

PULMONARY MEDICINE

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Asthma Exacerbation

DIFFERENTIAL DIAGNOSIS OF WHEEZING

EXTRATHORACIC AIRWAY OBSTRUCTION

- **OROPHARYNX**—enlarged tonsils, retropharyngeal abscess, obesity, post-nasal drip
- **LARYNX**—laryngeal edema, laryngostenosis, laryngocele, epiglottitis, anaphylaxis, severe laryngopharyngeal reflux, and laryngospasm
- **VOCAL CORDS**—vocal cord dysfunction, paralysis, hematoma, tumor, cricoarytenoid arthritis

INTRATHORACIC AIRWAY OBSTRUCTION

- **TRACHEAL OBSTRUCTION**—tracheal stenosis, tracheomalacia, tracheobronchitis (herpetic), malignancy, benign tumor, aspiration
- **TRACHEAL COMPRESSION**—goiter, right-sided aortic arch
- **LOWER AIRWAY OBSTRUCTION**—asthma, COPD, bronchiolitis, bronchiectasis, carcinoid tumor, aspiration, malignancy
- **PARENCHYMA**—pulmonary edema
- **VASCULAR**—pulmonary embolism

PATHOPHYSIOLOGY

EXACERBATORS OF ASTHMA

- **INFECTIONS**—viral, bacterial
- **OUTDOORS**—respirable particulates, ozone, sulfur dioxide, cold air, humidity, smoke
- **INDOORS**—smoke, dust mites, air conditioners, humidity, perfumes, scents, smoke
- **NON-ADHERENCE**

CLINICAL FEATURES

HISTORY—history of asthma and any life-threatening exacerbations, number of ER visits/hospital admissions in the last 6 months or ever, any ICU admissions, previous prednisone use, triggers for attacks, normal peak expiratory flow rate, change in peak flow rates, wheezing, cough, dyspnea, decreased function, exercise limitation, nocturnal symptoms, absenteeism from work/school, post-nasal drip, recurrent sinusitis, GERD, occupational and work environment, past medical history, medication history, psychosocial issues, home environment (pets, heating source, filter changes)

CLINICAL FEATURES (CONT'D)

PHYSICAL—HR ↑, RR ↑, pulsus paradoxus, O₂ requirement, moderate-severe dyspnea, barrel chest, cyanosis, hyperresonance, decreased breath sounds, wheezing, forced expiratory time

TYPES OF WHEEZING—inspiratory wheeze and expiratory wheeze are classically associated with extrathoracic and intrathoracic airway obstruction, respectively. However, they are neither sensitive nor specific and cannot help to narrow differential diagnosis

INVESTIGATIONS

BASIC

- **LABS**—CBC/D, lytes, urea, Cr, troponin/CK
- **MICROBIOLOGY**—sputum Gram stain/AFB/C&S
- **IMAGING**—CXR

SPECIAL

- **ABG**—if acute respiratory distress
- **PEAK FLOW METER**—need to compare bedside reading to patient's baseline
- **SPIROMETRY/PFT** (non-acute setting)—↑ FEV₁ >12% and an absolute ↑ by 200 mL post-bronchodilators suggest asthma
- **METHACHOLINE CHALLENGE** (non-acute setting)—if diagnosis of asthma not confirmed by spirometry alone. A decrease of FEV₁ >20% after methacholine challenge suggests asthma. Sens 95%

ACUTE MANAGEMENT

ABC—O₂ to keep sat >92%, IV

BRONCHODILATORS—*salbutamol* 2.5–5.0 mg NEB q6h + q1h PRN and *ipratropium* 0.5 mg NEB q6h (frequency stated is a guide, can increase or decrease on a case by case basis)

STEROID—*prednisone* 0.5–1 mg/kg PO daily ×7–14 days (may be shorter depending on response) or *methylprednisolone* 0.4–0.8 mg/kg IV daily (until conversion to prednisone)

OTHERS—if refractory case and life-threatening, consider IV epinephrine, IV salbutamol, theophylline, inhaled anesthetics, MgSO₄

MECHANICAL VENTILATION—BIPAP, intubation

LONG-TERM MANAGEMENT

EDUCATION—smoking cessation (see p. 418).

Asthma action plan. Puffer technique education and review

ENVIRONMENTAL CONTROL—avoidance of outdoor/indoor allergens, irritants, and infections; home environment cleanliness (e.g. steam cleaning)

VACCINATIONS—influenza vaccine annually and pneumococcal vaccine booster at 5 years

FIRST LINE—short-acting β_2 -agonist (*salbutamol* 2 puffs PRN). Proceed to second line if using more than 2 \times /week or 1 \times /day for exercise-induced symptoms, symptoms $>2 \times$ /week, any nocturnal symptoms, activity limitation or PEF $<80\%$

SECOND LINE—inhaled corticosteroids plus short-acting β_2 -agonist PRN

THIRD LINE—inhaled corticosteroid plus **long-acting β_2 -agonist** (note that long-acting β_2 -agonist should never be used alone in asthma), **leukotriene receptor antagonist** (most effective in asthma complicated with sinus disease and exercise-induced asthma)

FOURTH LINE—anti-IgE therapy (omalizumab) for refractory allergic asthma, administered subcutaneously q2–4weeks, dosed by IgE level and body weight, for add-on therapy or inadequately controlled moderate-to-severe allergic asthma despite use of high doses of inhaled corticosteroid therapy

NEJM 2009 360:10

TREATMENT ISSUES

COMMON INHALED MEDICATIONS

- **SHORT-ACTING β -AGONISTS**—*salbutamol* metered dose inhaler (MDI) 100 μg 1–2 puffs PRN or 2.5 mg NEB PRN, *fenoterol* MDI 100 μg 1–2 puffs PRN, *terbutaline* 500 μg INH PRN
- **SHORT-ACTING ANTICHOLINERGICS**—*ipratropium* MDI 20 μg 2 puffs QID or 500 μg NEB QID
- **LONG-ACTING β -AGONISTS**—*formoterol* 6–24 μg INH BID, *salmeterol* diskus 50 μg i puff BID
- **LONG-ACTING ANTICHOLINERGICS**—*tiotropium* 18 μg INH daily
- **INHALED CORTICOSTEROIDS**—*beclomethasone* 50–400 μg INH BID, *budesonide* turbuhaler 200–400 μg INH BID or 0.5–1 mg NEB BID, *fluticasone* 125–250 μg INH BID, *ciclesonide* MDI 100–400 μg INH daily (only indicated for asthma at this time, not COPD)

Related Topics

Chronic Obstructive Pulmonary Disease (p. 3)
Pulmonary Function Tests (p. 21)

ADMISSION CRITERIA

	FEV1 (L)	PEF (L/min)	PaO ₂	Action
Very severe	–	–	$<90\%$ with O ₂	Admit
Severe	<1.6 ($<40\%$)	<200 ($<40\%$)	$<90\%$	Admit
Moderate	1.6–2.1	200–300	$>90\%$	Admit?
Mild	>2.1 ($>60\%$)	>300 ($>60\%$)	$>90\%$	Send home

DISCHARGE CRITERIA—consider discharging patient if peak flow $>70\%$ of usual (or predicted) value for at least 1 h after bronchodilator

OXYGEN DELIVERY DEVICES

Device	Flow rates	Delivered O ₂		
Nasal cannula	1 L/min	21–24%		
	2 L/min	25–28%		
	3 L/min	29–32%		
	4 L/min	33–36%		
	5 L/min	37–40%		
	6 L/min	41–44%		
	Simple oxygen face mask	6–10 L/min	35–60%	
		Face mask with oxygen reservoir (non-rebreather mask)	6 L/min	60%
			7 L/min	70%
			8 L/min	80%
Venturi mask	9 L/min	90%		
	10–15 L/min	95+%		
	4–8 L/min	24–40%		
	10–12 L/min	40–50%		

NOTE: delivered O₂ (FiO₂) is approximate. Oxygen delivery can approach 100% with intubation and mechanical ventilation

