

## Vesalius SCALpel™ : Chest

### Chest wall

chondrosarcoma most common primary tumor of chest wall

### Mediastinum

#### compartments

anterior: thymoma, teratoma, germ cell, lymphoma

middle/visceral: cyst, foregut cyst/duplication (bronchogenic, esophagus), lymphoma

posterior/paravertebral: neurilemmoma/Schwannoma, neurofibroma, ganglioneuroma, ganglioneuroblastoma, chemodectoma, paraganglioma

other: thyroid, cystic hygroma, diaphragmatic (hiatal) hernia, aortic & ventricular aneurysm

#### mediastinal cyst

15-20% of mediastinal masses

unilocular, smooth, round

bronchogenic (60%)(near carina), esophageal duplication

epithelial lined, small risk malignant transformation

usually asymptomatic, small

may or may not communicate w esophagus or trachea

surgery recommended because of chance of infection, rupture, malignancy

more difficult surgery

pleuro-pericardial cyst

near cardiophrenic angle, 70% R

no infection or malignancy risk

aspirate

#### adult tumors

thymoma > lymphoma > germ cell

20-40yo 50% malignant

> 40 >40%

1/3 symptomatic

#### pediatric

neurogenic > thymic > lymphoma

1/3 malignant < 20yo

2/3 symptomatic: Horner's, SVC syndrome, hoarseness

#### thymoma

thymic epithelial cell origin worse prognosis

50% of anterior mediastinal masses

stage based on operative findings not histology

myasthenia: autoimmune complement mediated antibody damage to Ach receptors

30-50% of thymomas associated with myasthenia

10-15% of pts with myasthenia have thymoma

35% complete remission, 75% improvement with thymectomy

shorter interval onset to surgery better result

young more likely complete remission

myasthenia has no effect on survival with thymoma, only stage and completeness of resection

#### lymphoma

multiple discrete nodules v single mass germ cell and thymoma  
most common mediastinal malignancy, most anterior  
nodular sclerosing Hodgkins most common  
symptomatic have slightly worse prognosis

#### germ cell

seminoma: very radiosensitive; residual mass after RT probably scar, no AFP  
non-seminomatous: chorio, embryonal, endodermal sinus (yolk sac)  
teratoma most common (66%) mediastinal germ cell tumor  
smooth, lobulated, at least 2 of 3 germ layers  
benign are marker negative  
very elevated betaHCG, AFP at Dx; Bx for Dx, then chemo  
chemotherapy: cisplatin, bleomycin  
restage w tumor markers, if still elevated more chemo  
if normalized and residual mass resect (may represent teratomatous component)

#### neurogenic

neuroblastoma: child, malignant, metastasize early  
ganglioneuroma: most common benign neurogenic tumor in child  
ganglioneuroblastoma: intermediate differentiation  
neurilemmoma/benign Schwannoma  
malignant schwannoma  
childhood neurogenic paravertebral tumors 75% benign  
adult neurogenic paravertebral tumors 95% benign  
schwannoma, neurofibroma most common  
sympathetic chain or intercostals nerve ramus  
exceptions to benignity: neurofibroma (5% chance of malignancy) and hx of radiation  
neurofibroma 10% intraspinal component (dumbbell tumor)

## Heart

PDA: physiological in preemia, indomethacin  
in term baby = structural, surgery  
double aortic arch most common ring anomaly  
respiratory, dysphagia symptoms  
VSD: many small ones close spontaneously  
aortic stenosis (AS) w significant gradient risk for sudden death: operate  
PAT: > 90% focus in pulmonary vein  
Maze procedure 90% successful  
CABG: recurrence of angina > 5y = progressive atherosclerosis in native coronary arteries  
extracorporeal circulation: maximum 6-8h  
post-pericardiectomy syndrome (Dressler's)  
@ 2-4w, treat with anti-inflammatories

## Pericardium

### pericarditis

most idiopathic

causes: infection, neoplasm, post MI, post-op, uremic, drug, autoimmune

chest pain, malaise, fever, friction rub

treat underlying cause, NSAIDs

### chronic constrictive pericarditis

90% idiopathic, 10% prior acute pericarditis

fatigue, CHF, edema, ascites, pulsus paradoxus

Kussmaul's sign (paradoxical increase JVD with inspiration)

cardiac cath to differentiate from restrictive cardiomyopathy

surgical pericardiectomy

### tamponade

Beck's triad: hypotension, neck vein distention, muffled heart sounds

present in 30%

neck veins may not be distended with hemothorax

US (FAST exam) 99% accurate

pericardiocentesis, window temporize, sternotomy to correct cause

### pericardial malignancy:

most metastatic: breast > lung > lymphoma

mesothelioma most common primary malignancy

palliative Rx: drain malignant effusion

## Trachea

segmental arterial supply

benign: lipoma, fibroma, chondroma, GIST, hamartoma

hamartoma: resect (endobronchial if < 50% of diameter)

