Pediatric pulmonary puzzlers

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[1] Noisy breathing in a baby

A three month old baby comes to well child check with noisy breathing "since birth"

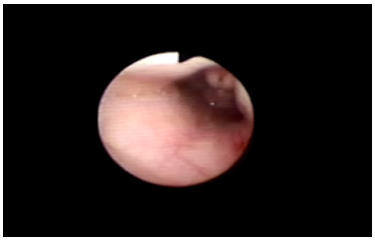
He is feeding vigorously with no choking or excessive spitting up and no respiratory distress with feeding. He has hiccups often

No history of pneumonia or otitis media

Physical Examination

Height and weight 50% for age. Not hypoxemic.
Happy baby
HEENT: Normal including intact palate by palpation. No head bobbing
Neck: No masses
Chest: No deformity or retractions
Lungs: bilaterally equal air entry with coarse breath sounds and loud inspiratory stridor, no wheezes

Investigations?



Laryngomalacia

- Most common cause of chronic stridor in infancy - 60-75%
- Prolapse of epiglottis or arytenoids into glottis causes upper airway obstruction
- Should NOT be confused with tracheomalacia
- Occasionally there is slow maturation of other cartilage
- May occurs as part of cartilage dysplasia syndrome

Laryngomalacia

- Sometimes there is a family history
- Coexisting GE reflux is common and due to air swallowing
- Air swallowing also causes hiccups, flatulence, and abdominal distention
- Tend to be vigorous feeders and grow well
- Stridor improves in prone position

Laryngomalacia

Time Course:

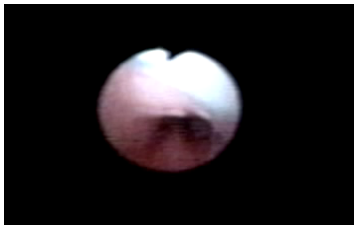
- Usually begins after 2-4 weeks
- Significant improvement by 1 year
- Mild symptoms persist for 2-4 years

Need for surgical intervention determined by

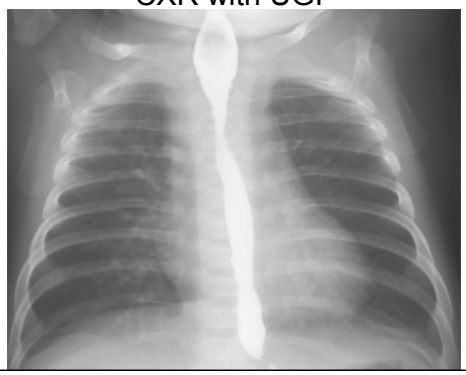
- adequacy of weight gain and growth
- degree of oxygen desaturation

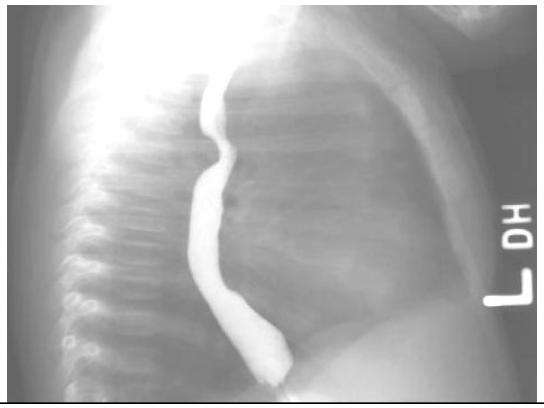
What if this baby had vomiting with feeds?

What is your next investigation?

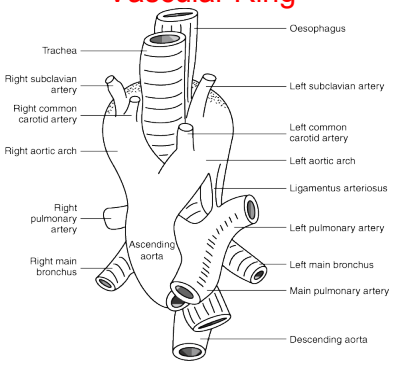


CXR with UGI





Vascular Ring

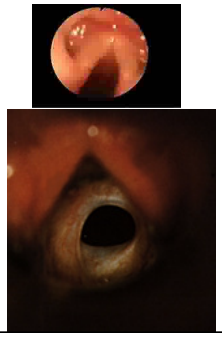


What if the baby was premature and had progressive respiratory distress?