SPECIFIC ENTITIES

EXERCISE-INDUCED ASTHMA

- **PATHOPHYSIOLOGY**—mild asthma with symptoms only during exercise due to bronchoconstriction as a result of cooling of airways associated with heat and water loss
- **DIAGNOSIS**—spirometry. Exercise or methacholine challenge may help in diagnosis
- **TREATMENTS**—prophylaxis with *salbutamol* 2 puffs, given 5–10 min before exercise. Consider leukotriene antagonists or inhaled glucocorticoids if frequent use of prophylaxis

TRIAD ASTHMA (Samter's syndrome)—triad of asthma, aspirin/NSAIDs sensitivity, and nasal polyps. Cyclooxygenase inhibition → ↓ prostaglandin E₂ → ↑ leukotriene synthesis → asthma symptoms. Management include ASA/NSAIDs avoidance and leukotriene antagonists (montelukast)

SPECIFIC ENTITIES (CONT'D)

ALLERGIC BRONCHOPULMONARY ASPERGILLOSIS (ABPA)

- **PATHOPHYSIOLOGY**—associated with asthma and cystic fibrosis. Due to colonization of the airways by *Aspergillus fumigatus*, leading to an intense, immediate hypersensitivity-type reaction in the airways
- **CLINICAL FEATURES**—history of asthma, recurrent episodes of fever, dyspnea, and productive cough (brownish sputum). Peripheral eosinophilia. CXR findings of patchy infiltrates and central bronchiectasis
- **DIAGNOSIS**—above clinical features plus *Aspergillus* extract skin test, serum IgE level, sputum for *Aspergillus* and/or serologic tests (IgE and IgG against *Aspergillus*)
- **TREATMENTS**—systemic glucocorticoids, itraconazole

COPD Exacerbation

NEJM 2004 250:26

DIFFERENTIAL DIAGNOSIS OF ACUTE DYSPNEA

RESPIRATORY

- **AIRWAY**—COPD exacerbation, asthma exacerbation, acute bronchitis, infectious exacerbation of bronchiectasis, foreign body obstruction
- **PARENCHYMA**—pneumonia, cryptogenic organizing pneumonia, ARDS, acute exacerbation of interstitial lung disease
- **VASCULAR**—pulmonary embolism, pulmonary hypertension
- **PLEURAL**—pneumothorax, pleural effusion

CARDIAC

- **MYOCARDIAL**—HF exacerbation, myocardial infarction
 - **VALVULAR**—aortic stenosis, acute aortic regurgitation, mitral stenosis, endocarditis
 - **PERICARDIAL**—pericardial effusion, tamponade
- SYSTEMIC**—sepsis, metabolic acidosis, anemia
OTHERS—neuromuscular, psychogenic, anxiety

PATHOPHYSIOLOGY

PRECIPITANTS OF COPD EXACERBATION—infections, lifestyle/environmental (10%, cigarette smoke, dust, pollutants, cold air), non-adherence, pulmonary embolism, pulmonary edema, pneumothorax, progression of COPD

CLINICAL FEATURES

RATIONAL CLINICAL EXAMINATION SERIES: DOES THE CLINICAL EXAMINATION PREDICT AIRFLOW LIMITATION?

History	Sens	Spc	LR+	LR–
Smoking >70 pack year	40%	95%	8	0.63
Smoking ever	92%	49%	1.8	0.16

CLINICAL FEATURES (CONT'D)

	Sens	Spc	LR+	LR–
Sputum >1/4 cup	20%	95%	4	0.84
Chronic bronchitis Sx	30%	90%	3	0.78
Wheezing	51%	84%	3.8	0.66
Any exertional dyspnea	27%	88%	2.2	0.83
Coughing	51%	71%	1.8	0.69
Any dyspnea	82%	33%	1.2	0.55
Physical				
Wheezing	15%	100%	36	0.85
Barrel chest	10%	99%	10	0.90
Decreased cardiac dullness	13%	99%	10	0.88
Match test	61%	91%	7.1	0.43
Rhonchi	8%	99%	5.9	0.95
Hyperresonance	32%	94%	4.8	0.73
FEV1 >9 s	–	–	4.8	–
FEV1 6–9 s	–	–	2.7	–
FEV1 <6 s	–	–	0.45	–
Subxyphoid cardiac apical impulse	8%	98%	4.6	0.94
Pulsus paradoxus (>15 mmHg)	45%	88%	3.7	0.62
Decreased breath sounds	37%	90%	3.7	0.70
Accessory muscle use	24%	100%	–	0.70

APPROACH—“no single item or combination of items from the clinical examination rules out airflow limitation. The best findings associated with increased likelihood of airflow limitation are objective wheezing, FEV1 >9 s, positive match test, barrel chest, hyperresonance and subxyphoid cardiac impulse. Three findings predict the likelihood of airflow limitation in men: years of cigarette smoking, subjective wheezing and either objective wheezing or peak expiratory flow rate”

JAMA 1995 273:4

CLINICAL FEATURES (CONT'D)

STEREOTYPES (not useful clinically)

- **BLUE BLOATER** (more chronic bronchitis)—cough and sputum, hypoxemia, CO₂ retention, pulmonary hypertension, right-sided heart failure
- **PINK PUFFER** (more emphysema)—cachexia, relatively preserved blood gases, dyspnea even at rest

PREDICTION RULE FOR OBSTRUCTIVE AIRWAY DISEASE

- **AGE ≥45 YEARS**—LR+ 1.3
- **SMOKING >40 PACK YEAR**—LR+ 8.3
- **SELF-REPORTED HISTORY OF CHRONIC OBSTRUCTIVE AIRWAY DISEASE**—LR+ 7.3
- **MAXIMUM LARYNGEAL HEIGHT <4 CM [<1.6 IN.]**—distance between the top of thyroid cartilage and suprasternal notch at end of expiration. LR+ 2.8

JAMA 2000 283:14

INVESTIGATIONS

BASIC

- **LABS**—CBCD, lytes, urea, Cr, troponin/CK, Ca, Mg, PO₄
- **MICROBIOLOGY**—sputum Gram stain/AFB/C&S/fungal
- **IMAGING**—CXR
- **ECG**—left atrial enlargement, atrial fibrillation, sinus tachycardia
- **SPIROMETRY/PFT**—FEV₁/FVC <0.7, partially reversible. Severity based on FEV₁
- **ABG**—if acute respiratory distress

SPECIAL

- **BNP**—if suspect HF
- **D-dimer**—if suspect PE
- **ECHOCARDIOGRAM**

PROGNOSTIC ISSUES

PROGNOSIS OF PATIENTS WITH ACUTE EXACERBATION OF COPD—in-hospital mortality 5–10%

GOLD CLASSIFICATION 2007—all have FEV₁/FVC <0.7

- **STAGE I (MILD)**—FEV₁ ≥80% predicted
- **STAGE II (MODERATE)**—FEV₁ 50–79% predicted
- **STAGE III (SEVERE)**—FEV₁ 30–49% predicted
- **STAGE IV (VERY SEVERE)**—FEV₁ <30% predicted, or <50% predicted + cor pulmonale

BODE INDEX

- **BMI**—0= >21, 1= ≤21
- **OBSTRUCTION** (post-bronchodilator FEV₁)—0 ≥65% predicted, 1=50–64%, 2=36–49%, 3= ≤35%
- **DISTANCE WALKED IN 6 MIN**—0= ≥350 m, 1=250–349 m, 2=150–249 m, 3= ≤149 m
- **EXERCISE MMRC DYSPNEA**—0=0–1, 1=2, 2=3, 3=4
- **SCORING**—hazard ratio for death from any cause per one-point increase in BODE score is 1.34

NEJM 2004 350:10

ACUTE MANAGEMENT

ABC—O₂ to keep sat >90%, or 88–92% if CO₂ retainer, IV

BRONCHODILATORS—**salbutamol** 2.5–5 mg NEB q4h ATC + q1h PRN and **ipratropium** 0.25–0.5 mg NEB q4h. Puffers preferable for acute management if proper technique used

STERIODS—**prednisone** 40–60 mg PO daily ×14 days (tapering dose not necessary in all cases) or **methylprednisolone** 60–125 mg IV daily (inpatient)

