinct, with some processes affecting multiple levels or presenting later in childhood despite an underlying congenital issue.

Anatomic Considerations

The oral cavity is the portion of the airway superior to the tongue & anterior to the soft palate. The nasopharynx is the portion of the airway superior to the soft palate & anterior to the adenoids. The oropharynx extends between the soft palate & the tip of the epiglottis. The hypopharynx extends inferior to this level & includes the remainder of the pharynx above the glottis & esophagus.

Retropharyngeal soft tissues: The retropharyngeal soft tissues should not exceed the thickness of 1 vertebral body width when the soft tissues are measured somewhere between the level of the adenoids superiorly & epiglottis inferiorly. Below the epiglottis, the esophagus is also present, & the soft tissues are normally thicker. "Pseudothickening" of the retropharyngeal soft tissues can occur in young children when there is poor inspiration, or if the neck is not fully extended.

Normal upper airway motion: On cine images, the upper airway of a normal sleeping child is relatively stationary. The walls of the upper airway should not move by more than several mm. The normal airway never demonstrates intermittent complete collapse.

Epiglottis: The normal epiglottis has very thin borders. Thickening results in a thumbprint appearance. The "omega" epiglottis is a term for a normal variant that occurs at imaging when the epiglottis is viewed obliquely & the left & right sides of the cylindrical epiglottis do not overlap perfectly.

Aryepiglottic folds: These are mucosal folds that extend from the epiglottis superiorly to the arytenoid cartilages posteroinferiorly. On the lateral view, they should appear thin & flat or convex inferiorly. With inflammation of the epiglottis, they become markedly thickened & convex superiorly.

Subglottic trachea: On the frontal view, the subglottic trachea should have symmetric lateral convexities ("shoulders"). With abnormal inflammation in this area, the convexities become concave (i.e., the shoulders are lost). This loss of the shoulders has been likened to a church steeple.

On radiography, the trachea should be consistent in diameter for its entire length & well visualized on frontal & lateral views. The normal left aortic arch should gently push the trachea toward the right & mildly indent the trachea on the left.

On axial cross-sectional imaging, the intrathoracic airway should be round or oval in configuration (& slightly greater in AP diameter). The posterior aspect of the trachea is noncartilaginous & may have a linear or flat appearance, especially in expiration. A very small & round trachea is suggestive of complete tracheal rings. A trachea that is flattened (small anterior to posterior diameter) is indicative of extrinsic compression or tracheomalacia.

Congenital Airway Obstructions

Within a short timeframe, the newborn makes the conversion from complete placental support as a fetus to extracting sustenance from the surrounding environment, including oxygen in the air. A normal caliber & reliably patent conduit (airway) from the nostrils to the alveoli is required for this transition. The lack of such a conduit will prevent a successful changeover & require emergent intervention in the delivery suite. Critical anomalies that compromise this conduit are often detected prenatally by secondary findings of a large extrinsic cervical mass (such as a teratoma) or abnormally dilated lungs with diaphragm eversion (as seen in CHAOS). In these circumstances, careful planning for airway management in the delivery suite is required, often utilizing the ex utero intrapartum therapy (EXIT) procedure that allows the airway to be secured while the newborn is maintained on placental circulation.

Most congenital airway anomalies are not immediately fatal & only manifest at times of feeding or stress. Lesions involving the nasal airway commonly present during feedings in the newborn period as young infants are obligate nose breathers. Typical such anomalies include choanal atresia, pyriform aperture stenosis, & bilateral nasolacrimal duct mucoceles.

Infectious Causes of Airway Compromise

This differential diagnosis can be narrowed by age of presentation & includes croup (mean age: 1 year), epiglottitis (postvaccine era mean age: 14.6 years), exudative tracheitis (mean age: 6-10 years), & retropharyngeal abscess (mean age: 6-12 months).

Noninfectious Intrinsic or Intraluminal Obstructions

A foreign body should be considered in any child who has the new onset of airway symptoms, particularly after an episode of choking. Secondary manifestations of air-trapping or atelectasis may be the only radiographic clue to an airway blockage if the foreign body is not radiopaque compared to the surrounding soft tissues. While expiratory or decubitus views may be helpful, the clinician should have a low threshold for CT or bronchoscopy in the correct setting.

Infantile hemangiomas of the airway are most commonly subglottic & present with stridor & asymmetric airway narrowing. CECT (which is rarely performed) will show eccentric, lobular, vigorously enhancing tissue partially effacing the airway.

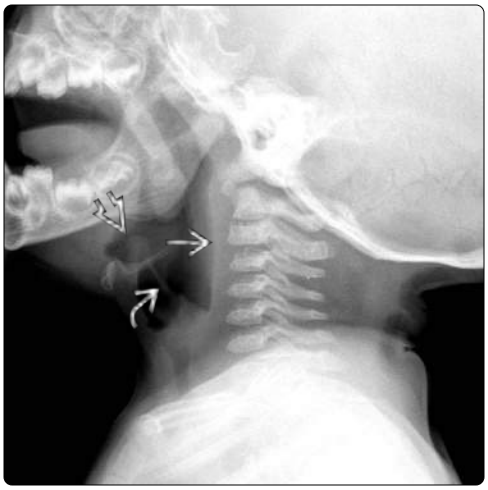
Tracheobronchomalacia (or abnormal collapsibility of the airway) is common & may be 1° or 2° (i.e., associated with extrinsic anomalies). Rings of complete cartilage that result in a round small caliber trachea are often associated with abnormal branching patterns & a pulmonary sling.

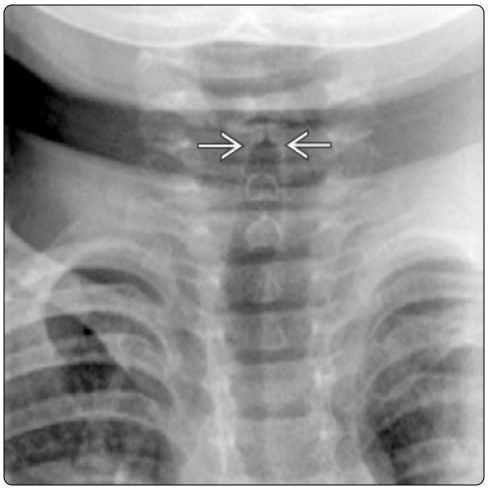
Extrinsic Compression of Lower Airway

This differential diagnosis includes vascular rings, midline descending aorta, thoracic deformity, & mediastinal masses.

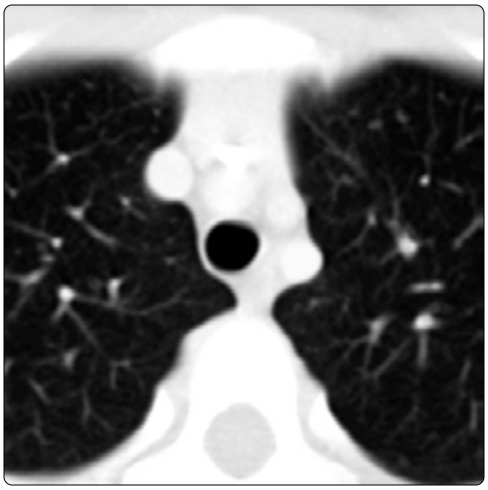
Obstructive Sleep Apnea (OSA)

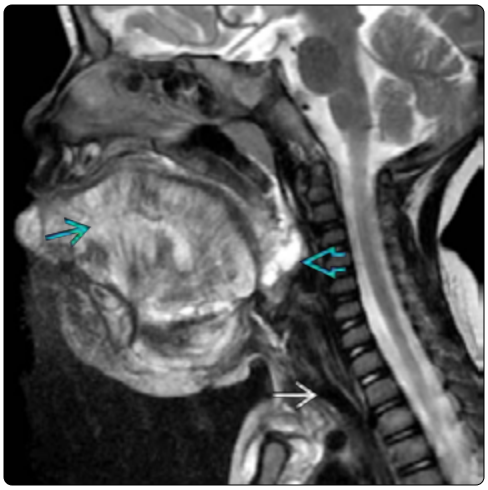
Most children with OSA are otherwise normal & have enlarged adenoid & palatine tonsils. Subgroups of children with more complex anatomic & dynamic (i.e., increased airway collapsibility) issues may benefit from MR sleep study evaluation, as may children with recurrent OSA after surgery.



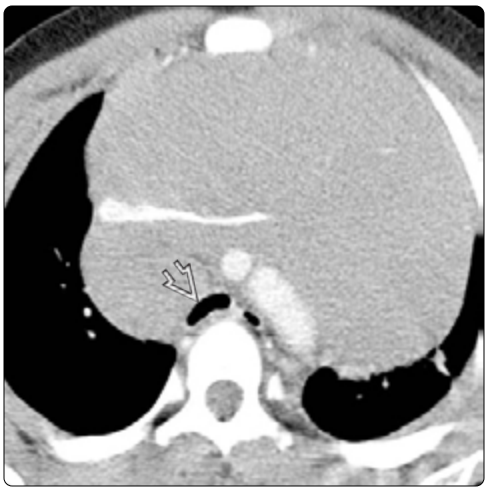


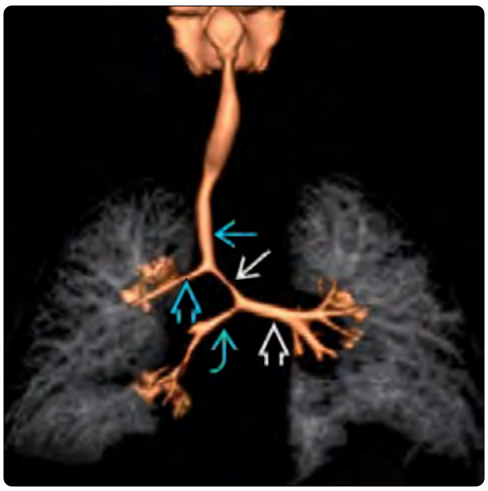
(Left) *Lateral radiograph of a normal airway shows a "thin" & well-defined epiglottis. Note the normal retropharyngeal soft tissue width & thin aryepiglottic folds.* **(Right)** *AP radiograph of a normal airway shows normal "shoulders" or lateral convexities in the subglottic region.*





(Left) *Axial CECT of a normal trachea shows a normal round morphology of the tracheal lumen. The posterior wall may flatten slightly with expiration.* **(Right)** *Sagittal T2 MR in a 17-month-old patient with an extensive facial lymphatic malformation shows marked infiltration of the tongue, floor of mouth tissues, & soft palate by the lesion, resulting in complete effacement of the oral cavity, oropharynx, & upper hypopharynx. A tracheostomy is partially visualized.*





