Choanal Atresia: Diagnosis, Management and Association with CHARGE syndrome

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Outline

• Anatomy
• Embryology
• Signs/Symptoms
• Diagnosis
• CHARGE syndrome (features, diagnosis, treatment considerations)
• Choanal Atresia Treatment
  – Transnasal vs Transpalatal
Basic Anatomy

• Choana (Greek→“funnel”) = posterior nasal aperture
• Entrance from nasal cavity to nasopharynx

Borders of Choana/Atresia Plate
• Superior→inferior surface of sphenoid body
• Lateral→medial pterygoid lamina
• Medial→vomer
• Inferior→horizontal portion of palatal bone
Anatomy

http://img23.imageshack.us/img23/2821/phyrandealopening.png

Netter Anatomy Atlas Plate 5
Anatomical Contributions to CA

- Narrowed nasal cavity
- Lateral impingement of the pterygoid plates
- Thickened abnormal posterior vomer
- +/- central membranous connection

Cummings 2694
Blood Supply

Netter Atlas
Causes of Nasal Obstruction

• Choanal atresia
• Nasal pyriform aperture stenosis
• Birth trauma with septal buckling/dislocation
• Sinusitis/infection (e.g. cystic fibrosis)
• Allergic rhinitis
• Adenoid hypertrophy
• Craniofacial anomalies with associated unfavorable nasal anatomy
• Nasal masses (hemangiomas, encephalocoeles)
Embryologic Formation

- 4-6 weeks: formation of columella, philtrum, and upper lip via neural crest cell migration
- Simultaneously, nasal pits burrow deep into mesenchyme to produce nasal cavities
- Nasal pits overlie the the frontal portion of stomadeum (primitive oral cavity), separated by nasobuccal membrane
- Nasobuccal membrane ruptures to create primitive nasal cavity and choana, followed by secondary choana

“Choanal atresia: Embryologic Analysis and Evolution of Treatment, a 30 year experience”
Stomodeum = precursor to the mouth
Nasal pits become nasal cavity --Cummings 2693
Nasal Pit, Stomadeum, Buccopharyngeal Membrane

Week 4

http://www.embryo.chronolab.com/digestive.htm

Week 5

Nasal Pit, Stomadeum, Buccopharyngeal Membrane

- Week 4
- Left picture: #8 buccopharyngeal membrane (thin membrane where ectoderm (mouth) and endoderm (pharynx) meet)
- Stomodeum: depression between brain and pericardium forming primitive mouth
Embryology

Week 6
1. Stomodeum
2. Nasobuccal membrane *
3. Tongue
4. Telencephalic wall
5. Nasal pit
6. Medial nasal swelling

Week 7
1. Primary palate
2. Primitive choana
3. Tongue
4. Oral cavity’

http://www.embryo.chronolab.com/palate.htm
Embryology of Choanal Atresia

• 4 theories of etiology of atresia plate
  1. Persistence of buccopharyngeal membrane from the foregut
  2. Abnormal persistence of the nasobuccal membrane
  3. Abnormal location of mesoderm forming adhesions in the choanal region
  4. Misdirection of neural crest cell migration

• Current popular theory- Neural Crest
Embryology of Choanal Atresia

• Nasobuccal (nose from pharynx); buccopharyngeal (oral cavity from pharynx)

• #2 was previously most popular theory; now it’s #4

• #4 supported by fact that Treacher Collins has high rate of choanal atresia and it’s a disease of abnormal neural crest migration
Choanal Atresia History

• First described in 1755 by Roederer
• First recorded surgical repair by Emmert in 1854
  – Technique: Blind nasal puncture
• Serious complications: CSF leak, midbrain trauma, Gradenigo’s syndrome

“choanal atresia” Keller
Gradenigo: Petrous apicitis (sx’s of periorbital unilateral pain, diplopia, otorrhea→ usually associated with otitis media)
Epidemiology

- Unilateral atresia greater than bilateral
  - 65-75% of patients
- 2:1 Female-to-Male ratio
- Right side most common
- Bilateral atresia associated with other congenital anomalies in 75% of cases
  - CHARGE, Crouzon’s, Treacher Collins
  - Polydactyly, craniosynostosis, cleft lip/palate, nasal/palatal deformities

“Choanal atresia, CHARGE, and Congenital nasal stenosis” – Keller, Kacker
Bony or Not?