ANTIBIOTICS—give if any two of the following criteria are met: ↑ sputum purulence, ↑ dyspnea or ↑ sputum volume. Other considerations include the need for non-invasive mechanical ventilation and “at risk” for poor outcome (substantial comorbidities, severe COPD, frequent exacerbations >3/year, recent antibiotics within 3 months); choices depend on clinical circumstance (**levofloxacin** 500 mg PO daily ×7 days, **doxycycline** 100 mg PO BID ×7–10 days, **amoxicillin** 500 mg PO BID ×7 days, **cefuroxime** 250–500 mg PO BID ×10 days, or **azithromycin** 500 mg PO ×1 day then 250 mg PO daily ×4 days)

MECHANICAL VENTILATION—**BIPAP, intubation**

OTHERS—DVT prophylaxis (**heparin** 5000 U SC BID), physiotherapy

NEJM 2002 346:13

LONG-TERM MANAGEMENT

EDUCATION—**smoking cessation** (see p. 418). Disease-specific self-management program. **Puffer technique** education and review

VACCINATIONS—influenza vaccine annually and pneumococcal vaccine booster at 5 years

REHABILITATION—**exercise training** (increases quality of life and exercise tolerance)

FIRST LINE—**short-acting β₂-agonist** or short-acting anticholinergic on an as-needed basis

SECOND LINE—**long-acting β₂-agonist** or **long-acting anticholinergic** (**tiotropium** 1 puff [18 μg/puff] INH daily) plus short-acting β₂-agonist PRN. Consider early initiation of long-acting agents if requiring regular PRN short-acting agents as long-acting agents are superior

THIRD LINE—**long-acting β₂-agonist** plus **long-acting anticholinergic**, with short-acting β₂-agonist PRN

FOURTH LINE—**long-acting anticholinergic** plus **long-acting β₂-agonist/inhaled corticosteroid combination** (e.g. Advair, Symbicort). No role for inhaled corticosteroid alone in COPD

FIFTH LINE—fourth line plus **theophylline** 400 mg PO daily ×3 days, then 400–600 mg PO daily, therapeutic level 10–20 μg/mL

SIXTH LINE—fifth line plus **home O₂**

LONG-TERM MANAGEMENT (CONT'D)

SEVENTH LINE—lung volume reduction surgery (may be beneficial if upper lobe involvement and poor functional capacity) or **lung transplant**

Canadian Thoracic Society Guidelines 2003

TREATMENT ISSUES

FACTORS FOR IMPENDING INTUBATION—cardiac or respiratory failure, hemodynamic instability, markedly elevated respiratory rate (>35/min), fatigue and labored respiration, use of accessory muscles, worsening hypercapnia, acidosis (especially lactic), stridor (impending upper airway obstruction), agonal breathing (impending respiratory arrest)

LIFE-PROLONGING MEASURES FOR COPD—smoking cessation, supplemental O₂

INDICATIONS FOR SUPPLEMENTAL HOME O₂—ABG done in room air. PaO₂ <55 mmHg alone or PaO₂ <60 mmHg in the presence of bilateral ankle edema, cor pulmonale, or hematocrit >56%

SPECIFIC ENTITIES**α1-ANTITRYPSIN DEFICIENCY**

- **PATHOPHYSIOLOGY**—production of an abnormal protease inhibitor (homozygous ZZ) with impaired transport out of the liver. Serum level is only 10–15% of normal → increased protease activity leads to emphysema and cirrhosis (10%)
- **DIAGNOSIS**—α1-antitrypsin levels
- **TREATMENTS**—similar to COPD, α1-antitrypsin replacement

BRONCHIOLITIS OBLITERANS

- **PATHOPHYSIOLOGY**—severe inflammation of bronchioles → airflow obstruction. Very different from bronchiolitis obliterans organizing pneumonia (BOOP)/cryptogenic organizing pneumonia (COP), a parenchymal lung disorder
- **CAUSES**—infection (viral, mycoplasma), inflammatory (ulcerative colitis, rheumatoid arthritis), transplant (bone marrow, lung), toxic fumes, idiopathic
- **TREATMENTS**—bronchiolitis obliterans (with an organizing intraluminal exudate and proliferative granulation tissue polyp) is usually steroid responsive. Constrictive bronchiolitis (late, fibrotic, concentric) is not responsive to glucocorticoids

BRONCHIECTASIS

- **PATHOPHYSIOLOGY**—airway obstruction, destruction, altered immunity → ↑ cellular and mediator

SPECIFIC ENTITIES (CONT'D)

inflammatory response → ↑ elastase, sputum production → recurrent infections → vicious cycle → permanent dilatation of bronchi. Major types of bronchiectasis include

- **CYLINDRICAL OR TUBULAR BRONCHIECTASIS**—dilated airways alone, sometimes represents residual effect of pneumonia and may resolve
- **VARICOSE BRONCHIECTASIS**—focal constrictive areas along the dilated airways
- **SACCULAR OR CYSTIC BRONCHIECTASIS**—most severe form. Progressive dilatation of the airways, resulting in large cysts or saccules
- **CAUSES**
 - **FOCAL**—broncholith, post-infectious, tumor, extrinsic lymph node compression, post-lobe resection, recurrent aspiration
 - **DIFFUSE**
 - **POST-INFECTIONS**—bacterial (*Pseudomonas*, *Haemophilus*), mycobacterium, fungal, viral (adenovirus, measles, influenza, HIV)
 - **IMMUNODEFICIENCY**—cancer, chemotherapy, hypogammaglobulinemia, immunosuppression, sequelae of toxic inhalation or aspiration of foreign body
 - **INTERSTITIAL LUNG DISEASE**—traction bronchiectasis
 - **INFLAMMATORY**—RA, SLE, Sjogren's syndrome, relapsing polychondritis, IBD
 - **INHERITED**—α1-antitrypsin deficiency, cystic fibrosis, primary ciliary dyskinesia (Kartagener's syndrome, Young's syndrome), tracheo-bronchomegaly (Mounier-Kuhn syndrome), cartilage deficiency (Williams-Campbell syndrome), Marfan's syndrome
- **DIAGNOSIS**—high-resolution CT chest (signet ring sign), PFT (obstruction ± reversibility)
- **TREATMENTS**—exercises, chest physiotherapy, and bronchodilators similar to COPD; however, if reversible, inhaled corticosteroids should be given early. Ensure adequate systemic hydration. Effective treatment of exacerbations

NEJM 2002 346:18

Related Topics

Cryptogenic Organizing Pneumonia (p. 15)
Pulmonary Function Tests (p. 21)
Smoking (p. 418)

Pneumonia

NEJM 2002 345:25; NEJM 2001 344:9

TYPES OF PNEUMONIA

COMMUNITY-ACQUIRED PNEUMONIA

- **BACTERIAL**—*Streptococcus pneumoniae*, *Staphylococcus aureus*, *Haemophilus*, *Moraxella*
- **ATYPICAL**—*Mycoplasma*, *Chlamydia*, *Legionella*, TB, community-acquired MRSA
- **VIRAL**—influenza, parainfluenza, metapneumovirus, RSV, adenovirus
- **FUNGAL**—blastomycosis, cryptococcus, histoplasmosis

ASPIRATION PNEUMONIA

- **POLYBACTERIAL INCLUDING ANAEROBES**—*Bacteroides*, *Peptostreptococcus*, *Fusobacterium* species and other Gram-positive bacilli
- **CHEMICAL PNEUMONITIS**

PNEUMONIA IN THE IMMUNOCOMPROMISED (see p. 259)

NOSOCOMIAL PNEUMONIA

- **POLYBACTERIAL**—*Staphylococcus aureus*, MRSA, *Pseudomonas aeruginosa*, Enterobacteriaceae (*Klebsiella*, *Escherichia coli*, *Serratia*), *Haemophilus*, *Acinetobacter*
- **VIRAL**—influenza

VENTILATOR-ASSOCIATED PNEUMONIA

NURSING HOME-ACQUIRED PNEUMONIA

PATHOPHYSIOLOGY

COMPLICATIONS OF PNEUMONIA

- **PULMONARY**—ARDS, lung abscess ± cavitory formation, parapneumonic effusion/empyema, pleuritis ± hemorrhage
- **EXTRAPULMONARY**—purulent pericarditis, hyponatremia, sepsis

CLINICAL FEATURES

RATIONAL CLINICAL EXAMINATION SERIES: DOES THIS PATIENT HAVE COMMUNITY-ACQUIRED PNEUMONIA?