(Left) *Axial CECT in a child with lymphoma shows a large mediastinal mass with a flattened appearance of the trachea (typical of extrinsic compression).* **(Right)** *Anterior view of a 3D NECT of the airways shows a round, narrow caliber distal trachea, typical of complete cartilage rings. There is an isolated right upper lobe bronchus arising from the trachea and leaving a narrowed intermediate left bronchus, which then gives rise to the left main bronchus & a right bridging bronchus.*

Expiratory Buckling of Trachea

KEY FACTS

TERMINOLOGY

- Intermittent normal change in transverse & craniocaudal configuration of trachea in infants during expiration

IMAGING

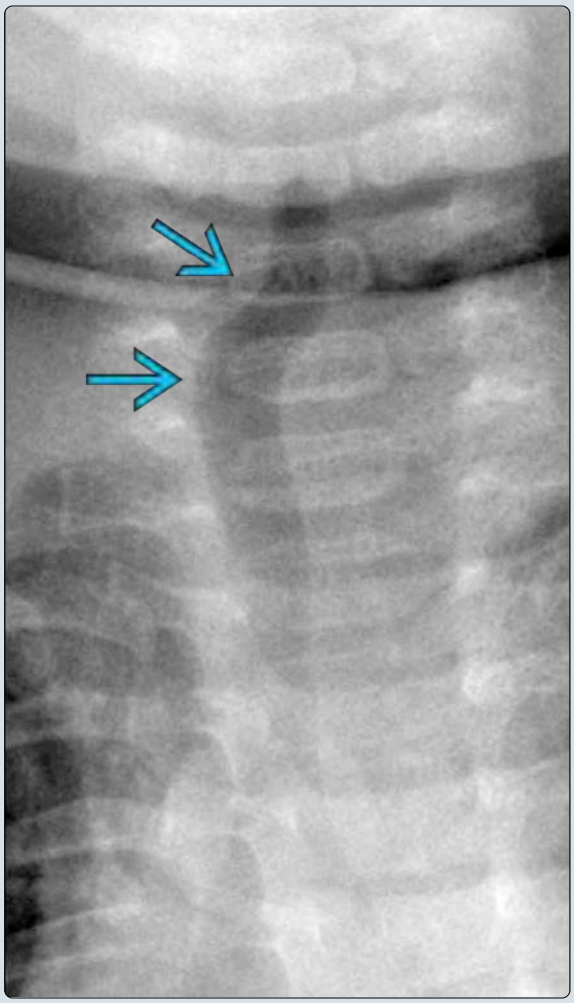
- On AP view, trachea is normally straight vertically in older children & adults throughout respiratory cycle
- In infants, trachea is normally straight during inspiration but changes with expiration
  - Focal shortening, crinkle, bend, or curve at/above thoracic inlet without caliber change
  - Directed toward right in patients with left aortic arch
    - Buckling toward left suggests right aortic arch
  - Trachea becomes straight again with inspiration
- No need to repeat radiograph

TOP DIFFERENTIAL DIAGNOSES

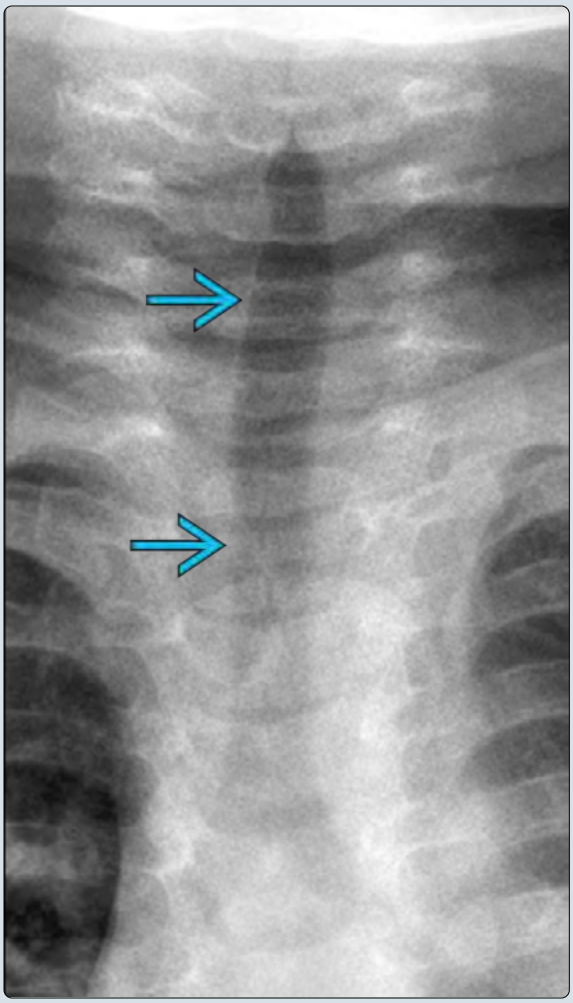
- Croup: Symmetric narrowing of subglottic trachea in young child with characteristic "barky" cough
- Infantile hemangioma: Persistent asymmetric tracheal narrowing by intraluminal benign vascular neoplasm
  - Often associated with cutaneous infantile hemangioma in "beard" distribution
- Tracheomalacia: Abnormal dynamic tracheal collapse in anterior to posterior dimension (not transverse)
  - Static lateral view may show caliber narrowing; dynamic change confirms tracheomalacia rather than fixed stenosis or compression
- Compression by extrinsic mass or aberrant vessel
  - Persistent focal airway narrowing with deviation away from mass/vessel; mass may enlarge mediastinum

CLINICAL ISSUES

- Incidental finding on chest or airway radiographs if morphology & patient age correct
- Does not cause symptoms that lead to imaging



AP radiograph of the airway in an 8-month-old patient shows the typical configuration of expiratory tracheal buckling; the trachea at & just above the thoracic inlet demonstrates a focal bend toward the right ⇨ but does not demonstrate narrowing.



AP radiograph in an 8-month-old patient during inspiration shows a trachea that is relatively straight vertically ⇨.

Pseudothickening of Retropharyngeal Tissues

KEY FACTS

TERMINOLOGY

- Transient thickening of normal retropharyngeal soft tissues of infant on lateral airway radiograph
  - "Swelling" with expiration or poor extension
  - Resolution with inspiration & adequate extension
- Contributing factors to this appearance include
  - Relatively short necks of infants & young children which lead to poor positioning for airway radiographs
  - Relatively long expiratory component of crying also challenges acquisition during maximal inspiration

IMAGING

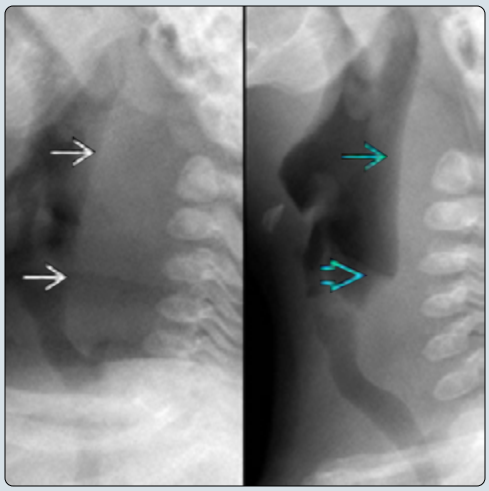
- Generalized thickening/bulging of prevertebral soft tissues
  - ± retention of normal "step-off" at junction of hypopharynx & cervical esophagus
    - Persistent "step-off" favors pseudothickening over true retropharyngeal pathology
- Resolves on repeat lateral radiograph with improved inspiratory timing of exposure & ↑ neck extension
- Observation of dynamic airway changes under fluoroscopy can confirm intermittent thickening & resolution
  - Use "last image capture/image hold" for documentation

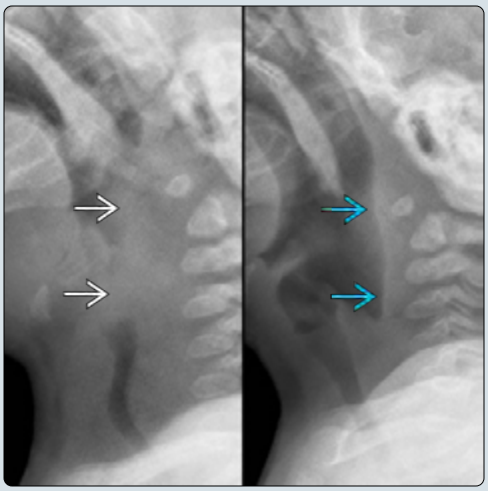
TOP DIFFERENTIAL DIAGNOSES

- Retropharyngeal cellulitis/abscess
  - Convex generalized bulging of prevertebral soft tissues persists despite inspiration & neck extension
  - Often lose normal "step-off" at hypopharyngeal-esophageal junction
- Cervical spine pathology
  - Trauma, inflammation/infection, or neoplasm → prevertebral soft tissue swelling
  - ± radiographically visible bony abnormality

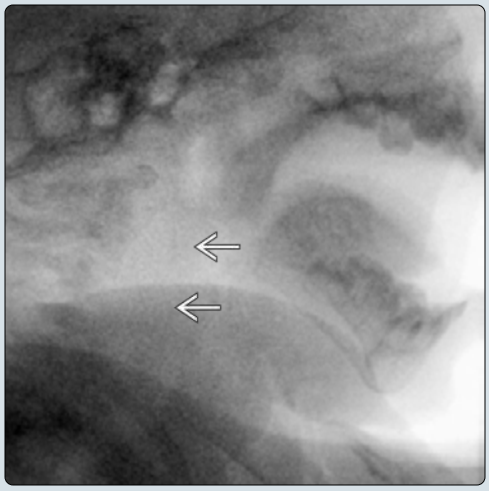
CLINICAL ISSUES

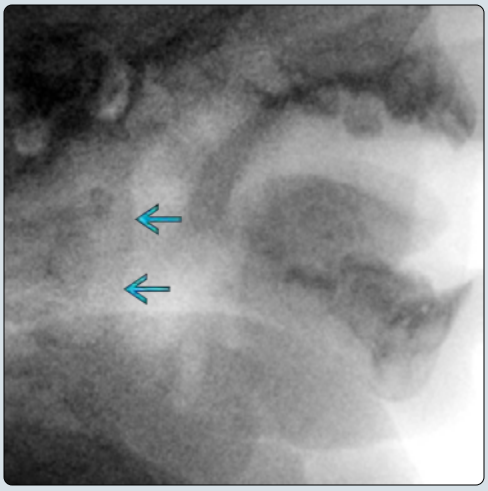
- Uncommon in children > 2 years of age
- Unlike true pathology, pseudothickening does not cause characteristic signs/symptoms