- Historically Fraser in 1910 (115 cases) classified as:
  - 90% bony
  - 10% membranous

- Brown et al. (1996) did study of 63 patients
  - 47 CT scans reviewed
  - Additional 16 patients from their operative clinical experience (CT and histology)
  - Results: 18 pure bony (29%), 45 mixed bony-membranous (71%)

* 0 pts were pure membranous

“Choanal atresia: A new anatomic classification” 1996 Laryngoscopy – UT Southwestern. All patients had stenting with ET tubes performed
The Problem

- Obligate nasal breathers
- Majority of length of neonatal tongue contacting the hard/soft palate
- Epiglottis larger and floppier
- Mouth breathing begins 4-6 weeks after birth
Signs/Symptoms- Bilateral Atresia

• Presents as a newborn
• Cyanosis
• Increased respiratory effort
• Chest retractions
• Classically cyanosis/saturations improve with crying
• May see polyhydramnios in pregnancy
Signs/symptoms - Unilateral

- Present later in life (non-emergent)
- Chronic nasal discharge
- Nasal obstruction
- Thick nasal secretions on exam

http://www.buzzle.com/articles/chronic-sinus-drainage.html
Diagnosis

- Inability to pass catheter or NG tube
  - 6 Fr
  - 32 mm as proposed distance
- Absence of fogging of mirror under nose
- CT scan
- Nasal endoscopy to confirm
Diagnosis

“Mirror” fogging

6 French NG-tube

http://ent4students.blogspot.com/2013/01/nose-congenital.html
View of Atresia- 120 degree scope

Unilateral

Bilateral

Pediatric ENT- Graham pg 292
Diagnosis - CT

http://imaging.birjournals.org/content/16/2/130/F1.large.jpg

http://www.fetalultrasound.com/online/text/30-232_files/image004.jpg
Diagnosis- CT

http://www.internationalarchives.org/conteudo/acervo_eng.asp?id=555
Figure 1: 5-year-old child with history of difficulty in breathing. (a) Axial image shows complete atresia of left nasal choana. Note small spurs at right nasal choana (arrows) which cause choanal stenosis. (b) 2D sagittal reformatted images show complete occlusion of left nasal choana. (c) 3D external reconstruction shows non-continuity of the nasopharyngeal air column on left side (Arrows). (d) 3D internal reconstruction through the nasopharynx confirmed complete atresia of the left nasal choana and partial obstruction of the right choana.
CHARGE syndrome- Acronym

- Also termed Hall-Hitner syndrome (1979)
- Pagon et al. (1981) coined “CHARGE” term based on non-random association of anomalies
- Occurs in 0.1-1.2/10,000 births

- Coloboma
- Heart defects
- Atresia of the Choana
- Retardation of Growth
- Genitourinary hypoplasia
- Ear anomalies

“CHARGE syndrome” Blake 2006
- Hall (Choanal atresia +) and Hitner (Coloboma +) seperately reported multiple anomaly association
Genetics of CHARGE

• Mutations in Chromodomain gene family
  – Chromodomain Helicase DNA-binding protein

• CHD-7 gene identified as the likely candidate

• Two large study series for identification
  – Jongmans et al. (2005) showing (+) mutation in 69/107 pts
  – Lalani et al. (2006) → (+) CHD-7 mut in 64/110

• Majority of mutations are sporadic
  – De novo autosomal dominant mutation
  – Some association with advanced paternal age
Coloboma

- Up to 80% of CHARGE patients
- Essentially a hole in one of the structures of the eye
- Unilateral or bilateral
- Affects iris, retina (most common), or both
- May extend to optic nerve
- Vision may be normal or impaired
- Dx = visual analysis, electroretinogram
Coloboma


http://pacificuoptometry.blogspot.com/2011_06_01_archive.html

http://www.djo.harvard.edu/files/7665_1178.jpg
Heart Defects

- 75-80% of patients with CHARGE
- MC defect is tetralogy of Fallot (33%)
- Also PDA, ASD, and VSD
- Dx = echo
- Tx
  - prostaglandin for PDA
  - Surgical correction

http://www.md.rcm.upr.edu/surgery/pedcardio_surgery_service.php
Heart Defects

http://www.heartpoint.com/congtetralogy.html

http://heart.phoenixchildrens.org/heart-conditions/ventricular-septal-defect-vsd-children
Atresia of the Choana

- Unilateral/bilateral in 50-60% of cases
- High rate of mortality with coinciding bilateral atresia and cardiac anomalies
- Often leads to middle ear disease
- Most commonly bilateral and primarily osseous
Atresia of the Choana

http://ent4students.blogspot.com/2013/01/nose-congenital.html


http://imaging.birjournals.org/cgi/content-nw/full/19/1/104/F8
Retardation of Growth