	LR+	LR–
History		
Cough	1.8	0.31
Sputum	1.3	0.55
Dyspnea	1.4	0.67
Fever	1.7–2.1	0.59–0.71
Asthma	0.10	3.8
Dementia	3.4	0.94
Immunosuppression	2.2	0.85
Physical		
RR >25	1.5–3.4	0.78–0.82
Dullness to percussion	2.2–4.3	0.79–0.93
Decreased breath sounds	2.3–2.5	0.64–0.78

CLINICAL FEATURES (CONT'D)

	LR+	LR–
Crackles	1.6–2.7	0.62–0.87
Bronchial breath sounds	3.5	0.90
Egophony	2.0–8.6	0.76–0.96

PREDICTION RULE—Diehr (rhinorrhea –2, sore throat –1, night sweats +1, myalgias +1, sputum all day +1, RR >25 +2, temp ≥37.8°C [≥100°F] +2. If cut off = 1 (i.e. ≥1 suggests pneumonia), LR+ 5, LR– 0.47. If cut off = 3, LR+ 14, LR– 0.82), Singal, Heckerling

APPROACH—“individual or combinations of symptoms and signs have inadequate test characteristics to rule in or rule out the diagnosis of pneumonia. Decision rules that use the presence or absence of several symptoms and signs to modify the probability of pneumonia are available, the simplest of which requires the absence of any vital sign abnormalities to exclude the diagnosis. If diagnostic certainty is required in the management of a patient with suspected pneumonia, then chest radiography (gold standard) should be performed”

JAMA 1997 278:17

SURFACE LUNG MARKINGS

- **INFERIOR MARGIN OF THE LUNGS**—level of 6th rib at the mid-clavicular line, level of 8th rib at the mid-axillary line, and level of 10th rib at the mid-scapular line
- **OBLIQUE (MAJOR) FISSURES**—draw a line diagonally from T3 vertebral body posteriorly to the 6th rib anteriorly
- **HORIZONTAL (MINOR) FISSURE**—draw a horizontal line at the level of right anterior 4th rib

Related Topics

Hypoxemia (p. 92)
Parapneumonic Effusion and Empyema (p. 10)
Ventilator-Associated Pneumonia (p. 96)

INVESTIGATIONS

BASIC

- **LABS**—CBCD, lytes, urea, Cr, troponin/CK, AST, ALT, ALP, bilirubin, urinalysis
- **MICROBIOLOGY**—blood C&S, sputum Gram stain/AFB/C&S/fungal, urine C&S
- **IMAGING**—CXR ± CT chest
- **ABG**—if respiratory distress, and for PSI if deciding on possible hospitalization

INVESTIGATIONS (CONT'D)

SPECIAL

- **BRONCHOSCOPY**
- **NASOPHARYNGEAL SWAB**—if suspect viral infection, check for influenza A/B, parainfluenza, human metapneumovirus, RSV, adenovirus
- **MYCOPLASMA IGM**
- **URINE FOR LEGIONELLA ANTIGEN**

DIAGNOSTIC AND PROGNOSTIC ISSUES

PNEUMONIA SEVERITY OF ILLNESS (PSI) SCORE

- **SCORING**—age, female (−10), nursing home (+10), cancer (+30), liver disease (+20), heart failure (+10), CVA (+10), renal failure (+10), altered mental status (+20), RR >30 (+20), SBP <90 mmHg (+20), temp >40°C [>104°F] (+15), HR >125 (+10), pH <7.35 (+30), BUN >10.7 mmol/L [>30 mg/dL] +20, Na <130 mmol/L (+20), glucose >13.9 mmol/L [>250 mg/dL] +10, hematocrit <30% (+10), P_aO₂ <60 mmHg or O₂ saturation <90% on room air (+10), pleural effusion (+10)
- **UTILITY**—originally developed as a prognostic tool. Consider admission if PSI score >90. Clinical judgment more important than PSI in determining admission

NEJM 2002 347:25

MANAGEMENT

ACUTE—ABC, O₂, IV, consider **salbutamol** 2.5 mg ACUT q6h + q1h PRN

ANTIBIOTICS

- **COMMUNITY-ACQUIRED PNEUMONIA**—see treatment issues for an approach to selecting the appropriate regimen (remember to adjust for renal function)
 - **TETRACYCLINE**—*doxycycline* 100 mg PO BID ×10 days
 - **MACROLIDES**—*azithromycin* 500 mg PO first day, then 250 mg PO daily ×4 days; *clarithromycin* 250–500 mg PO BID ×10 days
 - **FLUOROQUINOLONES**—*levofloxacin* 500 mg PO daily ×10 days (or 750 mg ×5 days), *moxifloxacin* 400 mg PO daily ×10 days; avoid if exposed to fluoroquinolone within last 3–6 months
 - **β-LACTAMS**—*amoxicillin* 1 g PO TID, *amoxicillin-clavulanate* 2 g PO BID, *cefuroxime* 750 mg IV q8h or 500 mg PO BID, *cefotaxime* 1 g IV q8h
 - **ANAEROBIC COVERAGE**—if suspect aspiration, add *clindamycin* 150–450 mg PO q6h or 600–900 mg IV q8h or *metronidazole* 500 mg PO/IV BID/TID
- **NOSOCOMIAL PNEUMONIA**—see treatment issues for an approach to selecting the appropriate regimen
 - **ANTI-PSEUDOMONAL**—ceftazidime, cefepime, meropenem, ciprofloxacin, aminoglycosides, piperacillin-tazobactam (do not use same class of agent when double covering for pseudomonas)

MANAGEMENT (CONT'D)

- **FURTHER GRAM-NEGATIVE COVERAGE**—*ciprofloxacin* 500 mg PO BID, *gentamicin* 6 mg/kg IV q24h, *tobramycin* 6 mg/kg IV q24h (follow levels to adjust dosing)
 - **ANAEROBIC COVERAGE**—if suspect aspiration, replace gentamicin with *clindamycin* 150–450 mg PO q6h or 600–900 mg IV q8h or add *metronidazole* 500 mg PO BID
 - **ANTIBIOTIC COURSE**—10–14 days for most, 21 days for *Pseudomonas*, *Staphylococcus aureus*, and *Acinetobacter*
 - **ASPIRATION PNEUMONIA**—*clindamycin* 600 mg IV BID, switch to 300 mg PO QID when stable. May add cefotaxime for Gram-positive and Gram-negative coverage
 - **TUBERCULOSIS PNEUMONIA**—see p. 250
 - **PNEUMOCYSTIS JIROVECI PNEUMONIA**—see p. 259
- NON-PHARMACOLOGIC TREATMENTS**
- **VACCINATIONS**—influenza vaccine annually and pneumococcal vaccine booster at 5 years
 - **CHEST PHYSIOTHERAPY**

TREATMENT ISSUES

IMPORTANT NOTE—avoid using the same antibiotic class if given within 3 months

OUTPATIENT ANTIBIOTICS CHOICE

- **PREVIOUSLY HEALTHY**—macrolide (azithromycin, clarithromycin, or doxycycline). Other antibiotic choices include fluoroquinolone, macrolide plus amoxicillin ± clavulanate
- **COMORBIDITIES** (COPD, diabetes, renal failure, HF, malignancy)—macrolide or fluoroquinolone
- **SUSPECTED ASPIRATION WITH INFECTION**—amoxicillin-clavulanate or clindamycin
- **INFLUENZA WITH BACTERIAL SUPERINFECTION**—β-lactam or fluoroquinolone

INPATIENT ANTIBIOTIC CHOICE—second-third-generation β-lactam plus macrolide or respiratory fluoroquinolone