(Left) *Lateral airway radiographs in an infant show pseudothickening of the prevertebral soft tissues initially ➡ with resolution upon improved neck extension ⇨. Note the normal "step-off" at the hypopharyngeal-esophageal junction ⇨ on the 2nd image.* **(Right)** *Lateral airway radiographs in a 4 month old show dynamic protrusion ➡ & collapse ⇨ of the retropharyngeal tissues between expiration (left) & inspiration (right). The 2nd image confirms a normal thickness & morphology of the prevertebral tissues.*





(Left) *Lateral fluoroscopic "image hold" in an 11 month old with stridor & suggested retropharyngeal thickening on preceding radiographs (not shown) demonstrates bulging of the prevertebral soft tissues ➡ during expiration.* **(Right)** *Lateral fluoroscopic "image hold" in the same patient during inspiration shows normal collapse of the prevertebral soft tissues ⇨, confirming pseudothickening on the initial image.*

Congenital Nasal Pyriform Aperture Stenosis

KEY FACTS

TERMINOLOGY

- Congenital narrowing of anterior bony nasal passageway [pyriform aperture (PA)]

IMAGING

- Best tool: Bone CT in axial & coronal planes
  - Medial deviation of anterior maxillae with thickening & convergence of nasal processes
    - PA axial width < 11 mm in term infant is diagnostic
  - Triangle-shaped hard palate on axial images
  - Abnormal maxillary dentition: Solitary median maxillary central incisor (SMMCI) in 75%

TOP DIFFERENTIAL DIAGNOSES

- Nasolacrimal duct mucoceles
- Choanal stenosis/atresia

PATHOLOGY

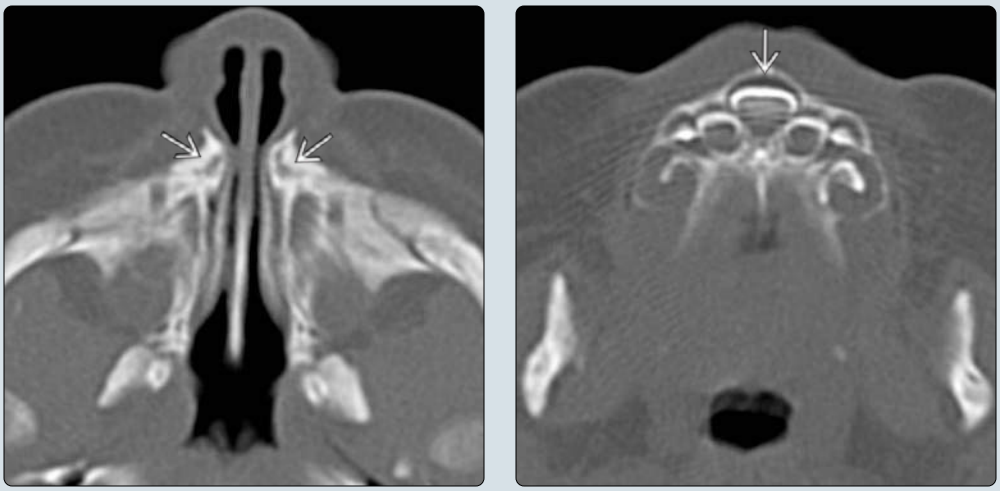
- Congenital nasal pyriform aperture stenosis (CNPAS) without SMMCI: Almost always isolated
- SMMCI in 75% of CNPAS
  - Associated with holoprosencephaly, pituitary-adrenal axis dysfunction, microcephaly, many other findings

CLINICAL ISSUES

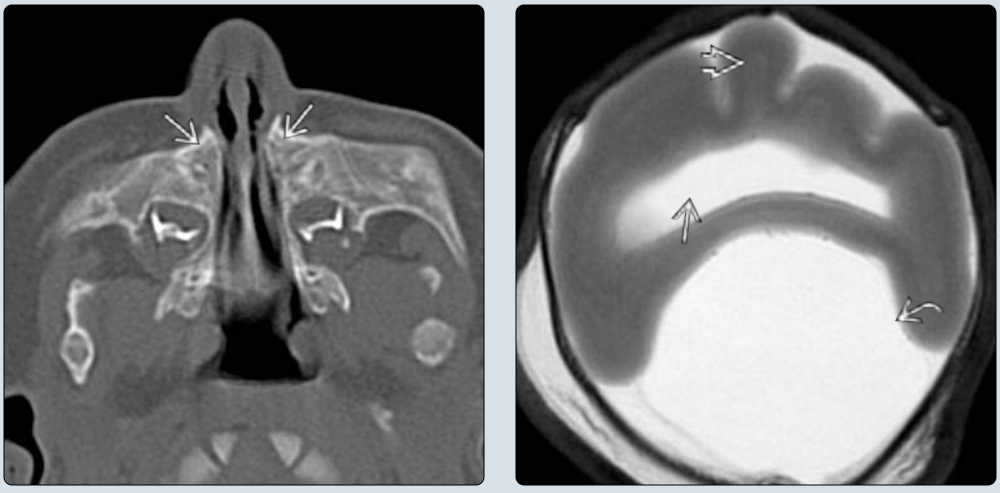
- Respiratory distress in newborn/infant
  - Symptoms more pronounced with feeding
  - Breathing problems may be triggered by URI
  - Narrow nasal inlet on clinical exam
- Can mimic choanal atresia/stenosis clinically
  - CNPAS 1/5 to 1/3 as common
- Nasal cavity eventually grows; mild cases may improve
- Surgery for persistent respiratory difficulties & poor weight gain; PA width < 5.7 mm may predict surgical need

DIAGNOSTIC CHECKLIST

- Bone CT to confirm/characterize bony narrowing & identify dental/palatal abnormalities
- Brain MR if SMMCI to exclude midline brain anomalies



(Left) *Axial bone CT in a newborn shows the typical features of congenital nasal pyriform aperture stenosis. There is overgrowth of the anterior maxillae ➡ with marked narrowing of the pyriform aperture/nasal inlet.* **(Right)** *Axial bone CT at the level of the anterior maxilla in the same patient shows a solitary median maxillary central incisor (or "megaincisor") ➡. This is a common associated finding in children with congenital pyriform aperture stenosis, with or without midline intracranial abnormalities.*



(Left) *Axial bone CT in a newborn with respiratory distress shows thickening of the anterior & medial aspects of the maxillae ➡ causing pyriform aperture stenosis. This child did not have an associated solitary median maxillary central incisor or intracranial anomaly.* **(Right)** *Axial T2 brain MR necropsy image in a child with a solitary median maxillary incisor (not shown) reveals a monoventricle ➡, absence of frontal lobe cleavage ➡, & a large dorsal midline cyst ➡, findings that are all typical of alobar holoprosencephaly.*

TERMINOLOGY

Abbreviations

- Congenital nasal pyriform aperture stenosis (CNPAS)

Definitions

- Pyriform aperture (PA): Single triangular bony opening of anterior skull to nasal passages
  - Anterior nasal passages separated by septal cartilage
- CNPAS: Narrowing of single bony opening by characteristic bilateral maxillary bony anomalies

IMAGING

General Features

- Best diagnostic clue
  - Medialization & thickening of anterior maxillae with narrowing of anterior nasal airway
- Size
  - PA size in CNPAS
    - Axial width < 11 mm in term infant diagnostic (normal: 13.4-15.6 mm)
    - Area: 0.2-0.4 cm² (normal: 0.7-1.1 cm²)

CT Findings

- Bone CT
  - Narrowed bony nasal inlet
    - Medial deviation of lateral walls of PA (anterior maxillae) ± thickened & converging bony nasal (frontal) processes
  - Triangle-shaped hard palate on axial images
    - Bony ridge along oral surface of hard palate on coronal images
  - ± abnormal maxillary dentition
    - Fused or malaligned central & lateral incisors
    - Solitary median maxillary central incisor (SMMCI) in 75%
  - Posterior choanae normal in caliber

Imaging Recommendations

- Best imaging tool
  - Bone CT to confirm/characterize bony narrowing & identify dental/palatal abnormalities
  - Brain MR recommended in cases of SMMCI to exclude midline brain anomalies
- Protocol advice
  - Bone CT with axial & coronal reformatted images
    - Cover from tips of incisors through nasal cavity
    - Contrast unnecessary

DIFFERENTIAL DIAGNOSIS

Nasolacrimal Duct Mucoceles

- Obstruction of distal nasolacrimal ducts by bulging cysts at inferior meatus that narrow anterior nasal cavity
- Bony aperture normal

Choanal Stenosis/Atresia

- Narrow or occluded posterior nasal passage: Membranous, osseous, or mixed
- Anterior nasal passage normal in caliber

PATHOLOGY

General Features

- Etiology
  - 2 theories of pathogenesis
    - Deficiency of primary palate derived from midline mesodermal tissue
      - Embryologically, medial maxillary swelling forms structures of primary palate, including 4 incisors
      - Primary palatal deficiency → narrowed anterior nasal cavity, abnormal incisors, & triangular palate
      - Mesoderm thought to have inductive effect on forebrain, hence association of SMMCI syndrome with holoprosencephaly
    - Overgrowth or dysplasia of nasal processes of maxilla
- Associated abnormalities
  - CNPAS without SMMCI almost always isolated
  - SMMCI syndrome (75% of CNPAS cases) with variable presence of
    - Semilobar or alobar holoprosencephaly
    - Endocrine dysfunction of pituitary-adrenal axis → short stature, ambiguous genitalia
    - Microcephaly & intellectual disability

CLINICAL ISSUES

Presentation

- Most common signs/symptoms
  - Respiratory distress, especially with feeding (as young infants are "obligate nasal breathers")
    - May be triggered by upper respiratory infection that further compromises narrowed airway
    - Can mimic choanal atresia/stenosis
  - Narrow nasal inlet on clinical exam

Demographics

- Age
  - Newborns or infants in 1st few months of life
- Epidemiology
  - Congenital airway obstruction affects 1 in 5,000 infants
    - Majority due to choanal atresia
    - CNPAS 1/5 to 1/3 as common as choanal atresia