- Usually normal length/weight at birth
- If growth delayed due to cardiopulmonary issues, may catch up once repaired
- Often GH deficiency in kids; obesity in adults
- IQ is variable: 70% cases IQ<70 (MR)
- Behavior issues common (e.g. autism)
Genitourinary Issues

• Hypoplasia; easier to recognize in males

Common defects
- Microphallus, penile agenesis, hypospadias
- Cryptorchidism, bifid scrotum
- Uterus, cervix, or vagina atresia
- Hypoplastic labia/clitoris
- Renal anomalies
Genitourinary issues

http://www.urologyhealth.org/urology/articles/images/anatomy_Hypospadias.jpg

Ear Abnormalities

- Reported in **80-100%** of cases
- Classic finding = Lop- or cup-shaped ear
  - Due to absence/malformation of cartilage and hypoplastic lobule
- Audiogram/ABR
- Consider CT temporal bone if already going for CT sinus
- Often candidate for cochlear implant*

* A contraindication for CI would be aberrant facial nerve → get MRI
Ear abnormalities - Pinna


http://howshealth.com/charge-syndrome/
CHARGE Ear Anomalies

• External Ear ➔ cup/lop-shaped, low set w/ decreased vertical height

• Middle Ear ➔ Absent stapedius, hypoplastic incus/stapes or ossicle fixation, absent oval window, chronic otitis media

• Inner Ear ➔ Mondini effect, absence of semi-circular canals

Mondini ➔ decreased number turns of cochlea
Conductive and sensory causes of hearing loss
Computed tomography findings of inner ear anomalies typically seen in patients with CHARGE syndrome.

(A) **Cochlear hypoplasia** is shown by a black arrow (Patient 1).  
(B) **Bony cochlear nerve canal is obliterated** (black arrowhead) and complete **aplasia of the semicircular canals** is seen (white arrowhead). The incus is dysmorphic and slightly rotated state (asterisk). Ankylosis between the incus and malleus (white arrow) and between the ossicles and epitympanic bone (black arrows) is shown (Patient 4).  
(C) **Bony obliteration of the round window** is seen (small white arrow) (Patient 6).  
(D) **Oval window atresia** is seen on the coronal image (large white arrow) (Patient 2).
Absent Semi-Circular Canals
Other CHARGE Anomalies

- Multiple CN palsy (I, II, V, VII, VIII, IX, X, XI)
  - Facial nerve palsy w/ facial asymmetry (50-90%)
  - Swallowing/feeding difficulty (80%) → aspiration risk
- Tracheoesophageal fistula
- GERD
- Laryngomalacia/laryngeal cleft/vocal paralysis
- Cleft lip/palate (15-20%)
- Arhinencephaly
- OSA

Feeding team including speech pathologist needs to be involved; likely G tube
Arhinencephaly → specifically hypoplastic olfactory bulb
Figure 2. Face 2a. 2 1/2-year-old female; square face, round eye, straight nose with broad nasal root, unilateral facial palsy.

2b. Five-year-old female; mild expression of CHARGE facies; relatively square face, prominent columella of the nose.

2c. Seven-year-old male; square face, somewhat broad nasal root. Note prominent ear with unfolded helix and wide neck.

2d. Nine-year-old female; square face, round eyes, wide neck, sloping shoulders. Note lack of facial expression as a result of bilateral facial palsy.

2e. Fifteen-year-old male. Note longer but still somewhat square face, wide neck with sloping shoulders.

2f. Eighteen-year-old female; square, asymmetric face, prominent ears, head tilted back, wide neck, and sloping shoulders.
3C Triad for Diagnosis - Verloes 2005

1. Coloboma
2. Choanal atresia
3. Absent Semicircular Canals

- Arhinencephaly (hypoplastic olfactory bulbs)
  - Most common CNS defect; Sx = anosmia
- Rhombencephalic dysfunction
  - Brainstem and cranial nerves

“CHARGE syndrome; an update” Sanlaville 2007
Criteria that are most suggestive of CHARGE syndrome
### CHARGE diagnostic criteria