> 50% sleeve resection or lobectomy (if distal lung diseased from obstruction)

malignant: squamous, adenoid cystic

Rx: excision with primary anastomosis

1/2 length of trachea can be removed, anastomosis with release maneuver

post-op radiotherapy may be beneficial

## Benign lung

sequestration: no airway communication

most LLL

intralobar:

intralobar sequestration most common (70%), blood supply thoracic aorta

anomalous systemic artery enters via inferior pulmonary ligament

posterior basilar

venous drainage into pulmonary vein

extralobar: surrounded by separate visceral pleura

systemic venous drainage to azygous or portal

extra associated with other anomalies: diaphragmatic hernia, congenital diaphragmatic hernia, congenital heart disease  
 resect for repeated infections  
 congenital cystic adenomatoid malformation: abnormal bronchi and vasculature, resect reported malignancy, especially rhabdomyosarcoma  
 congenital lobar emphysema: newborn, compromises good lung, resect first few days of life, LUL hyperinflation common, mediastinal shift  
 cystic fibrosis: epithelial exocrine glands  
 pneumothorax most common surgical problem  
 pulmonary most common cause of death  
 bilateral transplant end stage  
 hamartoma: popcorn calcifications on CXR  
 spontaneous pneumothorax  
 young, tall, male, smoker typical  
 50% chance of 1<sup>st</sup> recurrence, 60% chance of 2<sup>nd</sup>  
 rupture of small blebs most common cause  
 most blebs apical, easily resectable by video-assisted thoracoscopic (VATS), less than 10% recurrence after resection  
 catamenial: menstruating woman, 90% R, 15% recurrence  
 pleurodesis for recurrent, high risk: pilot, scuba diver  
 chemical: doxycycline, talc  
 mechanical: VATS  
 pleural effusion  
 exudate: high LDH, protein, low glucose, low pH  
 malignant, infectious, collagen vascular  
 malignant effusion: thoracoscopic instillation bleomycin, talc  
 50% relief of shortness of breath  
 pleuroperitoneal shunt if VATS fails  
 transudate: CHF, cirrhosis, nephrotic syndrome  
 empyema  
 strep previously most common organism, now combination pneumococcus, staph, strep, Gm negatives  
 parapneumonic most common cause, 20% mortality, worse elderly  
 3 stages:  
 exudative: few WBCs, low LDH (<1,000), high pH  
 fibrinopurulent: hi WBC & LDH, low pH  
 organizing: variable  
 early empyema: chest tube (thoracentesis, pigtail cath not effective), fibrinolytic, antibiotics  
 late empyema (complicated, loculated, organized peel): surgical drainage, decorticate  
 open Thoracotomy, decortication if primary Rx fails  
 treat secondary lung compression, restriction  
 correct bronchopleural fistula  
 obliterate dead space (transposition flap)  
 pulmonary embolus  
 risk: post-op, cancer, elderly, inflammation, trauma  
 D-dimers elevated in most cases

- helical CT 99% accurate (equivalent to angio)
  - sensitive for segmental and subsegmental
  - IV contrast contraindicated in renal failure
- circulatory collapse, R heart strain catheter directed thrombolysis
  - thrombolysis decreases mortality v heparin alone
  - angio suction thrombectomy in critical
    - can remove 30-80% of clot burden (esp. saddle embolus)
  - operative embolectomy rarely done
- US detects lower extremity clot in 50% of patients with PE
  - IVC filter indicated if clot detected to prevent further emboli

## Lung cancer

- leading cause of death men and women (30% of all cancer deaths)
  - second in incidence after prostate and breast
  - asymptomatic solitary pulmonary nodule by age: < 50: 5% Ca, > 50: 50%, > 80: 100%
- small cell and non-small cell types
  - small cell:
    - 20% of lung cancers
    - 2/3 metastatic @ Dx
      - bone, liver, brain, extrathoracic LNs
      - no surgery for metastatic
    - paraneoplastic syndromes:
      - SIADH most common 15%
        - vasopressin or atrial natriuretic hormone -> hyponatremia
      - ACTH: Cushing's syndrome, myasthenia, retinopathy, encephalomyelitis
    - chemotherapy primary treatment
      - cisplatin, cyclophosphamide, doxorubicin, vincristin (CAV)
      - with limited disease 80% response, 25% 5y survival
        - adding RT may improve
    - prophylactic brain RT may decrease mets 45%, but no long term survival benefit
  - non-small cell: squamous, adeno most common; large cell, carcinoid
    - squamous
      - most common (40-50%) lung Ca
      - central location more common than peripheral, cavitation, smoking
      - endobronchial, lymphatic spread
      - new lung lesion after squamous = new primary
    - adeno
      - increasing frequency
      - peripheral location more common
      - early hematogenous spread
  - prognosis
    - stage I: 65% 5y, II: 55%, III: 35%
  - paraneoplastic syndromes:
    - Cushing's, hypercalcemia, SIADH
    - resolve with resection