Treatment

- Mild cases may be treated conservatively with special feeding techniques as nasal cavity eventually grows
- Surgical intervention in patients with persistent respiratory difficulty & poor weight gain
  - PA width < 5.7 mm in neonate may correlate with need for surgical intervention
  - Resection of anteromedial maxillae ± anterior aspect of inferior turbinates + reconstruction anterior nasal orifice

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Nasolacrimal Duct Mucocele

KEY FACTS

TERMINOLOGY

- Synonym: Congenital dacryocystocele

IMAGING

- Well-defined, cystic medial canthal mass in continuity with enlarged nasolacrimal duct (NLD) in newborn
  - Unilateral or bilateral
- Absent or minimal wall enhancement (unless infected)
- Coronal/sagittal reformatted images show continuity of proximal cyst at lacrimal sac with distal inferior meatus cyst through dilated NLD

TOP DIFFERENTIAL DIAGNOSES

- Orbital dermoid & epidermoid
  - Lateral > medial canthus
- Acquired dacryocystocele
  - Typically posttraumatic, usually adults

PATHOLOGY

- Tears & mucus accumulate in NLD with imperforate Hasner membrane (i.e., distal duct obstruction)
- Most common abnormality of infant lacrimal apparatus

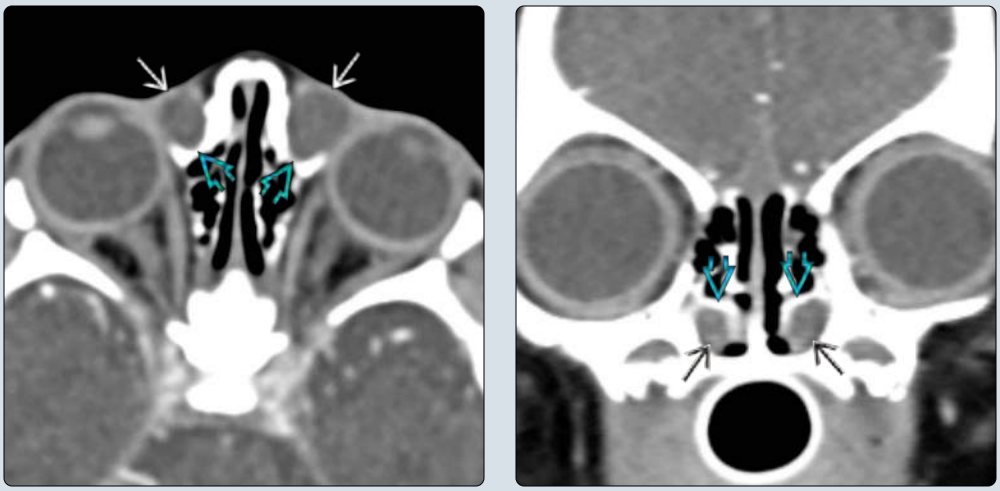
CLINICAL ISSUES

- Proximal cyst: Small, round, bluish, medial canthal mass identified at birth or shortly thereafter; ± cellulitis
- Distal cyst: Nasal airway obstruction with respiratory distress if bilateral (especially during feeding)

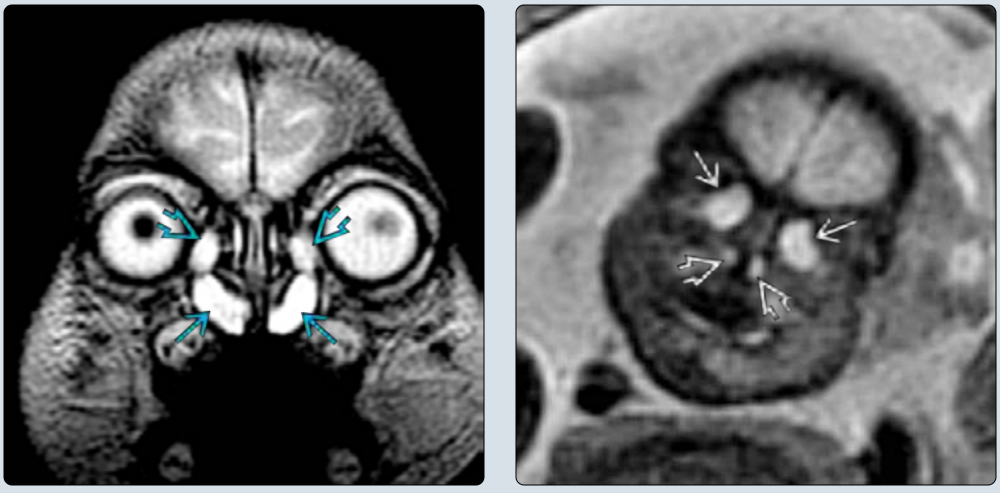
DIAGNOSTIC CHECKLIST

- Cross-sectional imaging evaluates extent of lesion along lacrimal apparatus & excludes other sinonasal causes of respiratory distress in newborn
- Comment on full extent of lesion from medial canthus to inferior meatus
- Exclude contralateral lesion

(Left) *Axial CECT in a 4 day old with bluish bilateral medial orbital swelling & left purulent drainage shows bilateral lacrimal sac enlargement ➡. Note also the bilateral lacrimal sac fossae splaying ⇨. (Right) Coronal CECT in the same patient demonstrates the typical locations of the distal intranasal components of nasolacrimal duct mucoceles ⇨ inferior to the inferior turbinates ⇨.*



(Left) *Coronal T2 MR in an infant shows hyperintense nasolacrimal duct mucoceles extending from the dilated lacrimal sacs proximally ⇨ to protrude inferomedially from the inferior nasolacrimal ducts ⇨. (Right) Coronal SSFSE T2 MR in a 2nd-trimester fetus demonstrates bilateral lacrimal sac enlargement ➡ with distal extension into each inferior meatus ➡, a typical appearance of nasolacrimal duct mucoceles.*



TERMINOLOGY

Synonyms

- Congenital dacryocystocele

Definitions

- Nasolacrimal duct (NLD) mucocele: Cystic dilation of nasolacrimal apparatus secondary to obstruction of NLD
- Canthus: Corner of eye where eyelids meet

IMAGING

General Features

- Best diagnostic clue
  - Well-defined, cystic, medial canthal mass in continuity with enlarged NLD in newborn
- Location
  - From lacrimal sac at medial canthus to distal aspect of NLD at inferior meatus
  - Unilateral or bilateral

CT Findings

- Hypodense, thin-walled cyst at medial canthus ± bulging cystic component at inferior meatus
  - Cysts communicate through enlarged NLD
- Minimal wall enhancement normally; thick rim enhancement ± fluid/debris level if infected

MR Findings

- T1-hypointense/T2-hyperintense, well-circumscribed mass(es)
- Signal intensity varies with protein content &/or infection
- Minimal wall enhancement normally
- If inflamed/infected → thick rim of enhancement with surrounding poorly defined soft tissue stranding

Imaging Recommendations

- Best imaging tool
  - Thin-section bone CT
  - ± contrast (for better soft tissue characterization)

DIFFERENTIAL DIAGNOSIS

Orbital Dermoid & Epidermoid

- Lateral > medial canthus
- Tethered at suture: Frontozygomatic > nasolacrimal
- 50% show fat density/intensity with thin rim enhancement

Dacryocystocele

- Acquired lacrimal sac cyst from trauma, other processes
- Typically in adults with history of prior regional trauma

PATHOLOGY

General Features

- Etiology
  - Tears & mucus accumulate in NLD due to distal imperforate Hasner membrane (i.e., distal duct obstruction)
    - Most membranes perforate during vaginal delivery or normal breathing & crying at birth
  - Nasolacrimal sac distension &/or anatomic variation compresses canalicular system → trapdoor nasolacrimal sac obstruction
  - If bacteria enter distended sac → dacryocystitis ± cellulitis

CLINICAL ISSUES

Presentation

- Most common signs/symptoms
  - Small, round, bluish, medial canthal mass identified at or shortly after birth = distended lacrimal sac
  - Nasal airway obstruction with respiratory distress (especially during feeding) with bilateral nasal components
    - Obligate nose breathers during infancy
- Other signs/symptoms
  - Tearing & crusting at medial canthus, preseptal cellulitis, dacryocystitis
  - Small NLD mucoceles may be identified incidentally on brain MR imaging in infants

Demographics

- Age
  - Infancy: 4 days to 10 weeks typically
- Gender
  - M < F (1:3)
- Epidemiology
  - Most common abnormality of infant lacrimal apparatus

Natural History & Prognosis

- 90% of simple distal NLD obstructions (or congenital dacryostenoses) resolve spontaneously by age 1
- Only 50% of patients recognized on prenatal MR ultimately have postnatal symptoms
- Intervention recommended before infection occurs to prevent nasal airway obstruction, dacryocystitis, & permanent sequelae

Treatment

- Daily manual massage ± prophylactic antibiotics
  - Manual massage inappropriate if NLD mucocele infected or causing airway obstruction
- 10% require probing with irrigation ± Silastic stent placement
- If endonasal component & no response to above → endoscopic resection with marsupialization
- Prognosis excellent with adequate initial treatment
- Theoretical risk of nasolacrimal apparatus scarring, amblyopia, & permanent canthal asymmetry if left untreated

DIAGNOSTIC CHECKLIST

Consider

- Cross-sectional imaging evaluates extent of lesion along lacrimal apparatus & excludes other sinonasal causes of respiratory distress in newborn

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1. Dagi LR et al: Associated signs, demographic characteristics, and management of dacryocystocele in 64 infants. J AAPOS. 16(3):255-60, 2012
2. Yazici Z et al: Congenital dacryocystocele: prenatal MRI findings. Pediatr Radiol. 40(12):1868-73, 2010
3. Takahashi Y et al: Management of congenital nasolacrimal duct obstruction. Acta Ophthalmol. 88(5):506-13, 2009
4. Rand PK et al: Congenital nasolacrimal mucoceles: CT evaluation. Radiology. 173(3):691-4, 1989

Choanal Atresia

KEY FACTS

TERMINOLOGY

- Congenital obstruction of posterior nasal aperture(s)

IMAGING

- Unilateral or bilateral osseous narrowing of posterior nasal cavity with complete obstruction by associated membrane or bony plate
  - Thickening of vomer
  - Medial bowing of posterior maxilla(e)
  - ± air-fluid level in obstructed nasal cavity
- Unilateral in up to 75% (right > left)
- Bilateral in up to 25%
  - 75% of bilateral cases have other anomalies