ICU ANTIBIOTICS CHOICE

- **PSEUDOMONAS UNLIKELY**—macrolide plus β-lactam or fluoroquinolone plus β-lactam
- **PSEUDOMONAS UNLIKELY BUT β-LACTAM ALLERGY**—fluoroquinolone with or without clindamycin
- **PSEUDOMONAS LIKELY**—double coverage with agents that are effective against *Pseudomonas* (different classes)
- **PSEUDOMONAS LIKELY BUT β-LACTAM ALLERGY**—aztreonam plus levofloxacin or aztreonam plus moxifloxacin, with or without aminoglycoside

NURSING HOME ANTIBIOTICS CHOICE

- **TREATMENT IN NURSING HOME**—fluoroquinolone or macrolide plus amoxicillin-clavulanate
- **IN HOSPITAL**—same as inpatient

TREATMENT ISSUES (CONT'D)

DISCHARGE DECISION—clinical stabilization usually takes 2–3 days. When symptoms have significantly improved, vital signs are normalized, and patient has defervesced, patients at low risk may be safely discharged on the day of switching to oral therapy without adverse consequences. Time to radiographic resolution is variable, with up to 5 months for pneumococcal pneumonia associated with bacteremia

IDSA Guidelines 2003

Note: consider vancomycin or linezolid if MRSA suspected; emergence of community-acquired MRSA associated with serious necrotizing infections

SPECIFIC ENTITIES

CAUSES OF NON-RESOLVING PNEUMONIA—**non-infectious** (malignancy especially bronchoalveolar carcinoma or lymphoma, cryptogenic organizing pneumonia, hemorrhage), **non-bacterial** (viral, fungal), **immunocompromised** host, **antibiotic resistance**, **pneumonia complications** (abscess, empyema, ARDS)

Pulmonary Embolism

NEJM 2008 359:26

DIFFERENTIAL DIAGNOSIS OF ACUTE DYSPNEA

RESPIRATORY

- **AIRWAY**—COPD exacerbation, asthma exacerbation, acute bronchitis, infectious exacerbation of bronchiectasis, foreign body obstruction
- **PARENCHYMA**—pneumonia, cryptogenic organizing pneumonia, ARDS, acute exacerbation of interstitial lung disease
- **VASCULAR**—pulmonary embolism, pulmonary hypertension
- **PLEURAL**—pneumothorax, pleural effusion

CARDIAC

- **MYOCARDIAL**—HF exacerbation, myocardial infarction
- **VALVULAR**—aortic stenosis, acute aortic regurgitation, endocarditis
- **PERICARDIAL**—pericardial effusion, tamponade

SYSTEMIC—sepsis, metabolic acidosis, anemia

OTHERS—neuromuscular, psychogenic, anxiety

PATHOPHYSIOLOGY

VRCHOW'S TRIAD—risk factors for venous thromboembolism

- **INJURY**—fracture of pelvis, femur, or tibia
- **HYPERCOAGULABILITY**—obesity, pregnancy, estrogen, smoking, **cancer** (high suspicion of occult malignancy in patients who develop pulmonary embolism while on anticoagulation), **autoimmune disorders** (anticardiolipin antibody syndrome, lupus anticoagulant, IBD), **genetics** (history of DVT/PE,

SPECIFIC ENTITIES (CONT'D)

CAUSES OF RECURRENT PNEUMONIA

- **IMMUNOCOMPROMISED ★SADDIST★**—Suppressants (steroids, chemotherapy, transplant medications, alcohol), **AIDS**, **Diabetics**, **Decreased nutrition**, **Immunoglobulin** (hypogammaglobulinemia), **Solid organ failure** (renal, liver, splenectomy), **Tumors**
- **PULMONARY**—bronchiectasis, COPD, cystic fibrosis, abnormal anatomy
- **GI**—aspiration

LUNG ABSCESS

- **CAUSES**—**anaerobes** (*Peptostreptococcus*, *Prevotella*, *Bacteroides*, *Fusobacterium*), **Gram positive** (*S. milleri*, microaerophilic streptococcus, *S. aureus*), **Gram negative** (*Klebsiella*, *Haemophilus*, *Legionella*). Nocardia and actinomycosis can rarely cause lung abscess
- **TREATMENTS**—clindamycin until radiographic improvement and stabilization (usually several weeks to months, can be completed with oral antibiotics once patient is stable). No need for percutaneous drainage. If complicated abscess, consider lobectomy or pneumonectomy

PATHOPHYSIOLOGY (CONT'D)

- factor V Leiden, antithrombin III deficiency, protein C/S deficiency, prothrombin G20210A mutation, hyperhomocysteinemia)
- **STASIS**—surgery requiring >30 min of anesthesia, prolonged immobilization, CVA, HF

CLINICAL FEATURES

HISTORY—dyspnea (sudden onset), pleuritic chest pain, cough, hemoptysis, pre/syncope, unilateral leg swelling/pain, past medical history (previous DVT/PE, active cancer, immobilization or surgery in last 4 weeks, miscarriages), medications (birth control pill, anticoagulation)

PHYSICAL—vitals (tachycardia, tachypnea, hypotension, fever, hypoxemia), respiratory examination (pulmonary hypertension if chronic PE), cardiac examination (right heart strain), leg swelling

RATIONAL CLINICAL EXAMINATION SERIES: DOES THIS PATIENT HAVE PULMONARY EMBOLISM?

PREDICTION RULES—Wells, PISA-PED, Geneva rule

APPROACH—"use of clinical prediction rules recommended. Not enough evidence to suggest any of the rules as superior. Clinical gestalt of experienced physician similar to use of rules. D-dimer can be used to rule out pulmonary embolism for patients with low pre-test probability"

JAMA 2003 290:21

INVESTIGATIONS

BASIC

- **LABS**—CBCD, lytes, urea, Cr, PTT, INR, troponin/CK $\times 3$, D-dimer (if low probability for PE or outpatient), β hCG in women of reproductive age
- **IMAGING**—CXR, duplex U/S of legs, V/Q scan, CT chest (PE protocol)
- **ECG**—may see normal sinus rhythm (most common), sinus tachycardia (most common abnormality), atrial fibrillation, right ventricular strain (T wave inversion in anterior precordial leads), non-specific ST-T wave changes, right axis deviation, right bundle branch block and/or $S_1Q_3T_3$ (tall S wave in lead I, Q wave and inverted T wave in lead III)
- **ABG**—if respiratory distress

SPECIAL

- **ECHOCARDIOGRAM**—to check for right heart strain (dilated RV and elevated RVSP). Particularly important if hemodynamic changes
- **PULMONARY ANGIOGRAM**—gold standard
- **THROMBOPHILIA WORKUP**—factor V Leiden, prothrombin G20210A, anticardiolipin antibody, lupus anticoagulant, protein C, protein S, antithrombin III, fibrinogen; consider homocysteine level and workup for paroxysmal nocturnal hemoglobinuria and antiphospholipid syndrome in cases of combined arterial-venous thrombosis

DIAGNOSTIC ISSUES

CXR FINDINGS IN PULMONARY EMBOLISM—normal, atelectasis, unilateral small pleural effusion, enlarged central pulmonary artery, elevated hemidiaphragm, Westermark's sign (abrupt truncation of pulmonary vessel), Hampton's hump (wedge infarct)

D-DIMER (sens 85–96%, spc 45–68%, LR+ 1.7–2.7, LR– 0.09–0.22)—can rule out PE if low clinical suspicion

V/Q SCAN (sens high, spc high)—useful but result often not definitive (intermediate probability) because of other intraparenchymal abnormalities

CT PE PROTOCOL (sens 57–100%, spc 78–100%)—can be very helpful as it provides clues to other potential diagnoses/pathologies as well. Not good for subsegmental pulmonary emboli

LEG VEIN DOPPLER (sens 50%, spc moderate)—serial dopplers may be used for diagnosis of DVT if CT or V/Q scan failed to demonstrate PE but clinical suspicion still high

WELL'S CRITERIA FOR PULMONARY EMBOLISM

- **SCORING**—signs/symptoms of DVT (+3), alternative diagnosis less likely (+3), HR >100 (+1.5), immobilization or surgery in last 4 weeks (+1.5), previous DVT/PE (+1.5), hemoptysis (+1), active cancer (+1)
- **LOW SUSPICION** (sum 0–1, $<10\%$ chance)—D-dimer \rightarrow if positive, CT or V/Q scan