Subglottic Stenosis

May be congenital but more commonly acquired secondary to airway manipulation/intubation

Symptoms usually begin weeks after birth (or the inciting stimulus) and may progress



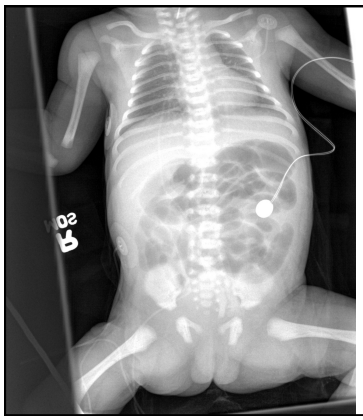
Subglottic Stenosis

Treatment is ***surgery***

- Cricoid split
- Laryngotracheoplasty with cartilage graft
- Tracheostomy

[2] A baby who won't breathe or poop

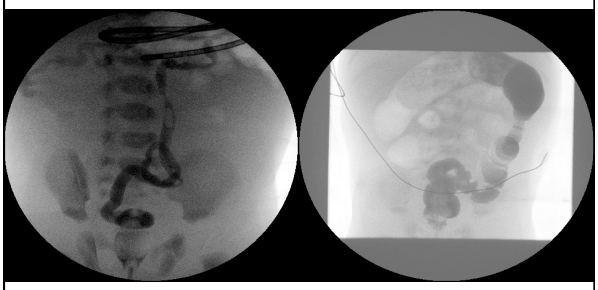
In the well baby nursery is a 3 day old who has not passed meconium. She was born by SVD at 35 weeks with a weight of 2.8 Kg.
When you examine her she is awake and vigorous, feeds well, not dysmorphic, afebrile with HR 148, RR 40 and SpO2 0.93.
Her abdomen is distended but not tender. The nurses note that she needs a "whiff" of oxygen when she is asleep to keep her SpO2 greater than 0.90



Chest Normal

Abdomen full of air but none in rectum

Barium contrast enema



What do you do next?

Capillary blood gas awake: pH 7.28 pCO2 61
Polysomnogram = central hypoventilation
MRI of head (brainstem) was normal

Phox2B positive for CCHS polyalanine expansion
Rectal suction biopsy positive for Hirschsprung's
Tracheostomy placed for nocturnal ventilation

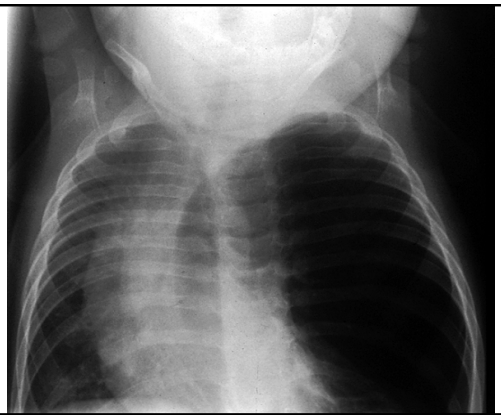
CCHS and Phox2B

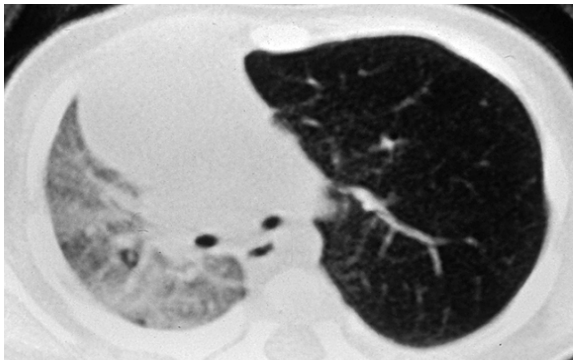
Paired mesoderm HomeobOX 2B
Transcription factor on chromosome 4 required for differentiation
Expressed exclusively in the nervous system, in neurons that control the viscera (respiratory (cardiovascular, and digestive systems).

Mutations in the Phox2B gene, usually polyalanine expansions, are responsible for most cases of CCHS.

[3] A baby with mild dyspnea

You are rounding in the newborn nursery and are asked to evaluate a baby with tachpnea and mild dyspnea.
He is awake, feeds well but slowly, not dysmorphic, afebrile with HR 148, RR 58 and SpO2 0.95.
His abdomen is distended but not tender.
Chest exam suggests decreased lung sounds on the left.
What should you do?