TOP DIFFERENTIAL DIAGNOSES

- Choanal stenosis
- Pyriform aperture stenosis
- Nasolacrimal duct mucocele

PATHOLOGY

- Choanal atresia is most common congenital abnormality of nasal cavity
- Choanal atresia types
  - Mixed bony & membranous atresia in up to 70%
  - Purely bony atresia in up to 30%

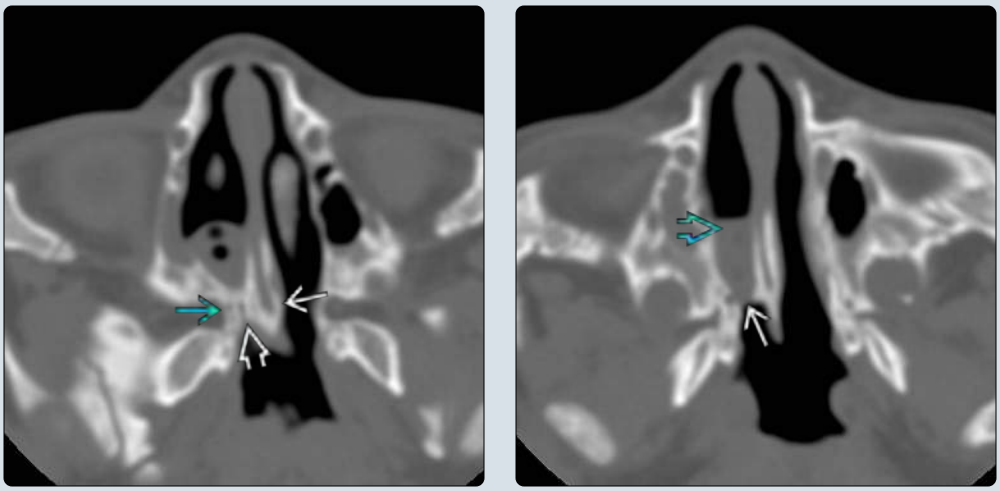
CLINICAL ISSUES

- Typical presentations include
  - Bilateral choanal atresia: Significant respiratory distress in newborn (due to "obligate nasal breather" status)
  - Unilateral choanal atresia: Chronic, purulent unilateral rhinorrhea with mild airway obstruction in older child

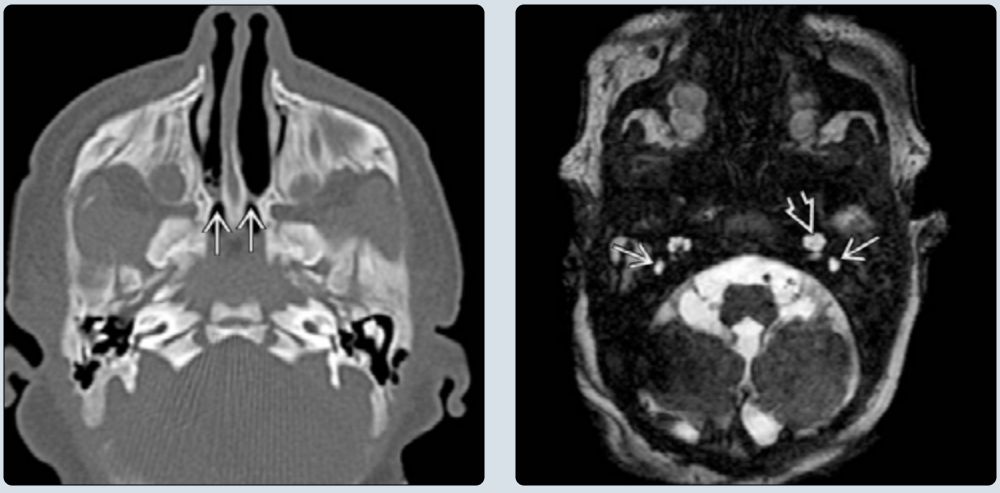
DIAGNOSTIC CHECKLIST

- Respiratory distress & suspected nasal obstruction in newborn should be evaluated with thin-section bone CT

(Left) *Axial NECT (in bone windows) through the upper choanae in a child shows a complete osseous right choanal obstruction secondary to fusion of an enlarged vomer to the thickened, medially positioned posterior maxilla.* **(Right)** *Axial NECT (in bone windows) in the same patient shows a component of membranous atresia at the narrowed inferior aspect of the choana. Note also the retained right nasal cavity secretions secondary to choanal obstruction.*



(Left) *Axial bone CT in a child with CHARGE syndrome demonstrates bilateral choanal obstructions secondary to linear membranes extending between the thickened vomer & each medially positioned posterior maxilla, typical of a mixed choanal atresia.* **(Right)** *Axial volume 3D FIESTA MR in the same child shows typical inner ear anomalies of CHARGE syndrome, including small/dysplastic vestibules, absent semicircular canals, & left cochlear dysplasia.*



TERMINOLOGY

Definitions

- Congenital obstruction of posterior nasal apertures
  - Choana: Junction of posterior nasal cavity & nasopharynx
  - Choanal atresia: Lack of communication between nasal cavity & nasopharynx

IMAGING

General Features

- Best diagnostic clue
  - Bony narrowing of posterior nasal cavity with membranous &/or osseous obstruction of choana
- Location
  - Unilateral in ~ 75% (right > left), bilateral in ~ 25%
- Size
  - Newborn choanal opening abnormal if < 0.34-cm wide
  - Newborn vomer abnormal if > 0.23-cm thick
- Morphology
  - Medial bowing of posterior maxilla (lateral nasal wall) & pterygoid plate
  - Large/thickened vomer
  - Bony narrowing ± soft tissue membrane/plug or bony plate obstructing choana
    - Mixed bony & membranous atresia in up to 70%
    - Purely bony atresia in up to 30%

CT Findings

- Bone CT
  - Choanal narrowing by medially bowed posterior maxilla & thickened vomer
  - Narrow gap between maxilla & vomer bridged by continuous bony plate or membrane
    - Membranous atresia may be thin/strand-like or thick/plug-like
  - Air-fluid level frequently present in obstructed nasal passage
    - Nasal cavity may also be filled with soft tissue, hypertrophied inferior turbinates

Imaging Recommendations

- Best imaging tool
  - High-resolution unenhanced bone CT
- Protocol advice
  - Suction secretions from nasal cavity prior to scanning
  - Axial images angled 5° cephalad to palate
    - If angle too great, region of choanae at level of skull base creates false appearance of choanal atresia
  - Edge enhancement bone kernel helps delineate bone margins in partially ossified skull base
  - Multiplanar reformations as needed
    - Sagittal usually best plane for this entity
  - 3D reconstructions may be helpful for clinical decision making & surgical planning

DIFFERENTIAL DIAGNOSIS

Choanal Stenosis

- Posterior nasal airway narrowed (not completely occluded)

Pyriform Aperture Stenosis

- Narrowed anterior inferior nasal passage(s)
- Thickened anteromedial maxilla(e)
- ± single central megaincisor
- Must evaluate brain for holoprosencephaly

Nasolacrimal Duct Mucocele

- Bilobed cystic mass extending from medial orbital nasolacrimal fossa to inferior meatus

PATHOLOGY

General Features

- Associated abnormalities
  - Syndromes common in bilateral atresia (up to 75%)
    - CHARGE syndrome
  - Unilateral choanal atresia more likely to be isolated

CLINICAL ISSUES

Presentation

- Most common signs/symptoms
  - Bilateral choanal atresia: Respiratory distress in newborn
    - Infants breathe through nose ("obligate nasal breathers") up to 6 months of age
    - Aggravated by feeding, relieved by crying
  - Unilateral choanal atresia or stenosis: Chronic, purulent, unilateral rhinorrhea in older child

Treatment

- Establish oral airway immediately to ensure proper breathing
- Membranous atresia may be perforated upon passage of nasogastric tube
- Surgical treatment effective for alleviating respiratory symptoms

DIAGNOSTIC CHECKLIST

Consider

- Once airway established, respiratory distress with suspected nasal obstruction in newborn should be evaluated with thin-section bone CT

Image Interpretation Pearls

- Determine if choanal atresia unilateral or bilateral
- Look for associated anomalies in head & neck

Reporting Tips

- Describe choanal atresia as
  - Unilateral or bilateral
  - Mixed membranous/bony or purely bony
    - Comment on thickness of atretic bone plate

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Congenital High Airway Obstruction Sequence

KEY FACTS

TERMINOLOGY

- Rare congenital anomaly of airway with complete, intrinsic laryngeal &/or tracheal obstruction
- Results in dysfunctional & hyperexpanded lungs, everted hemidiaphragms, & cardiac/venous compression with ascites/hydrops

IMAGING

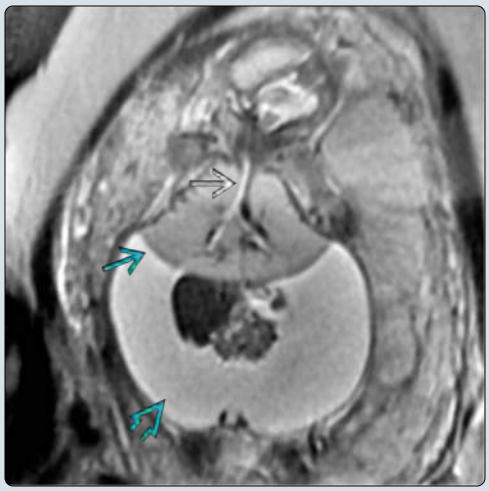
- Diffusely enlarged lungs, flattened/everted diaphragm
  - Prenatal imaging: Echogenic (US) or T2 hyperintense (MR) lungs with dilated, fluid-filled trachea inferior to obstructing lesion, ± polyhydramnios
  - Site of obstruction appears as persistent short or long segment of absent airway fluid at or below glottis
- Centralized, compressed heart
- Limited motion of abnormal diaphragm
- Abdominal distention with large volume of ascites
- Findings lessened with stenosis, membrane perforation, or fistula (as each enables airway decompression)