DIAGNOSTIC ISSUES (CONT'D)

- **INTERMEDIATE SUSPICION** (sum 2–6, 30% chance)—D-dimer \rightarrow CT or V/Q scan \rightarrow if negative but suspicious, leg doppler \rightarrow if negative but still suspicious, pulmonary angiogram
- **HIGH SUSPICION** (sum >6 , $>70\%$ chance)—CT or V/Q scan \rightarrow if negative but suspicious, leg doppler \rightarrow if negative but still suspicious, pulmonary angiogram

NEJM 2003 349:13

Related Topics

Anticoagulation Therapy (p. 160)

DVT (p. 158)

Hypercoagulable States (p. 156)

Pulmonary Embolism in Pregnancy (p. 410)

MANAGEMENT

ACUTE—ABC, O₂ to keep sat $>94\%$, IV, consider thrombolysis (must be done in ICU) for massive PE (hemodynamic instability, right ventricular strain)

ANTICOAGULATION—if moderate to high risk of developing PE, consider initiating anticoagulation while waiting for investigations. **Heparin** (*unfractionated heparin* 5000 U IV bolus, then 1000 U/h and adjust to 1.5–2.5 \times normal PTT), **LMWH** (*enoxaparin* 1 mg/kg SC BID or 1.5 mg/kg SC daily), or **fondaparinux** 5 mg SC daily (<50 kg), 7.5 mg SC daily (50–100 kg), or 10 mg SC daily (>100 kg). Start **warfarin** 5 mg PO daily within 72 h and continue heparin/LMWH/fondaparinux until INR is between 2 and 3; ensure overlap of heparin and coumadin with therapeutic INR for at least 48 h

THROMBOLYTICS—controversial as increased risk of intracranial bleed and multiple contraindications (see below). Consider only if hemodynamically unstable or life-threatening pulmonary embolism. **TPA** 100 mg IV over 2 h, or **streptokinase** 250,000 IU over 30 min, the 100,000 IU/h over 12–24 h or 1.5 million IU over 2 h. Unfractionated heparin may be used concurrently

SURGICAL—embolectomy. Consider if thrombolysis failed or contraindicated or if hemodynamically unstable

IVC FILTER—if anticoagulation contraindicated

TREATMENT ISSUES

CONTRAINDICATIONS TO THROMBOLYTIC THERAPY

- **ABSOLUTE CONTRAINDICATIONS**—history of hemorrhagic stroke or stroke of unknown origin, ischemic stroke in previous 3 months, brain tumors, major trauma in previous 2 months, intra-cranial surgery or head injury within 3 weeks

TREATMENT ISSUES (CONT'D)

- **RELATIVE CONTRAINDICATIONS**—TIA within 6 months, oral anticoagulation, pregnancy or within 1 week postpartum, non-compressible puncture sites, traumatic CPR, uncontrolled hypertension (SBP >185 mmHg, DBP >110 mmHg), advanced liver disease, infective endocarditis, active peptic ulcer, thrombocytopenia

ANTICOAGULATION DURATION

- **FIRST PULMONARY EMBOLISM WITH REVERSIBLE OR TIME-LIMITED RISK FACTOR**—anticoagulation for at least 3 months
- **UNPROVOKED PE**—at least 3 months of treatment. If no obvious risk factors for bleeding, consider indefinite anticoagulation
- **PE AND MALIGNANCY**—treatment with SC LMWH better than oral warfarin. Treatment should be continued until eradication of cancer as long as there are no significant contraindications to anticoagulation
- **PE AND PREGNANCY**—SC LMWH is preferred for outpatient treatment. Total duration of therapy should be 6 months unless patient has risk factors for hypercoagulable state

SPECIFIC ENTITIES

FAT EMBOLISM

- **PATHOPHYSIOLOGY**—embolism of fat globules to lungs, brain, and other organs → metabolized to fatty acids leading to inflammatory response. Commonly caused by closed fractures of long bones, but may also occur with pelvic fractures, orthopedic procedures, bone marrow harvest, bone tumor lysis, osteomyelitis, liposuction, fatty liver, pancreatitis, and sickle cell disease
- **CLINICAL FEATURES**—triad of dyspnea, neurological abnormalities (confusion), and petechial rash (head and neck, chest, axilla). May also have fever, thrombocytopenia, and DIC
- **DIAGNOSIS**—clinical diagnosis (rash is pathognomonic). Investigations may include CXR, V/Q scan, CT chest, and MRI head
- **TREATMENTS**—supportive care as most patients will fully recover. Mortality is 10%. Primary prophylaxis includes early mobilization and maybe steroids

Pleural Effusion

NEJM 2002 346:25

DIFFERENTIAL DIAGNOSIS

EXUDATIVE—malignancy, infections, connective tissue disease, pulmonary embolism, hemothorax, pancreatitis, chylothorax

TRANSUDATIVE—HF, hypoalbuminemia (GI losing enteropathy, cirrhosis, nephrotic syndrome, malnutrition), SVC obstruction, hepatohydrothorax, urinothorax, atelectasis, trapped lung, peritoneal dialysis, hypothyroidism, pulmonary embolism

Note: pulmonary embolism, malignancy, and sarcoidosis can present as either exudative or transudative effusions. HF following diuresis may become "pseudo-exudative" (check albumin gradient)

CLINICAL FEATURES

HISTORY—dyspnea, cough, hemoptysis, chest pain, weight loss, fever, trauma, occupational exposures, past medical history (pneumonia, liver disease, kidney disease, thyroid disease, cancer, HF, thromboembolic disease, connective tissue disease, smoking), medications

PHYSICAL—vitals, cyanosis, clubbing, tracheal deviation away from side of effusion (if no collapse or trapped lung), peripheral lymphadenopathy, Horner's syndrome, respiratory examination (decreased breath sounds and tactile fremitus, stony dullness to percussion), cardiac examination, leg swelling (HF or DVT)

RATIONAL CLINICAL EXAMINATION SERIES: DOES THE PATIENT HAVE PLEURAL EFFUSION?

AUSCULTATORY PERCUSSION—auscultate with the diaphragm of the stethoscope over the posterior chest wall while gently tapping over the manubrium with the distal phalanx of one finger. Diminished resonance suggests effusion

	Sens	Spc	LR+	LR-
Physical				
Asymmetric chest expansion	74%	91%	8.1	0.29
Auscultatory percussion	77%	92%	7.7	0.27
Crackles	56%	62%	1.5	0.71
Diminished breath sounds	42–88%	83–90%	4.3–5.2	0.15–0.64
Dullness to conventional percussion	73%	91%	8.7	0.31
Pleural friction rub	5.30%	99%	3.9	0.96

CLINICAL FEATURES (CONT'D)

	Sens	Spc	LR+	LR-
Reduced tactile fremitus	82%	86%	5.7	0.21
Reduced vocal resonance	76%	88%	6.5	0.27

APPROACH—“dullness to percussion and tactile fremitus are the most useful findings for pleural effusion. Dull chest percussion makes the probability of a pleural effusion much more likely but still requires a CXR to confirm the diagnosis. When the pretest probability of pleural effusion is low, the absence of reduced tactile fremitus makes pleural effusion less likely so that a CXR might not be necessary depending on the overall clinical situation”

JAMA 2009 301:3

INVESTIGATIONS

BASIC

- **LABS**—CBCD, lytes, urea, Cr, LDH, total protein, AST, ALT, ALP, bilirubin, INR, PTT, albumin
- **IMAGING**—CXR (PA, lateral, decubitus), CT chest
- **THORACENTESIS**—send pleural fluid for cell count and differential, Gram stain, C&S, AFB and fungal cultures, LDH, total protein, pH, and cytology. Under special circumstances, also consider amylase, glucose, cholesterol, adenosine deaminase (for TB), albumin

SPECIAL

- **BIOPSY**—closed pleural biopsy, medical thoracoscopy, bronchoscopy, surgical biopsy (video-assisted thoracic surgery)