Ambiguous/imprecise Terms

"Cystic adenomatoid malformation (CCAM)" = may have aortic or pulmonary artery blood supply, may histologically resemble sequestration in part

"Sequestration" = may have aortic or pulmonary artery blood supply, may histologically resemble CCAM in part

Preferred term is congenital thoracic (UK) or lung (US) malformation

Why Treat CLM?

Unequivocal indications

Present symptoms (tachypnea, failure to thrive, usually neonatally) not responding to medical management

Complication (infection etc.) already present

(Ignorance - is it cancer?)

(PAVM) - risk of systemic embolism and abscess, hyperviscosity

How Treat CLM?

Do nothing

Surgical excision

Coil embolization

Asymptomatic CLM

Discuss what is known and unknown antenatally

HRCT scan in first few weeks, no contrast, follow up

HRCT with contrast at 18-21 months

Surgery if unchanged or larger

OP follow up with no routine re-imaging

What We Know

Many CTMs regress ante-natally and even some post-natally: beware of the meddler!

Even modern surgery is not totally risk free

There may be late complications of CLM
- Infection
- Pneumothorax
- Air embolism
- Cancer
- High output cardiac failure
- Bleeding

What We Do Not Know

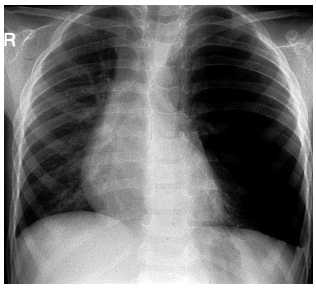
THE SLIDE IS NOT BIG ENOUGH!!

Follow-up age 4

Child asymptomatic

Cyst is not growing with child

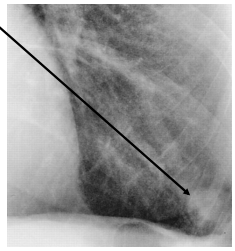
No evidence of growth or functional impairment



Congenital large hyperlucent cyst at age 4, completely well

[4] Cough, hypoxemia, abnormal CXR

Six year old girl with stuffy nose and headache.
At family doctor's office, found to have SpO2 0.87 and a 3 cm round LLL lesion on CXR.
Rest of CXR clear.



Past history unremarkable
Family history – sibs have URTI, mother has allergies, neurofibromatosis in cousins
On no medications.

Examination

Height at 5%ile but parents are also short
No fever. No rash or clubbing, nose slightly stuffy.
Chest is clear to auscultation. No distress.

Normal HR and BP. RR 22.
WBC 12,400. Hb 16.1 g/dL

She was given antibiotics and returned 4 days later. No change in CXR, no fever, SpO2 0.87

She was given albuterol and 30 minutes later SpO2 was 0.84 but she was not in distress.
She received an additional week of antibiotics plus ICS and albuterol but returned unchanged

What are the causes of hypoxemia?

[1] Most common acute cause is ventilation/ perfusion (V/Q) mismatch. This is the reason for hypoxemia in asthma, pneumonia, CF. This is also why there can be hypoxemia after beta agonists - improve perfusion before ventilation.
[2] Low inspired oxygen concentration - can occur at altitude for example.
[3] Hypoventilation due to low effective tidal volume or low respiratory rate leading to increased pCO_2 and subsequent decreased pO_2.

[4] Diffusion defects or poor alveolar-capillary gas transfer. This is uncommon in children except with fluid overload (e.g. surgery), ILD, or collagen vascular disease. Diffusion defects tend to present as hypoxemia with exercise.
[5] Right to left shunt, when unoxygenated blood bypasses the pulmonary vascular bed and admixes with fully oxygenated blood.
[6] Bad data. Broken oximeter probe, poor peripheral perfusion, bad probe placement, etc.

Clues: The child had no respiratory distress.

Her mum only thought she was developing sinusitis and wanted an antibiotic before everyone came for Thanksgiving dinner.

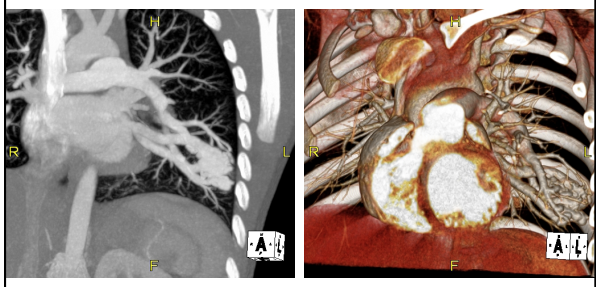
Oximetry was a routine vital sign in the referring pediatrician's office.