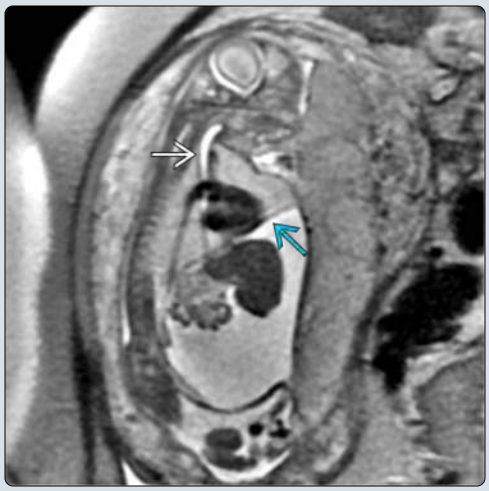
PATHOLOGY

- Most commonly due to laryngeal membrane or atresia
  - Obstruction prevents clearance of fluid from lungs
  - ↑ tracheal & lung pressures cause hyperexpansion & maldevelopment
- 50% have additional anomalies

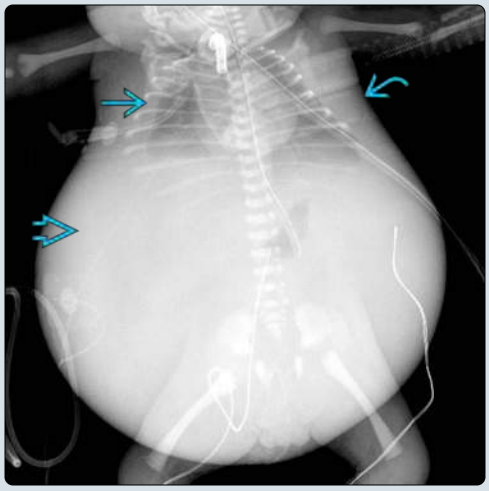
CLINICAL ISSUES

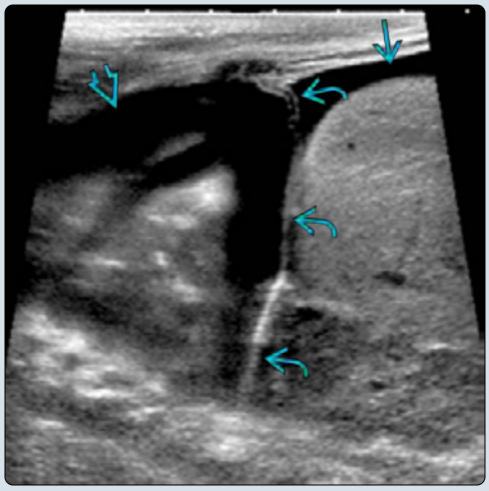
- Presentations
  - In utero: Large, bilateral solid lung masses + ascites
  - At birth: Respiratory distress, aphonia, & failed intubation
    - Lethal at delivery without prenatal detection
- Ex utero intrapartum therapy (EXIT) procedure: Controlled delivery with airway secured via tracheostomy while placental circulation maintained
  - Improves survival at delivery
  - Respiratory function remains poor
  - Survival > 1 year ~ 20%, with high morbidity





(Left) *Coronal SSFSE T2 MR in a fetus at 20 weeks gestation shows dilated, fluid-distended bronchi & trachea up to the larynx. The hemidiaphragms are everted, & the lungs show diffuse high signal intensity. There is a large volume of ascites.* **(Right)** *Sagittal SSFSE T2 MR in the same patient again shows the dilated, fluid-filled trachea (with obstructing membrane at the larynx), enlarged & high signal intensity lungs with flattened diaphragm, & ascites in this patient with CHAOS. The oligohydramnios was due to renal anomalies.*





(Left) *Coronal AP radiograph of a newborn with CHAOS shows marked abdominal distention (due to ascites), a pleural effusion, & chest wall edema, consistent with hydrops. The hemidiaphragms are flattened. A tracheostomy was placed during an EXIT procedure.* **(Right)** *Right parasagittal ultrasound of the lower thorax/upper abdomen in the same patient shows an abnormal, everted, & lax diaphragm, which did not move during the exam. The pleural effusion & ascites are noted.*

KEY FACTS

TERMINOLOGY

- Rare, highly lethal anomaly with absence of majority of trachea from subglottis to main bronchi

IMAGING

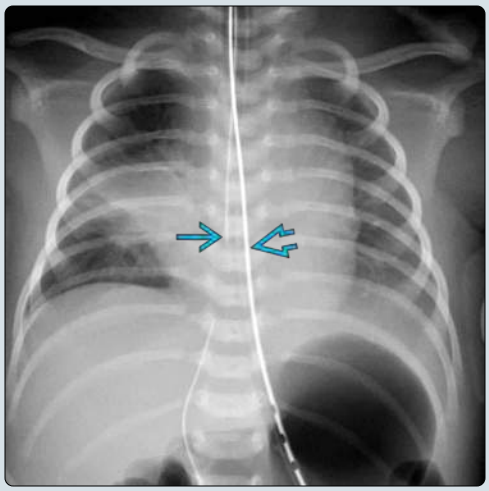
- Uncommon detection prenatally, as majority of cases have fistula from residual lower airway to esophagus
  - Allows decompression of otherwise obstructed lungs
  - May only demonstrate polyhydramnios in utero
    - If airway anomaly suspected, MR performed due to superior in utero airway evaluation vs. ultrasound
  - Minority of cases have no fistula, presenting as CHAOS
    - Lacks dilated, fluid-filled trachea of CHAOS
- Postnatally, temporary ventilation occurs via fistula
  - Low lung volumes with patchy opacities of atelectasis or aspiration
  - Low origin, horizontally oriented main bronchi
  - Endotracheal tube (ETT) in midline esophagus, possibly below expected location of carina
  - Nasogastric tube (NGT) may curve into main bronchi

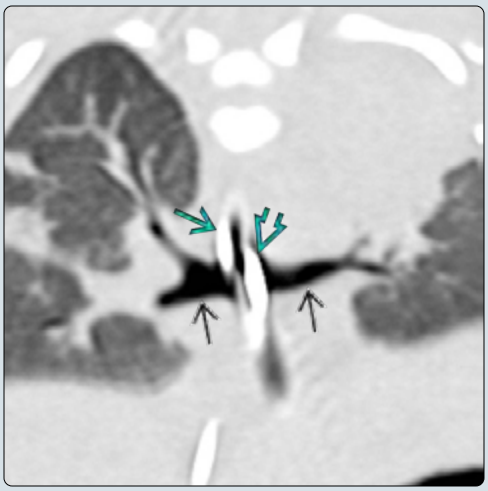
PATHOLOGY

- Classification by Floyd (most widely used): Types I-III
  - I: Absent proximal trachea; short distal trachea + TEF
  - II: Absent trachea; residual carina with main bronchi ± bronchoesophageal fistula
  - III: Absent trachea & carina; main bronchi arise from esophagus
- Associated anomalies in up to 94%

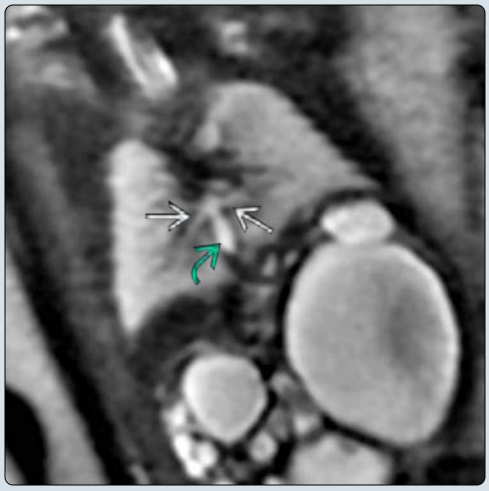
CLINICAL ISSUES

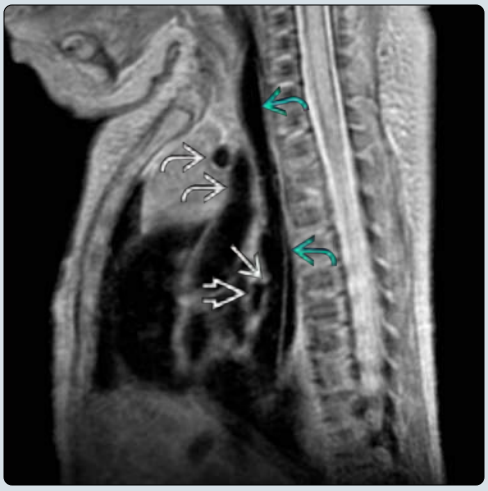
- Inability to conduct air at delivery → aphonia & insufficient ventilation; intubation difficult
- Highly lethal due to lack of sustainable conduit for air transit from glottis to lungs
- Long-term tracheal replacement options sparse
  - Rarely successful reconstruction with esophagus
  - Bioengineered graft material may be future therapy





(Left) *AP chest radiograph in a 34-week gestation newborn with cyanosis, aphonia, & poor ventilation at delivery shows the tip of the endotracheal tube (ETT) in the thoracic midline below the expected level of the carina. The ETT follows a similar course to the nasogastric tube (NGT).* **(Right)** *Coronal CECT in the same patient shows a horizontal orientation of low-lying main bronchi that connect to the esophagus. Note that both the NGT & low ETT lie in the esophagus in this patient with complete tracheal agenesis.*





(Left) *Coronal T2 SSFSE MR in a 31-week gestation fetus shows an abnormal connection of the bilateral main bronchi to the esophagus. No trachea was identified. This fetus had numerous anomalies, including radial ray, genitourinary, gastrointestinal, & cardiac.* **(Right)** *Sagittal PD MR in a 34-week gestation newborn shows a fistula from the carina to the esophagus. Vessels are seen anterior to the esophagus without a discernible trachea, consistent with tracheal agenesis.*

Epiglottitis

KEY FACTS

TERMINOLOGY

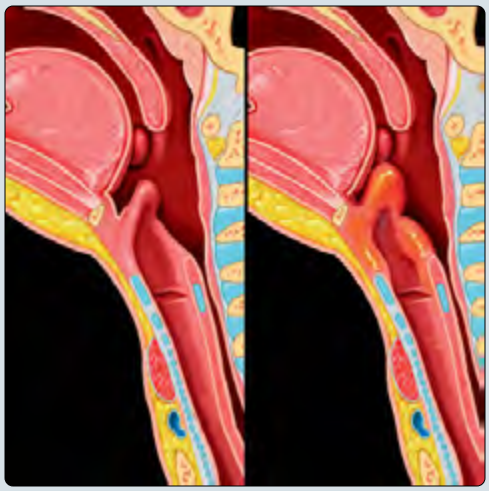
- Airway obstruction secondary to inflammation of epiglottis & surrounding tissues