Dx/w/u

bronchoscopy, sputum cytology  
criteria for surgery: FEV1 >1L, FRC >800cc  
refine with quantitative V/Q (ventilation-perfusion scan)  
determine which parts functional

surgery

stage I & II lung parenchyma: resect and mediastinal LN dissection  
IIIa: ipsilateral mediastinal nodes: pre-op chemoradiation  
IIIb, IV: chemoradiation, non-operative  
lobectomy better 5y survival than wedge

superior sulcus (Pancoast) tumor

pain, Horner's

pre-op radiation: 3-5,000 cGy, restage  
resect lobe, ribs  
good results when complete resection

### **Metastatic disease to lung**

liver mets to lung no resection, incurable (v colon)  
melanoma, sarcoma, breast, colon common

### **Asbestos**

lung mesothelioma, esophagus, stomach Ca

### **Thoracic outlet**

multiple anatomic causes of constriction  
vascular and neurologic components  
first rib resection usual treatment

### **Thoracic trauma**

cause of 25% of trauma mortality  
rib fx elderly: 2X risk morbidity and mortality; 19% increase for each rib  
most elderly not candidates for epidural  
hemothorax: initial output > 1,500cc to OR  
innominate artery most common vascular injury in blunt trauma: median sternotomy  
tension pneumo: kink superior and inferior vena cava, circulatory collapse  
aorta  
90% of blunt thoracic aortic rupture die at scene  
if cross clamp necessary limit to 30m to avoid spinal cord ischemia  
10-15% paraplegia  
cardiac contusion: echocardiogram, enzymes  
more common than valvular damage  
troponin I specific for cardiac injury

- rises by 4-10 hours, 50% sensitivity within 4h, 100% @12
  - confirmatory, too late for emergency screening
  - peaks 4-8d
  - peak correlates with subsequent cardiac events
  - conservative Rx
  - severe can go into CHF, need aortic balloon pump
- thoracotomy
  - R anterolateral rarely used
  - double lumen tube prevent blood and secretions compromising non-involved side
- penetrating, tamponade, usually R ventricular injury
  - clinical or FAST Dx
  - needle pericardiocentesis temporizing only, not necessary for diagnosis
  - sternotomy for definitive repair of injury
- flail chest: primary problem is pulmonary contusion
  - pain control: intercostal block, epidural
  - mechanical ventilation if necessary
- diaphragmatic rupture
  - blunt 3X incidence of penetrating, usually (70%) L
  - 80% present with dyspnea
  - X-ray NG tube above diaphragm
  - acute: explore through abdomen for associated abdominal injuries (85%), most spleen
  - chronic/late: repair through thorax because of adhesions

## Mechanical ventilation

FEV1 < 800 risk post op pulmonary compromise

physics/definitions

minute ventilation = tidal volume X respiratory rate

hypoventilation:  $\text{PaCO}_2 > 40$

hypoxemia:  $\text{PaO}_2 < 60$ ,  $\text{SaO}_2 < 90$

O<sub>2</sub> delivery (DO): cardiac output X O<sub>2</sub> content

CO = stroke volume X heart rate

O<sub>2</sub> content = [Hb] X SaO<sub>2</sub> X 13.4

therefore: DO = CO X [Hb] X SaO<sub>2</sub> X 13.4

Dalton's law of partial pressure: each gas in a mixture acts independently

$P(\text{air}) = p\text{O}_2 + p\text{CO}_2 + p\text{H}_2\text{O} + p\text{N}_2$

$p\text{O}_2 = \text{FO}_2 \times P$

F = fraction, P = atmospheric pressure

eg: atm press 760,  $\text{FO}_2 = .21$ , then  $p\text{O}_2 = 160$

alveolar pO<sub>2</sub> modified by H<sub>2</sub>O and CO<sub>2</sub>

$760 - 47$  (water),  $-40$  (CO<sub>2</sub>) X .21 = 110mmHg pAO<sub>2</sub> (partial pressure of alveolar O<sub>2</sub>)