ECHO cardiogram and pCO2 were normal

No oxidant drug or environmental exposure to cause drug-induced methemoglobinemia (e.g. benzocaine). Absence of cyanosis makes methemoglobinemia unlikely.

The high Hb suggests that she has been hypoxemic for a while and is compensating.

CT angiography



Pulmonary AV Malformations

Although AVM are present from birth they are usually diagnosed later – often in adulthood.

Hereditary hemorrhagic telangiectasia (HHT) is the most common associated cause of AVM in otherwise healthy children.
HHT type 1 (HHT1) is caused by mutation in the gene encoding endoglin on chromosome 9q34

In HHT, if there is one AVM there are probably more!

This girl had the HHT1 mutation. The family was then screened.
She had no cutaneous haemangiomas.
MRI of her head showed two small right frontal vascular malformations.

Mother and sister also had the gene defect.
Both had normal CXR and had normal SpO2.

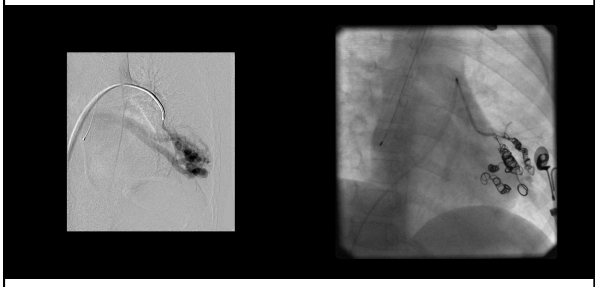
Sister had normal head MRI but mother had hypoxemia and a critically large AVM requiring urgent neurosurgical clipping.

Therapy

Although she has had this AVM her entire life, it needs to be fixed. She is at risk for hypercoagulation on the basis of high hemoglobin and also high output heart failure.

For pulmonary AVM, embolization is safer than resection and usually as effective.

Coil embolization



What risks are there for the future?

After AVM embolization it is important to detect persistent, re-perfused, or enlarging lesions.
These often cause symptoms, but a significant minority are asymptomatic.
Check for oxygen desaturation with exercise!

She is also at risk for intracranial haemorrhage and needs monitoring of cranial malformations.

[5] Runny nose, runny ears, and cough

A 5 year old is a new patient in your practice
Parents report that he has had a runny nose “since birth”. He was born at term with weight 3.6 Kg but spent 4 days in hospital for congestion.

He has had rhinitis and frequent otitis media with 3 sets of PE tubes that drain smelly pus.

He has had frequent bronchitis treated with antibiotics, albuterol, and prednisone and takes a long time to recover from colds.

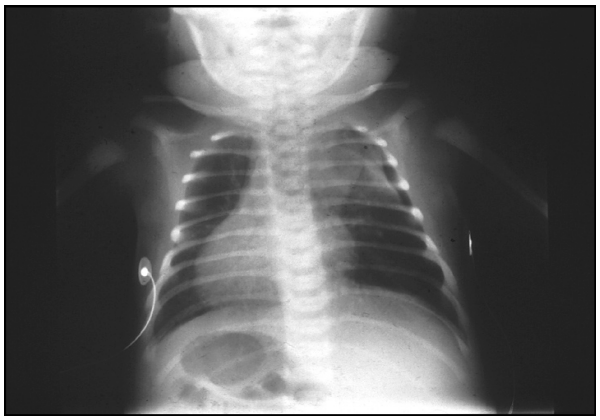
Otherwise he is well.

He has had allergy testing twice - both times negative. He has also had an upper GI showing significant GE reflux.

There is a family history of asthma and lung cancer but there is no other history of lung diseases
Both parents smoke but only outside.

He is on daily Xopenex, Claritin, Mucinex, Pulmicort, Nexium, and Zantac

To examination he is a pleasant, quiet, thin boy.
His parents smell of tobacco smoke
His height is 10%ile, weight 5%ile. He is afebrile HR 76 RR 20 SpO2 0.96 in ambient air
HEENT shows draining grommets in his ears, poor dentition, intact palate, mild cervical lymphadenopathy, congested nose
Lungs show diffuse coarse breath sounds that clear with cough
Heart sounds are displaced
Abdomen is soft and not tender
Neurological screening exam is normal
Diagnosis?
What next?