DIAGNOSTIC ISSUES

OVERALL APPROACH—generally, if the effusion is $>1/4$ of hemithorax, enough fluid is present for diagnostic thoracentesis; obtain decubitus film to assess for loculation. In the absence of loculation, and with >10 mm [0.4 in.] layering of fluid on decubitus film, bedside thoracentesis can be attempted; otherwise, request U/S-guided thoracentesis. If only a small amount of fluid is present (<10 mm [<0.4 in.]) and/or HF suspected, start with diuresis for 2–3 days. If no improvement, perform thoracentesis to distinguish between transudative and exudative causes

LIGHT'S CRITERIA FOR EXUDATIVE EFFUSION—any one of the following criteria would suggest exudative effusion: fluid/serum total protein ratio >0.5 , fluid/serum LDH ratio >0.6 , fluid LDH $>2/3$ upper limit of normal serum level

THORACENTESIS PROCEDURE—see NEJM 2006 355:e16

PLEURAL FLUID ANALYSIS

- **FLUID ACIDOSIS** (pH <7.2)—complicated parapneumonic, TB, paragonimiasis, malignancy, rheumatoid arthritis, SLE, hemothorax, esophageal rupture
- **FLUID GLUCOSE** (<3.3 mmol/L [<60 mg/dL])—parapneumonic, TB, paragonimiasis, malignancy, rheumatoid arthritis, Churg–Strauss, hemothorax

DIAGNOSTIC ISSUES (CONT'D)

- **FLUID EOSINOPHILIA** ($>10\%$)—paragonimiasis, malignancy, Churg–Strauss, asbestos, drug reaction, pulmonary embolism, hemothorax, pneumothorax, idiopathic (20%)
- **CYTOLOGY FOR MALIGNANCY**—the yield for diagnosis with single attempt is 60%, two attempts is 85%, three attempts is 90–95%; obtain as much fluid as possible to increase diagnostic yield
- **FLUID FOR AFB**—obtain as much fluid as possible and ask laboratory to centrifuge collection and to culture sediment to increase diagnostic yield

MANAGEMENT

SYMPTOM CONTROL— O_2 , diuresis (furosemide), drainage (thoracentesis, pigtail catheter, PleurX catheter, chest tube), pleurodesis (talc slurry or poudrage), surgery (talc slurry, pleuroperitoneal shunt, pleural abrasion, pleurectomy)

TREAT UNDERLYING CAUSE

SPECIFIC ENTITIES

PARAPNEUMONIC EFFUSION

- **UNCOMPLICATED**—exudative effusion that resolves with resolution of pneumonia. Generally disappears with antibiotics alone
- **COMPLICATED**—persistent bacterial invasion and fluid collection. Characterized by pleural fluid acidosis but sterile fluid. Pleural loculation may occur as fibrin gets deposited from inflammation. Treated the same as empyema
- **EMPHYEMA**—presence of bacteria in Gram stain or pus in drainage (culture not necessary). pH often <7.2 . For unloculated fluid, chest tube/small-bore catheter drainage usually adequate. For loculated effusions, thrombolytics such as streptokinase or TPA could be considered. Thoracoscopy represents an alternative to fibrinolytics. Open decortication is the last resort

TRAPPED LUNG—stable chronic effusion, especially with history of pneumonia, pneumothorax, thoracic surgery or hemothorax. Diagnosis is established by measuring negative change in intrapleural pressure

SPECIFIC ENTITIES (CONT'D)

during thoracentesis. Treat by lung re-expansion, sometimes requiring thoracotomy with decortication

HEPATOHYDROTHORAX—suspect if cirrhosis and portal hypertension, even in the absence of ascites. Pleural effusion results from passage of

SPECIFIC ENTITIES (CONT'D)

peritoneal fluid into pleura because of negative intrathoracic pressures and diaphragmatic defects. Do not insert chest tube. Treat with diuresis, salt restriction, and consider liver transplantation/TIPS procedure

Chronic Cough

DIFFERENTIAL DIAGNOSIS

NON-PULMONARY—post-nasal drip, GERD, ACE inhibitors, occult congestive heart failure

PULMONARY

- **AIRWAY**—asthma, chronic bronchitis, bronchiectasis, neoplasm, foreign body, post-viral
- **PARENCHYMA**—occult infection, occult aspiration, interstitial lung disease, lung abscess
- **VASCULAR**—early pulmonary hypertension

PATHOPHYSIOLOGY

DEFINITION OF CHRONIC COUGH—>3 weeks

COMPLICATIONS OF CHRONIC COUGH—exhaustion, insomnia, anxiety, headaches, dizziness, hoarseness, musculoskeletal pain, urinary incontinence, abdominal hernias

COUGH REFLEX

- **AFFERENT**—chemical or mechanical stimuli → cough receptors in the epithelium of the upper and lower respiratory tracts, pericardium, esophagus, diaphragm, and stomach → afferent nerves (vagus, glossopharyngeal, trigeminal, and phrenic) → cough center in the medulla
- **EFFERENT**—cough center with cortical input → efferent signals travel down the vagus, phrenic, and spinal motor nerves → expiratory muscles → cough

INVESTIGATIONS

BASIC

- **MICROBIOLOGY**—sputum Gram stain/AFB/C&S

INVESTIGATIONS (CONT'D)

- **IMAGING**—CXR (order inspiratory and expiratory views if foreign body aspiration or endobronchial lesion suspected)
 - **SPIROMETRY/PFT**
- SPECIAL**
- **SINUS IMAGING**
 - **METHACHOLINE CHALLENGE**
 - **ESOPHAGEAL PH MONITORING**

MANAGEMENT

SYMPTOM CONTROL—*codeine* 20 mg PO q4h PRN, *dextromethorphan* 20 mg PO q4h PRN

TREAT UNDERLYING CAUSE—switch to ARB if ACE inhibitor suspected as cause of chronic cough

SPECIFIC ENTITIES

POST-NASAL DRIP

- **PATHOPHYSIOLOGY**—secretions in the upper airway stimulate cough receptors within the pharyngeal or laryngeal mucosa
- **CAUSES**—allergic, perennial non-allergic, vasomotor rhinitis, acute nasopharyngitis, sinusitis
- **DIAGNOSIS**—non-specific findings
- **TREATMENTS**—reduce irritant exposure, antihistamine-decongestant combinations (*diphenhydramine* 25–50 mg PO q4–6h PRN, pseudoephedrine, *ipratropium nasal spray* 0.03% 2 sprays/nostril BID–TID, nasal corticosteroids, nasal saline rinses BID), surgical correction for anatomical abnormalities

Hemoptysis

DIFFERENTIAL DIAGNOSIS

NON-CARDIOPULMONARY—epistaxis, upper GI bleed, coagulopathy

CARDIAC—HF, mitral stenosis

PULMONARY

- **AIRWAY**—bronchitis (acute, chronic), bronchiectasis, malignancy, foreign body, trauma
- **PARENCHYMA**
- **MALIGNANCY**—lung cancer, metastasis

DIFFERENTIAL DIAGNOSIS (CONT'D)

- **INFECTIONS**—necrotizing pneumonia (*Staphylococcus*, *Pseudomonas*), abscess, septic emboli, TB, fungal
- **ALVEOLAR HEMORRHAGE**—Wegener's granulomatosis, Churg–Strauss, Goodpasture disease, pulmonary capillaritis, connective tissue disease
- **VASCULAR**—pulmonary embolism, pulmonary hypertension, AVM, iatrogenic

PATHOPHYSIOLOGY

MASSIVE HEMOPTYSIS—100–600 mL blood in 24 h. Patients may die of asphyxiation (rather than exsanguination)

CLINICAL FEATURES

HISTORY—characterize hemoptysis (amount, frequency, previous history), cough (productive), dyspnea, chest pain, epistaxis, hematemesis, weight loss, fever, night sweats, exposure, travel, joint inflammation, rash, visual changes, past medical history (smoking, lung cancer, TB, thromboembolic disease, cardiac disease), medications (warfarin, ASA, NSAIDs, natural supplements)

PHYSICAL—vitals, weight loss, clubbing, cyanosis, lymphadenopathy, Horner's syndrome, respiratory and cardiac examination, leg swelling (HF or DVT), joint examination, skin examination