arterial pO<sub>2</sub> does not equal alveolar pO<sub>2</sub>

oxyhemoglobin dissociation curve

rapid increase saturation up to 60mm, ~85% saturation; 97% @ 100mm

acidosis (decrease ATP, 2,3DPG, increase CO<sub>2</sub>) shift curve to right

easier unloading of O<sub>2</sub> (normal p<sub>50</sub> = 27mm, acidosis p<sub>50</sub> = > 27)  
organs compensate for decreased blood flow by extracting more O<sub>2</sub>  
body normally consumes 25% of O<sub>2</sub>, mixed venous O<sub>2</sub> is normally 75% saturated (pO<sub>2</sub> 40mm)  
mixed venous O<sub>2</sub> (SvO<sub>2</sub>) increases in septic shock, L-R shunt  
normal work of breathing consumes 2% of O<sub>2</sub>; post op as high as 50%  
need for ventilator support: R > 35, PaCO<sub>2</sub> > 60, A-a O<sub>2</sub> difference > 350, VD/VT > 0.6, shunt fraction > 20%

#### ventilation modes

volume ventilation (eg anesthesia machine in OR)

flow is square wave

tidal volume (TV) remains constant

airway pressure depends on compliance

machine delivered breaths evenly spaced

awake patient may become asynchronous, uncomfortable

no patient-initiated breaths allowed

assist control (AC)

same as volume control, but separate patient initiated breaths permitted

unevenly spaced, all same TV

awake patient may hyperventilate

IMV (intermittent mandatory ventilation)

intermittent mandatory breaths

no assisted spontaneous breaths

synchronized triggered mandatory breaths, more comfortable

machine breaths are volume controlled

good weaning mode

spontaneous breaths increase the work of breathing

pressure support eases the work of triggered breaths

SIMV (synchronized IMV) + PS (pressure support)

machine breaths are volume controlled

spontaneous breaths are pressure-supported

guaranteed minimum minute ventilation, best of both

improved safety as weaning mode

graded unloading of work of breathing

O<sub>2</sub>, ventilation, work of breathing independently controlled

SIMV alone without pressure support increases work of breathing

pressure controlled/non-spontaneous

for severe lung disease in paralyzed patient

pts with poor compliance

limit airway pressure to protect lungs

PEEP (positive end expiratory pressure)

recruits collapsed alveoli, increased FRC

can be combined with any ventilator mode

improves alveolar oxygenation

reduces physiologic shunting

downside: increases mean intrathoracic pressure, barotrauma  
autoPEEP: reverse I/E ratio ventilation, breath stacking  
progressive PEEP trial for optimal O<sub>2</sub> delivery  
protection strategies against pressure/volume trauma, O<sub>2</sub> toxicity  
reduce FiO<sub>2</sub> to < .50 as soon as possible  
keep positive airway pressure (PAP) < 50cm  
use PEEP early in ARDS, may decrease PAP, barotrauma  
select at lower inflection point  
smaller tidal volume: 3-6cc/Kg  
permissive hypercapnea (with added O<sub>2</sub>)

#### weaning parameters

FiO<sub>2</sub> < .50  
PEEP < 10  
negative inspiratory force (NIF) > 20-30cm, H<sub>2</sub>O  
T-tube trial: R < 24, TV > 5-8cc/Kg, minute vol > 10L/m, pCO<sub>2</sub> < 50  
rapid shallow breathing index: rate/TV < 105 (higher than 105 = rapid shallow breathing; fast shallow breaths not as effective as slow deep)  
A-a gradient < 300-350mm  
PaO<sub>2</sub>/FiO<sub>2</sub> > 200  
shunt fraction < 15

#### weaning strategies

SIMV + PS + PEEP + O<sub>2</sub>  
each can be weaned independently  
continuous v intermittent process  
gradual v abrupt physiological changes  
comfort level, lack of sedation  
control work of breathing, exercise  
may still need to provide rest, prevent fatigue

prone positioning: alveolar recruitment dorsal lung, improved drainage of secretions, increased FRC

#### air/CO<sub>2</sub> embolus

abrupt drop end tidal CO<sub>2</sub>, drop BP due to venous return obstruction  
R lateral decubitus, central venous catheter aspiration of gas from right atrium

#### CO poisoning

carboxyHb > 10% Rx 100% O<sub>2</sub>  
> 30% intubate

#### References:

Feins, R. What's new in general thoracic surgery. JACS, 199(2), Aug. '04: 265-272.