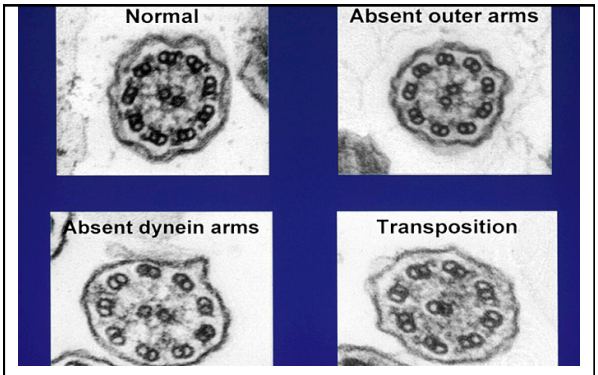


Primary ciliary dyskinesia - PCD

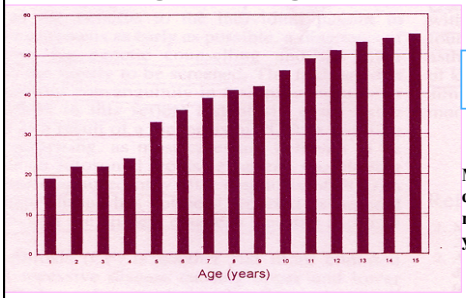
A spectrum of conditions characterized by a failure of normal mucociliary clearance due to congenital ciliary disease

This definition encompasses Kartagener's syndrome, primary disorders of ciliary orientation and ciliary dysmotility

This must be distinguished from 2^{ry} ciliary disease



Age at diagnosis PCD



N = 55 patients

Mean age at diagnosis 12; median 4.4 years

Acta Paediatr 2002; 91: 667-69

Presentations of PCD - Child

Abnormal Chest Xray with *situs inversus*

Neonatal rhinitis and congestion

Chronic cough and sputum; bronchiectasis

Very severe gastroesophageal reflux

Rhinosinusitis (polyps RARE)

Chronic severe discharging glue ear

Screening after diagnosis in a sibling

Presentations of PCD - Adult

As in infant and older child

Infertility or subfertility

Ectopic pregnancy

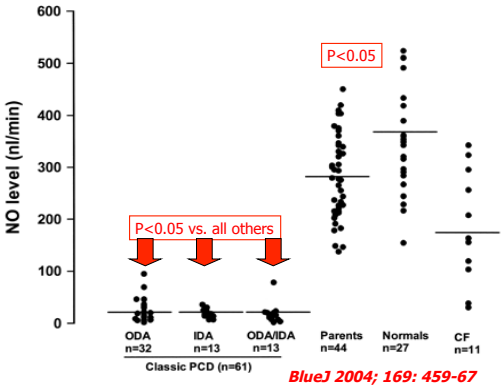
Arch Dis Child 2007; 92: 1136-40

Diagnosis

Eliminate other possibilities as appropriate
CF, Aspiration, Immunodeficiency etc.

Distinguish 1^{ry} from 2^{ry} ciliary disease

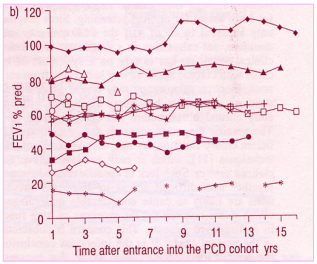
Look specifically for ciliary disease
Screening: saccharine test, nNO, radionuclide
Definitive: CBF & pattern, EM, Ciliary culture
The future: Genetics, IHC



BlueJ 2004; 169: 459-67

Prognosis of PCD

Adults (above 18 years)



Eur Res J 1997; 10: 2376-79

[6] A child with failure to thrive and dyspnea on exertion

A six year old girl is referred for evaluation of progressive exercise-induced asthma.

She has 2 year history of progressive dyspnea despite high dose ICS and daily albuterol.

Gestation, delivery, birth weight (3.66 kg, 50th percentile) and development were normal.

There is no history of cough, fever, pneumonia or pulmonary disease, chest pain, environmental exposure or drug use.

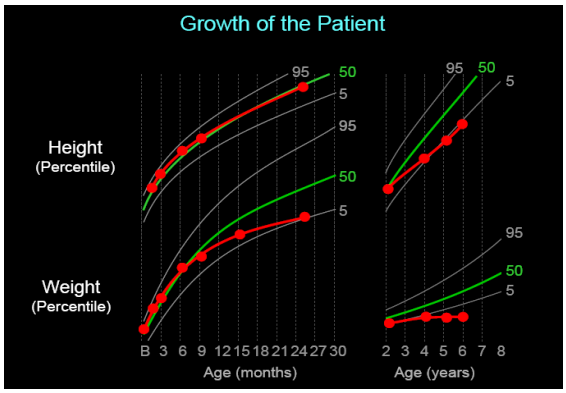
She has never had wheezing or nocturnal awakening. She is an engaging, intelligent child.