<table>
<thead>
<tr>
<th>Major criteria</th>
<th>Minor criteria</th>
<th>Inclusion rule</th>
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</table>
| **Pagon** | 1. Heart defects of any type  
2. Retardation (of growth and/or of development),  
3. Genital anomalies  
4. Ear anomalies (abnormal pinnae or hearing loss) | Four criteria out of six, and at least one major |
| 1. Choanal atresia  
2. Ocular coloboma | | |
| **Blake** | 1. Genital hypoplasia – males: micropenis, cryptorchidism; females: hypoplastic labia; both males and females: delayed, incomplete pubertal development  
2. Developmental delay – delayed motor milestones, language delay, mental retardation  
3. Cardiovascular malformations – all types, especially conotruncal defects (eg, tetralogy of Fallot), AV canal defects, and aortic arch anomalies  
4. Growth deficiencies – short stature, growth hormone deficiency  
5. Orofacial cleft – cleft lip and/or palate  
6. Tracheoesophageal-fistula – tracheoesophageal defects of all types  
7. Characteristic face – sloping forehead, flattened tip of nose | Four majors OR three majors + three minors |
| 1. Coloboma of iris, retina, choroid, disc; microphthalmia  
2. Choanal atresia unilateral/bilateral, membranous/bony, stenosis/atresia  
3. Characteristic ear abnormalities, external ear (lop or cup-shaped), middle ear (ossicular malformations, chronic serous otitis), mixed deafness, cochlear defects  
4. Cranial nerve dysfunction – facial palsy (unilateral or bilateral), sensorineural deafness and/or swallowing problems | | |
| **Verloes** | 1. Rhombocephalic dysfunction (brainstem and cranial nerve III to XII anomalies, including sensorineural deafness)  
2. Hypothalamo-hypophyseal dysfunction (including GH and gonadotrophin defects)  
3. Malformation of the ear (internal or external)  
4. Malformation of mediastinal organs (heart, esophagus,)  
5. Mental retardation | Typical CHARGE: three majors OR two majors + two minors  
Partial CHARGE : two majors +one minor  
Atypical CHARGE: two majors but no minors OR one major + two minors |
| 1. Ocular coloboma  
2. Choanal atresia  
3. Hypoplasia of semicircular canals | | |

[http://www.nature.com/ejhg/journal/v15/n4/fig_tab/5201778t2.html#figure-title](http://www.nature.com/ejhg/journal/v15/n4/fig_tab/5201778t2.html#figure-title)
Choanal Atresia Treatment

• Stabilize patient (bilateral CA at birth)
• Transnasal vs. Transpalatal Approach
• To stent or not to stent?
• Mitomycin C
• Complications
Stabilize Patient Before Surgery

• McGovern Nipple (large opening to force oral respiration)
• Oral airway
• Endotracheal intubation
• Tracheostomy
  – may be needed if definitive surgery needs to be delayed due to other health concerns (e.g. cardiologic issues)
Stabilize Patient

Nipple has large hole in the center
McGovern nipple on the right

http://ent4students.blogspot.com/2013/01/nose-congenital.html
Transnasal Approach

- **Endoscopic vs Microscope vs Blind Puncture**
- Curved/straight urethral sounds- puncture
- May choose to puncture with dilation only
- Powered instruments (microdebrider, diamond burr drill)- open choana
- Must direct the dissection inferomedially
- Preserving mucosal flaps

Puncture aimed at junction of septum and floor of nose, pointing down “Choanal atresia” Keller 2000
Transnasal Endoscopic Approach

1. Topically decongest nose (Afrin) and inject 1% lidocaine w/ 1:100,000 epi into posterior septum, lateral wall, atretic plate
2. +/- mouth gag to expose palate and visualize atresia w/ 120 degree scope
3. 25 spinal needle → inferomedial plate → confirm with scope
4. Create anterior mucosal flaps with knife over atretic plate
5. Drill out plate (diamond burr) * and remove posterior vomer with drill or backbiter **
6. Enlarge to 16 Fr urethral/Van Buren sound
7. +/- stent placement

*Junction of plate, hard palate, and vomer
** Care taken to avoid eustachian tube opening

* Focus on junction of atetic plate, hard palate, and vomer
** May use self retaining ear speculum
Transnasal Technique

Meyer’s Operative Otolaryngology
Ibrahim et al 2009
Curved Urethral Sound

http://www.ssvmmh.org/virtual_tour/Slide64Case10.html
Transnasal Endoscopic
Transpalatal approach

1. Place mouth gag, inject lido into palate
2. Create a “U”-shaped palatal flap based on greater palatine vessels
3. Remove palatal bone anterior to vessels, vomer, and atretic plate with drill/rongeur
4. Stent placement
5. Mucosa over palate used to resurface new choana