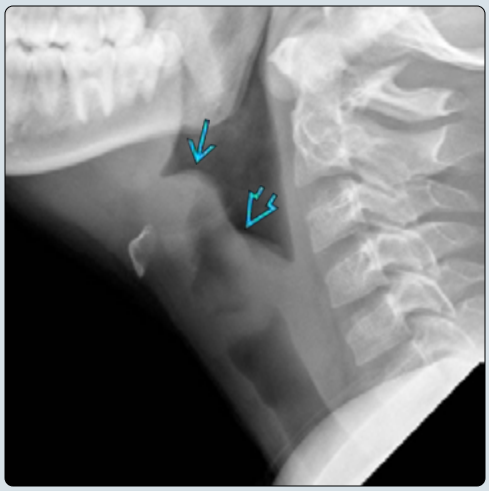
IMAGING

- Frontal & lateral radiographs only obtained in stable patients with questionable diagnosis
  - Child should be kept upright & comfortable
  - Patient may drool due to difficulty handling oral secretions: Should not be agitated or placed supine
- Lateral radiograph
  - Marked thickening of epiglottis
  - Thickening of aryepiglottic folds
    - Extend from epiglottis anterosuperiorly to arytenoid cartilages posteroinferiorly
    - Normally thin & convex inferiorly
    - May become thickened & convex superiorly
    - Swelling of these folds → actual airway obstruction
- Frontal radiograph
  - Only lateral radiograph should be obtained when epiglottitis highly suspected
  - ± symmetric subglottic tracheal narrowing, similar to that seen in croup
  - Swelling of epiglottis & aryepiglottic folds often not seen on frontal view; may be visualized through foramen magnum
- CT does not play routine role in diagnosing epiglottitis

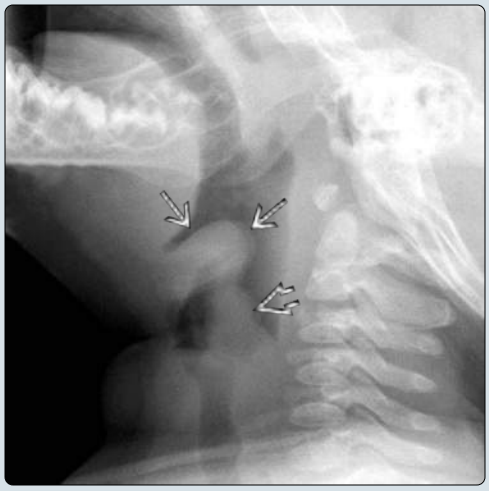
CLINICAL ISSUES

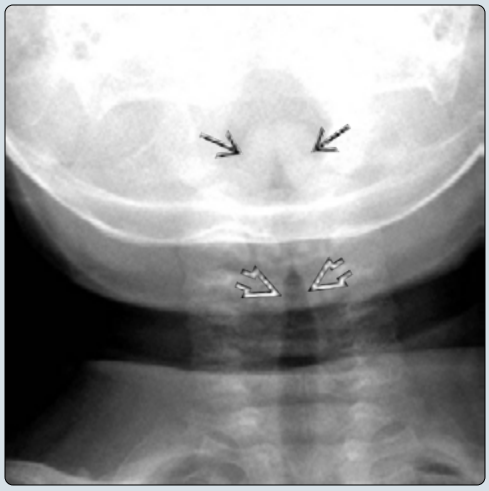
- Marked ↓ in incidence in children since vaccine for *Haemophilus influenzae* introduced
  - Mean age in children has shifted from 3.5 years to 14.6 years
  - Now more common in adults than children
- Life threatening if untreated
- Direct laryngoscopy & bronchoscopy with intubation performed in operating room with otolaryngology present
- Steroids & broad-spectrum IV antibiotic therapy





(Left) *Sagittal graphics shows epiglottitis (right) as compared with a normal epiglottis (left). The epiglottis & aryepiglottic folds are swollen & diffusely enlarged (right).* **(Right)** *Lateral radiograph of the airway in a 13 year old with lymphoma shows thickening of the epiglottis & aryepiglottic folds, consistent with epiglottitis.*





(Left) *Lateral radiograph in a 6 month old shows marked thickening of the epiglottis & the aryepiglottic folds, typical of epiglottitis.* **(Right)** *AP radiograph of the same child shows thickening of the epiglottis & aryepiglottic folds seen through the skull base/foramen magnum. There is mild subglottic narrowing, which can be seen in varying degrees with epiglottitis.*

TERMINOLOGY

Synonyms

- Supraglottitis

Definitions

- Airway obstruction secondary to inflammation of epiglottis & surrounding tissues

IMAGING

General Features

- Best diagnostic clue
  - Classic imaging appearance: Lateral radiograph shows enlargement/thickening of epiglottis & aryepiglottic folds
    - Epiglottis often appears like thumbprint (or frontal perspective of thumb with nail en face to x-ray beam)
  - Not to be confused with Ω epiglottis: Normal variant when epiglottis imaged obliquely
    - May appear like hitchhiker thumb (or lateral perspective of thumb with nail tangential to x-ray beam)
    - Epiglottis maintains sharp interfaces with well-defined central posterior border; no thickening of aryepiglottic folds
- Location
  - Serious, life-threatening inflammation & swelling of epiglottis & surrounding tissues (i.e., aryepiglottic folds)
- Morphology
  - Swelling of epiglottitis → thumbprint appearance on lateral radiograph

Radiographic Findings

- Lateral radiograph
  - Marked thickening of epiglottis
  - Aryepiglottic folds
    - Extend from epiglottis anterosuperiorly to arytenoid cartilages posteroinferiorly
    - Normally thin & convex inferiorly, outlined by air
    - May become thickened & convex superiorly
    - Swelling of these folds causes actual airway obstruction
  - ± nonspecific "ballooning" (air distention) of hypopharynx
- Frontal radiograph
  - Only lateral radiograph obtained if epiglottitis highly suspected
    - Supine positioning of ill-patient could lead to airway occlusion
  - ± symmetric subglottic narrowing, similar to that seen in croup
  - Swelling of epiglottis & aryepiglottic folds may not be seen on frontal view
    - May see swollen epiglottis through skull base

CT Findings

- CECT
  - CT has no role in diagnosing epiglottitis
  - If obtained (occasionally for other reasons), will show edematous, enlarged epiglottis with involvement of aryepiglottic folds
    - Epiglottis slightly lower in attenuation when compared with other soft tissue
  - In rare cases, may see phlegmonous collection within adjacent soft tissues
  - May be helpful in evaluating for complications such as deep neck space infection/abscess
    - Very rare in pediatric population as opposed to adult population where it can be seen in 2-29% of cases

Imaging Recommendations

- Best imaging tool
  - Due to serious, life-threatening airway emergency, unstable patients with classic clinical presentation undergo direct laryngoscopy & bronchoscopy with intubation in operating room by otolaryngology as indicated
  - Only lateral radiograph should be obtained in cases suspecting epiglottis
- Protocol advice
  - Child should be upright & comfortable
  - Patient may drool due to difficulty handling oral secretions; patient should not be agitated or placed supine
  - Patient with suspected epiglottitis should be accompanied by physician with readily available supportive equipment to secure airway if necessary
  - Obtaining lateral radiograph should never interfere with securing airway given potential for rapidly fatal outcome

DIFFERENTIAL DIAGNOSIS

Ω Epiglottis (Normal Variant)

- Artificially widened appearance of obliquely imaged normal epiglottis
  - Left & right sides of epiglottis being imaged adjacent to each other
- May appear as hitchhiker thumb, but epiglottis maintains sharp margins & well-defined central posterior border
- Lacks thickening of aryepiglottic folds

Croup

- Most common acute airway condition of children
- Benign, self-limited condition with "barky" cough in patients < 3 years of age
- Symmetric subglottic tracheal narrowing (steeple sign)

Exudative Tracheitis

- Children typically older than those with croup
- Intraluminal filling defects (membranes), tracheal wall plaque-like irregularity, poorly defined tracheal margins, asymmetric subglottic narrowing

Retropharyngeal Abscess

- Pyogenic infection of retropharyngeal space
- Persistent thickening of retropharyngeal soft tissues despite inspiration & neck extension on lateral view
  - Loss of normal "step-off" at junction of hypopharynx & esophagus

Enlarged Lingual Tonsils

- Rounded mass bulging from posterior tongue base, potentially filling vallecula & displacing epiglottis

Vallecular Mass

- Most commonly cyst but rarely sarcoma
- Fills vallecula, potentially displacing or effacing epiglottis depending on exact site of origin

PATHOLOGY

General Features

- Etiology
  - Most common agent remains *Haemophilus influenzae*
    - Dramatic changes in incidence, etiology, & patient demographics since *H. influenzae* (HiB) vaccine introduction
    - More cases of epiglottitis resulting from other bacterial, viral, or combined viral-bacterial infections now seen since introduction of HiB vaccination
      - Other organisms include group A β-hemolytic *Streptococcus*, *Staphylococcus aureus*, *Klebsiella pneumoniae*, *Moraxella catarrhalis*, *Pseudomonas* species, *Candida albicans*, *Pasteurella multocida*, & *Neisseria* species
      - Bacterial superinfections of preceding viral infections such as herpes simplex, parainfluenzae, varicella-zoster, & Epstein-Barr
  - Can also rarely occur from noninfectious etiologies such as angioneurotic edema, trauma, Stevens-Johnson syndrome, caustic ingestion, & bee stings

Gross Pathologic & Surgical Features

- Marked inflammation & edema of epiglottis & aryepiglottic folds
- Complete airway obstruction may occur at any time

CLINICAL ISSUES

Presentation

- Most common signs/symptoms
  - Abrupt onset of stridor (usually inspiratory), often associated with dysphagia
- Other signs/symptoms
  - High fever, sore throat, dysphonia, "hot potato voice," hoarseness, & drooling
  - Patients have toxic appearance with fever
  - Patients described as anxious & uncomfortable
  - ↑ respiratory distress when recumbent
  - May have characteristic "tripod position" (sitting up with neck extended & leaning forward with jaw thrust out to maximize laryngeal opening)
  - Viral prodrome & cough more likely with croup

Demographics

- Age
  - Marked ↓ in incidence in children since HiB vaccine introduced
    - 0.6-0.8 cases /100,000 persons immunized
    - Vaccine effectiveness 98%
  - Mean age in children has shifted from 3.5 years to 14.6 years since introduction of HiB vaccine
    - Significantly older than children with croup (mean age: 1 year)
  - Adult incidence has remained steady (although relatively uncommon) post vaccine
  - Now more common in adults than children (mean age: 40 years)
- Gender
  - M:F = 1:1