Physical examination

Her height and weight were 3%ile. RR 60 HR 106 and mild inspiratory crackles otherwise OK.

PFT revealed FEV1 and FVC both 44% predicted with no gas trapping. Unable to measure D_LCO

SpO2 was 0.88 while breathing ambient air and decreased to 0.81 after walking a short distance.

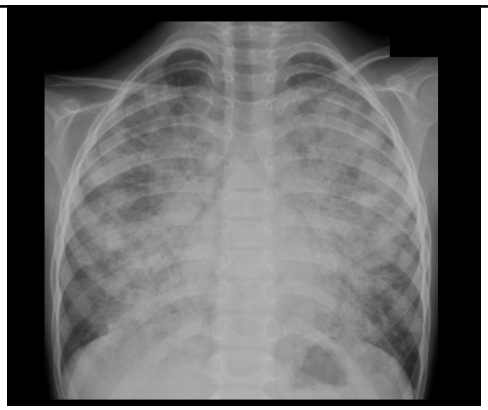


This girl was not cyanotic but it takes a low oxygen saturation to see cyanosis.
Perioral cyanosis in a non-distressed child is nearly always clinically benign. True cyanosis in an infant is almost always cardiac in origin.

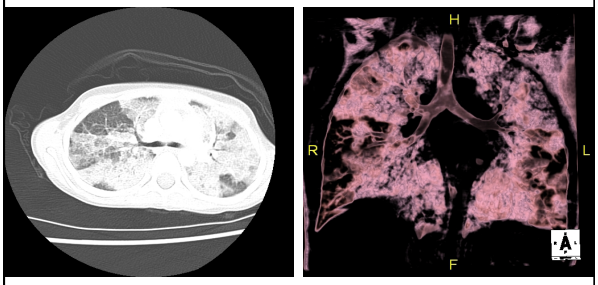
Normal oxygen saturation at sea level is 0.975. Commercial jets are pressurized to 8000 feet and mean oxygen saturation is 0.91 to 0.93.

Cardiac screening should also be part of the assessment.

An EKG is useful but the ECHO cardiogram is best for evaluation of RVH and *cor pulmonale* and should be part of the assessment of any infant or child with documented chronic hypoxemia.



"Crazy paving" on CT is diagnostic for
Pulmonary alveolar proteinosis



PAP is a rare disorder of surfactant metabolism leading to accumulation of phospholipids in the airways.
There is no inflammation or scarring of the lung.
It is primarily seen in newborns as the congenital form, and in adults who are usually smokers.
The prevalence has been estimated at 3 cases per million population and about 500 cases have been recorded in the literature.

The neonatal form is due to abnormalities of the hydrophobic surfactant-associated apoproteins: surfactant protein (Sp)B, SpC, and ABCA3 (ATP-binding cassette, sub-family A, member 3).
SpB deficiency produces very severe disease from birth. SpC deficiency usually presents in early infancy although it has been reported in children as old as 4 years.

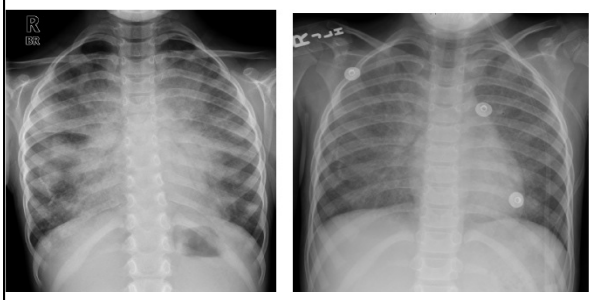
Definitive therapy for PAP due to surfactant apoprotein defects is lung transplantation.

Therapy

Therapy for PAP depends on the etiology
[1] Congenital abnormalities of surfactant apoproteins, especially SpB deficiency, usually requires lung transplantation
[2] GM-CSF therapy (systemic or by aerosol) has been effective in patients with antibodies.
[3] These girls may be cured either by bone marrow transplantation or by gene therapy correcting autologous stem cells.