Choanal atresia” Keller 2000
U-shaped Flap

Cummings Otolaryngology pg 2695

Rongeur Palatal Bone

Meyer’s Operative Otolaryngology
Transpalatal- Advantages

• Direct visualization
• Creation of mucosa-lined cavity
• Decreased duration of stenting needed
Transpalatal- Complications

Why It’s Not Firstline

• May stunt/alter palate growth
• **Crossbite deformity**- 52% chance
• Palate flap necrosis and fistula
• High rate of restenosis

• Key point: often recommend only in **kids > 5 yo** after most palatal growth finished

.Choanal atresia” Keller 2000
Crossbite due to narrowed maxillary dental arches
Stenting

Often use ET or Portex tubes
Controversy of Stenting

To stent

• Friedman et al. (2000) reviewed 46 cases and found favorable prognosis (i.e. less operations) with stenting >12 weeks

• Gujrathi et al. (2004) reviewed 52 pts who underwent a puncture/dilation technique with stenting
  – Stented for median of 12 weeks
  – Only 2 patients required revision surgery (transpalatal approach)

Friendman, CM Bailey (UTMB/Great Ormand)
Gujrathi (Toronto)
Controversy of Stenting

Not to stent

- Retrospective review from Schoem (2004)
  - 13 kids via transnasal approach without stents
  - 4 required no further intervention; 9 to OR for microdebrider one time
  - Believed stenting to increase mucosal trauma and granulation formation; advocated oral/nasal steroids, irrigation, oral antibiotics

- Llorente et al. (2013) → 10 patients via transnasal without stenting (5 patients were failed restenosis from other hospital)
  - 100% patency after follow up of 27 months

- Success defined as less than 50% restenosis
- Second study → SPain
Use of Mitomycin C

• An antiproliferative/antitumor agent that inhibits fibroblast growth and proliferation
• Commonly used in treatment subglottic stenosis and LTR as well as sinus surgery
• Applied topically via a pledget
Mitomycin C

• Retrospective study by Holland et al (2001)
  – 8 patients used on after repair; 15 controls
  – Outcome measure: # of dilations needed post op
  – Study group: 0.375 (± 0.183) dilations/patient
  – Control group: 3.667 (± 0.583) dilations/patient
    • P = .006 \rightarrow \text{significant}
  – Median follow up \rightarrow 8.5 months
  – Stents used in all

• Study group 5/8 did not require any further dilations
• Majority were transpalatal; 2/8 endoscopic in study group; 4/15 in control
Complications

1. Stent complications: foreign body complications (Tx with nasal saline and abx), alar erosions, pressure necrosis from columella stitch
2. Transpalatal approach: discussed previously
3. Mucosal flap death
4. Eustachian tube dysfunction: damage to tori
5. Restenosis: if multiple endoscopic attempts failed, consider transpalatal approach and adjuncts such as Mitomycin C
6. CNS trauma: entrance to anterior cranial fossa with blind puncture (rare)

Pg 865 “Choanal atresia: embryologic analysis”
Prognosis for Definitive Repair

• Retrospective study in 2000 with UTMB & Great Ormond Street

• 46 children total
  – 28 bilateral, 18 unilateral
  – 26 (40%) with major anomalies (13 met CHARGE criteria)

• Technique: Transnasal drillout; Portex ET tube stents

Dr. Friedman“ Management and outcome of choanal atresia correction 2000”
Prognostic Indicators (cont)

- Data mainly for bilateral atresia
- Measure: Mean # of procedures before pt becomes asymptomatic for 6 months after last procedure
- Standard of comparison was set to 4 procedures
- Less procedures = more favorable outcome

Favorable outcome predictors for bilateral atresia
1. Weight at initial surgery > 2.3 kg
2. Stent size > 3.5 mm
3. Stent duration > 12 weeks
4. No associated facial anomalies

* Unilateral atresia → duration of stenting nor presence of facial anomalies affected outcomes

- Weight was arbitrarily established based on patient population
- Average procedure # for bilateral was 4.6; unilateral was 2.8
Take Home Points

• Consider CA in newborn/child with symptoms of nasal obstruction
• High association of choanal atresia with other congenital defects
• **Bilateral** choanal atresia is considered an **upper airway emergency** ➞ stabilize then surgery
• CHARGE syndrome seen commonly with CA and other heart/eye/ear abnormalities
• Treatment via transnasal or transpalatal approach
  – Treatment adjuncts controversial (stenting/Mitomycin)
Questions?