Natural History & Prognosis

- Life-threatening disease often requiring emergent intubation
  - Mortality 0.89%, majority adults
- Intubation period usually short (2-3 days)

Treatment

- Emergent tracheal intubation to relieve/prevent airway obstruction & respiratory failure
  - Has evolved from tracheotomy to direct laryngoscopy & bronchoscopy with intubation performed in operating room with otolaryngology present
- Steroids & broad-spectrum IV antibiotic therapy

DIAGNOSTIC CHECKLIST

Consider

- Frontal & lateral radiographs should be obtained only in stable patients with questionable diagnosis
  - Patient should be quickly returned to emergency department
- Patient should remain in comfortable position, typically upright

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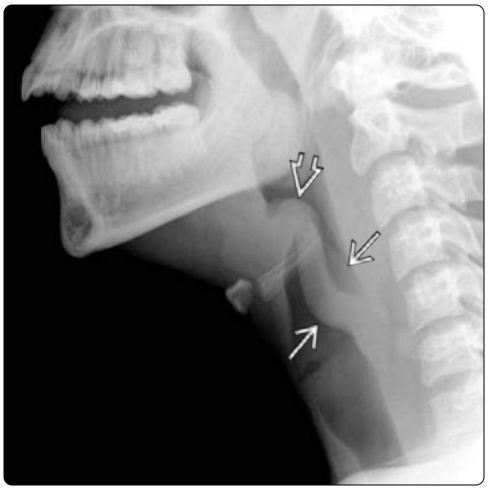
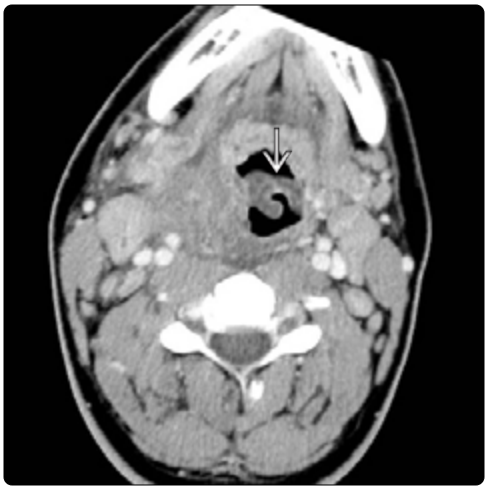
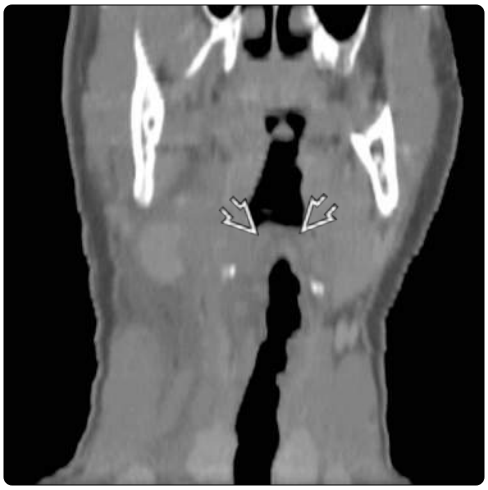
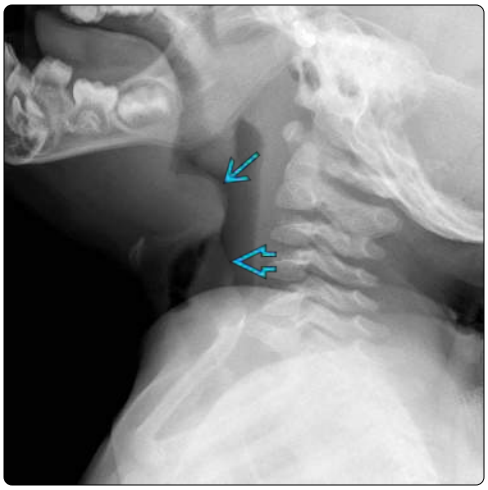


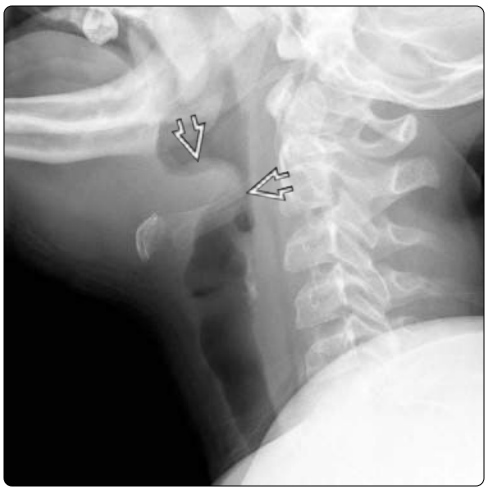


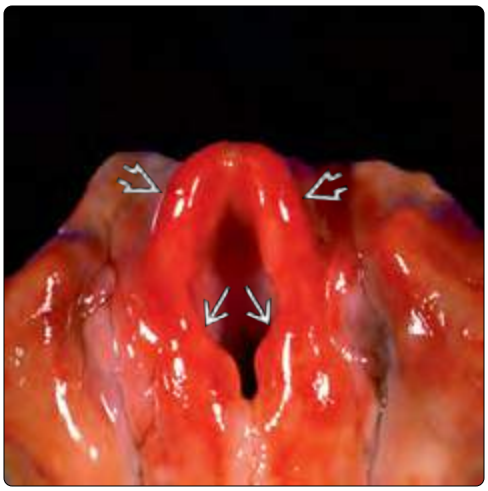
(Left) *Lateral radiograph shows marked thickening of the epiglottis & aryepiglottic folds.* **(Right)** *Axial CECT at the level of the hypopharynx shows an enlarged & low-attenuation, edematous epiglottis.*





(Left) *Coronal CECT reformatted image shows enlarged aryepiglottic folds.* **(Right)** *Lateral airway radiograph in an 18 month old with epiglottitis shows a markedly enlarged epiglottis with poorly defined margins. The right aryepiglottic fold was thickened at laryngoscopy. The patient was subsequently intubated.*





(Left) *Lateral airway radiograph shows epiglottitis as a markedly swollen & poorly defined epiglottis that has a thumbprint appearance in a patient with congenital insensitivity to pain.* **(Right)** *Gross pathology shows an inflamed & edematous epiglottis with swollen aryepiglottic folds. It is the swelling of the aryepiglottic folds that leads to airway obstruction.*

Croup

KEY FACTS

TERMINOLOGY

- Benign self-limited viral inflammation of upper airway
- Symmetric subglottic edema results in stridor & characteristic "barky" cough

IMAGING

- Radiographs used to exclude more serious causes of stridor (rather than diagnosing croup)
- Frontal view: Often more revealing than lateral view
  - Gradual symmetric tapering of subglottic trachea from inferior to superior
    - "Steeple," "pencil tip," or "inverted V" configuration
    - Loss of normal "shoulders" (focal lateral convexities) of subglottic trachea secondary to edema
- Lateral view: Best for excluding other diagnoses
  - Relatively mild narrowing of AP dimension
  - Haziness with loss of subglottic tracheal wall definition
  - ± hypopharyngeal overdistention

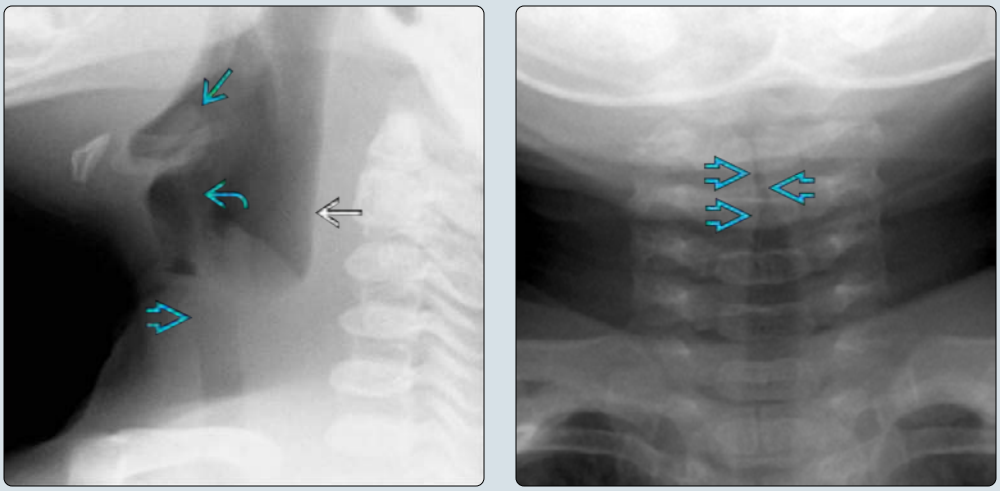
TOP DIFFERENTIAL DIAGNOSES

- Foreign body
- Epiglottitis
- Exudative tracheitis
- Angioedema
- Infantile hemangioma
- Iatrogenic subglottic stenosis

CLINICAL ISSUES

- Acute clinical syndrome characterized by "barky" or "seal-like" ("croupy") cough, inspiratory stridor, hoarseness
  - Age range: 6 months to 3 years; peak age: 1 year
- ± prodrome of low-grade fever, mild cough, rhinorrhea
- Affected child usually well otherwise
- Most cases successfully treated with corticosteroids ± nebulized epinephrine with < 4 hours of observation
- Recurrent episodes or atypical age suggest alternate diagnosis

(Left) *Lateral radiograph in a 9-month-old infant with stridor shows haziness of the subglottic airway. Overdistention (ballooning) of the hypopharynx is noted. The epiglottis & aryepiglottic folds are normal.* **(Right)** *AP radiograph in the same patient shows symmetric narrowing of the subglottic trachea, typical of croup. The loss of the normal abrupt subglottic/glottic shouldering plus gradual tapering of the subglottic airway lumen from inferior to superior is referred to as the steeple sign.*



(Left) *Endoscopic photograph shows a normal appearance of the subglottic airway. The subglottis is widely patent such that the mucosa is actually hidden beneath the vocal cords.* **(Right)** *Endoscopic photograph in a child with viral croup shows edematous subglottic mucosa, which is visualized through the vocal cords. There is marked narrowing of the subglottic airway lumen, predominantly in the transverse dimension.*