[4] Total lung lavage can provide long-term symptomatic relief.

Lung lavage has helped this 6-year old girl



Before

After

[7] Dyspnea with exercise

8 year old boy with longstanding history of asthma. He has chest pain with running but never cough or wheeze. He has bronchitis each year in the winter, but no other symptoms. He has not been admitted to hospital before.

He is now in the ED with cough, dyspnea, hypoxemia, and chest pain developing over the past 3 days. This was not relieved by albuterol.

Dyspnea is due to
(1) neuromuscular (myopathy, neuropathy) including deconditioning, obesity
(2) psychological (conversion, depression, high expectations)
(3) cardiac problems (shunt)
(4) pulmonary problems.

In evaluating dyspnea, the history is everything! The most common cause of dyspnea that I see is deconditioning or unrealistic expectations

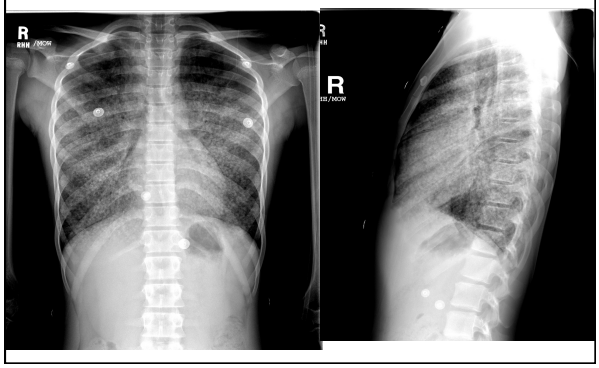
Hypoxemia and growth failure makes this most likely cardiac or pulmonary in origin.

He is sitting upright, not distressed but frightened. He is thin (90%ile height, 10%ile weight). HR is 140 RR 48 and SpO2 0.83. Chest auscultation shows diffuse crackles and bounding tachycardia. There is no fever, rash, clubbing, or heart murmur.

You are asked to start continuous nebs…

Capillary blood gas pH 7.43 pCO2 32.

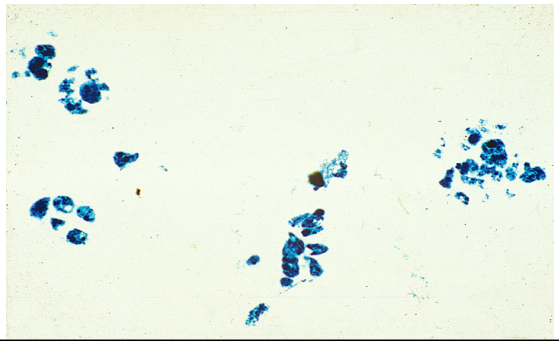
Chest radiographs



Blood count
WBC 12 000 with 74% PMN and 5% bands. 10% lymphs 2% eosinophils.
Hb 8.3 g/dL. Hematocrit 25.1 Platelets 348 000.
Low MCV and RBC counts.

Urine analysis. No blood or protein.
Stools – no blood.
Nose – no bleeding seen.

Idiopathic pulmonary hemosiderosis
or Diffuse alveolar hemorrhage (BALF)



Idiopathic pulmonary hemosiderosis
or Diffuse alveolar hemorrhage.

Pulmonary hemorrhage can be primary (idiopathic) or secondary to other illnesses.

Primary diffuse alveolar hemorrhage is of unknown etiology, although in infancy it has been weakly associated with milk protein allergy or exposure to *Stachybotrys chartarum* (formerly *S. atra*)

Secondary pulmonary hemosiderosis

Can occur with cardiac disease like mitral stenosis or pulmonary venoocclusive disease.

Cab be part of autoimmune disease including pulmonary-renal basement membrane disease - e.g. Goodpasture syndrome, Beçhet syndrome, lupus, and ANCA associated pulmonary vascular disease with capillaritis.

Can be part of the tuberous sclerosis-lymphangiomyomatosis (LAM) complex

Drug-induced diffuse alveolar hemorrhage (amiodarone, carbamazepine, cyclosporine, etc)

Not associated with coagulopathy alone.

Therapy

Identify and eliminate secondary causes if any
Blood transfusion if needed
Immune suppression – systemic corticosteroids

Lung transplantation

[8] Dyspnea with exercise

14 year old girl with asthma as an infant has been a competitive swimmer and runner since age 10. She now has chest pain and dyspnea with exercise, especially during meets. Her pediatrician prescribed salbutamol inhalation before exercise and she thinks this helps a bit.

She has been referred because the parents are concerned that she is not keeping up with members of her sports teams. She is well developed, of normal height and weight, and not in visible distress.

Acute severe dyspnea with abnormalities in gas exchange is usually easy to “figure out”

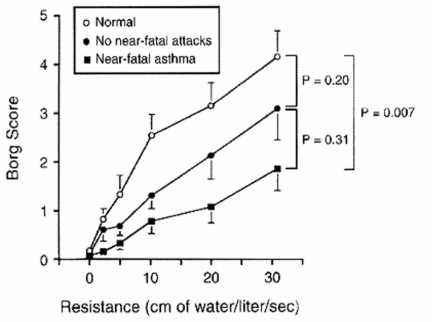
Chronic dyspnea is a bit more difficult

However by far, dyspnea occurring with exercise is the most common complaint of shortness of breath that I evaluate in pulmonary clinic.

Lung disease does not always cause dyspnea. Children with chronic lung disease like CF rarely complain of dyspnea. Even with severe disease they tend to limit what they do so that they do not become short of breath.

Exercise for a baby is feeding; so infants manifest dyspnea by slow or incomplete feeding.
A muffled cry in a baby suggests neuromuscular weakness but it can also be due to laryngeal dysfunction. It is common to have a weak cry without much visible dyspnea.

Chronic disease = blunted recognition



Kikuchi Y, Okabe S, Tamura G, Hida W, Homma M, Shirato K, Takishima T. NEJM 1994; 330:1329-1334

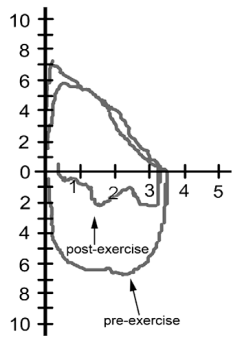
Exercise-induced asthma

Is not associated with hypoxemia
Is an *uncommon* cause of dyspnea
Is diagnosed by dyspnea with exercise, with a 12% or greater decrease from baseline FEV1 and little change in FVC. If FEV1 and FVC fall by a similar amount, this suggests *deconditioning*. If the fall in FVC is greater than that of the FEV1 it suggests a neuromuscular problem.

The FEV1 decrease and dyspnea should reverse after inhaling a SABA

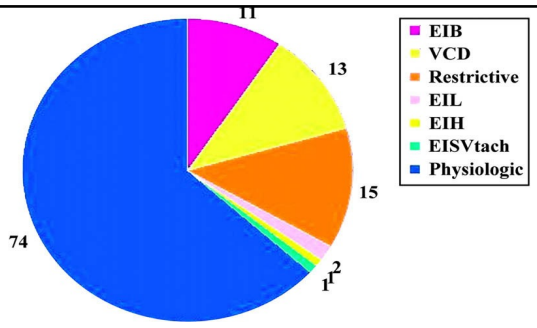
Cardiopulmonary exercise testing is most helpful in evaluating dyspnea.
Dysrhythmia suggests a cardiac problem. Hypoxemia with exercise (as in this patient) is either right to left shunting or a diffusion defect Hypoxemia during exercise can usually be considered "poor man's diffusion test".

A cardiopulmonary exercise test is only accurate if the child exercises hard enough that the sensation of dyspnea is reproduced.



Spirometry before and after exercise showing the marked decrease in the inspiratory portion of the flow-volume loop in association with dyspnea, and an inspiratory high-pitched stridor.

From Weinberger M, Abu-Hasan M. Pseudo-asthma: when cough, wheezing, and dyspnea are not asthma.



Diagnoses by treadmill exercise testing with physiologic monitoring.
EIB, exercise-induced asthma; EIH, EI hyperventilation; EIL, EI laryngomalacia;
EIVTach, EI supraventricular tachycardia; Physiologic, physiologic limitation without other abnormality;
Restrictive, apparent restriction of chest wall movement; VCD, vocal cord dysfunction.
Weinberger M, Abu-Hasan M. Pediatrics 2007;120:862

How to treat dyspnea

Identify the cause of dyspnea
Explain this to the family in terms that can be understood.
Improve ventilation if elevated P_{CO_2} is the cause and it is possible to improve rate of depth of breathing
Provide supplemental oxygen cautiously and only for documented hypoxaemia

Obviously treat underlying disease
Not quite as obviously, don't treat diseases that are present.