INVESTIGATIONS**BASIC**

- **LABS**—CBCD, lytes, urea, Cr, INR, PTT, urinalysis
- **MICROBIOLOGY**—blood C&S, sputum Gram stain/AFB/fungal/C&S/cytology
- **IMAGING**—CXR, CT chest (warranted in most patients unless obvious explanation)
- **BRONCHOSCOPY**—warranted in most patients unless obvious explanation

INVESTIGATIONS (CONT'D)**SPECIAL**

- **ETIOLOGY WORKUP**—ANA, p-anca (myeloperoxidase MPO antibodies), c-anca (antiproteinase-3 PR3 antibodies), anti-GBM antibody, rheumatologic screen
- **ABG**—if respiratory distress

MANAGEMENT

ACUTE—ABC, O₂, IV, intubation to protect airway if significant hemoptysis

SYMPTOM CONTROL—cough suppressants, sedatives, stool softeners. **Transfusions.** Urgent interventional **bronchoscopy** (topical epinephrine, cold saline, cautery). **Angiographic arterial embolization.** **Lung resection**

TREAT UNDERLYING CAUSE—correct coagulopathy (vitamin K 10 mg SC × 1 dose or FFP); **antibiotics;** **radiation** for tumors; **diuresis** for HF; **immunosuppression** for vasculitis

SPECIFIC ENTITIES**GOODPASTURE DISEASE**

- **PATHOPHYSIOLOGY**—antibasement membrane antibodies → attack pulmonary and renal basement membrane
- **CLINICAL FEATURES**—hemoptysis and hematuria, with respiratory and renal failure if severe
- **DIAGNOSIS**—lung/kidney biopsy
- **TREATMENTS**—steroids, cyclophosphamide, plasmapheresis

Solitary Pulmonary Nodule

NEJM 2003 348:25

DIFFERENTIAL DIAGNOSIS

MALIGNANT—bronchogenic, carcinoid, metastatic cancer

BENIGN—healed infectious granuloma, benign tumors (hamartoma), AVM, rheumatoid nodule, Wegener's granulomatosis, hydatid cyst, round atelectasis, intra-pulmonary lymph nodes, pseudotumor

CLINICAL FEATURES

HISTORY—dyspnea, cough, hemoptysis, wheezing, chest pain, weight loss, fever, night sweats, rheumatologic screen, past travel history, occupational exposures, medical history (smoking, lung cancer or other malignancies, TB, infections, rheumatoid arthritis), medications

PHYSICAL—vitals, weight loss, clubbing, cyanosis, Horner's syndrome, SVC syndrome, lymphadenopathy, respiratory examination, abdominal examination (hepatomegaly), bony tenderness

INVESTIGATIONS**BASIC**

- **LABS**—CBCD, lytes, urea, Cr, LDH, AST, ALT, ALP, bilirubin, INR, PTT
- **IMAGING**—old films (2 years ago), CXR, CT chest

SPECIAL

- **ABG**
- **SCREENING FOR INFLAMMATORY DISORDERS**—ESR, CRP, ANA, ANCA
- **BIOPSY**—bronchoscopy or CT guided
- **PET/CT SCAN**—if moderate to high suspicion of lung cancer

DIAGNOSTIC ISSUES**FINDINGS SUGGESTIVE OF MALIGNANCY****★ABCD★**

- **Age** >50
- **Border**—irregular, nodular cavity with thick wall, or spiculation
- **Calcification**—eccentric or uncalcified

DIAGNOSTIC ISSUES (CONT'D)

- Diameter >3 cm (>1.2 in.). If <3 cm, 20–50% malignant. If \geq 3 cm, 50% malignant

TIMING—if malignant, usually able to detect an increase in size of SPN between 30 days and 2 years. Unlikely to be malignant if significant change in <30 days or no change in 2 years

CALCIFICATION CLUES

- **MALIGNANCY**—eccentric/uncalcified calcification
- **TUBERCULOSIS OR HISTOPLASMOSIS**—central/complete calcification
- **BENIGN HAMARTOMA**—popcorn calcification

MANAGEMENT

TREAT UNDERLYING CAUSE—if **low probability**, observation with serial CT scans. If **medium probability**, bronchoscopy with biopsy/brush or trans-thoracic (CT/US-guided) biopsy. If **high probability**, thoracotomy with resection or video-assisted thoracotomy (for patients who cannot tolerate thoracotomy medically and physiologically)

SPECIFIC ENTITIES**PANCOAST TUMOR**

- **PATHOPHYSIOLOGY**—superior sulcus tumors (mostly squamous cell carcinoma) invading and compressing the paravertebral sympathetic chain and brachial plexus
- **CLINICAL FEATURES**—shoulder and arm pain (C8, T1, T2 distribution), **Horner's syndrome** (upper lid ptosis, lower lid inverse ptosis, miosis, anhidrosis, enophthalmos, absence of ciliary-spinal reflex and heterochromia), and neurological symptoms in the arm (intrinsic muscles weakness and atrophy, pain and paresthesia of 4th and 5th digit). Other associated findings include clubbing, lymphadenopathy, phrenic or recurrent laryngeal nerve palsy, and superior vena cava syndrome
- **DIAGNOSIS**—CXR, CT chest, percutaneous core biopsy
- **TREATMENTS**—concurrent chemoradiotherapy

SPECIFIC ENTITIES (CONT'D)**THORACIC OUTLET OBSTRUCTION**

- **PATHOPHYSIOLOGY**—obstruction of the neurovascular bundle supplying the arm at the superior aperture of the thorax. Common structures affected include the brachial plexus (C8/T1 >C5/C6/C7, 95%), subclavian vein (4%), and subclavian artery (1%)
- **CAUSES**—**anatomic** (cervical ribs, congenital bands, subclavian artery aneurysm), **repetitive hyperabduction/trauma** (hyperextension injury, painters, musicians), **neoplasm** (supraclavicular lymphadenopathy)
- **CLINICAL FEATURES**—triad of numbness, swelling and weakness of the affected upper limb, particularly when carrying heavy objects. Brittle finger nails, Raynaud's, thenar wasting and weakness, sensory loss, decreased radial and brachial pulses, pallor of limb with elevation, upper limb atrophy, drooping shoulders, supraclavicular and infraclavicular lymphadenopathy. Specific maneuvers include **Roos test** (repeatedly clench and unclench fists with arms abducted and externally rotated), **modified Adson's maneuver** (Valsalva maneuver with the neck fully extended, affected arm elevated, and the chin turned away from the involved side), **costoclavicular maneuver** (shoulders thrust backward and downward), **hyperabduction maneuver** (raise hands above head with elbows flexed and extending out laterally from the body), and **Tinel's maneuver** (light percussion of brachial plexus in supraclavicular fossa reproduces symptoms)
- **DIAGNOSIS**—cervical spine films, CXR, MRI
- **TREATMENTS**—conservative (keep arms down at night, avoiding hyperabduction), surgery

Related Topics

Lung Cancer (p. 185)
SVC Syndrome (p. 228)

Pulmonary Hypertension

NEJM 2004 351:15; NEJM 2004 351:16

WHO CLASSIFICATION OF PULMONARY HYPERTENSION**GROUP I. PULMONARY ARTERIAL HYPERTENSION**

- **IDIOPATHIC**—primary
- **FAMILIAL AND RELATED DISORDERS**—collagen vascular disease, congenital systemic-to-pulmonary shunts, portal hypertension, HIV, drugs and toxins, thyroid disorders, glycogen storage disease, Gaucher's disease, hereditary

WHO CLASSIFICATION OF PULMONARY HYPERTENSION (CONT'D)

- hemorrhagic telangiectasia, hemoglobinopathies, myeloproliferative disorders, splenectomy
- **ASSOCIATED WITH SIGNIFICANT VENOUS OR CAPILLARY INVOLVEMENT**—pulmonary veno-occlusive disease, pulmonary–capillary hemangiomatosis
- **PERSISTENT PULMONARY HYPERTENSION OF NEWBORN**
- GROUP II. PULMONARY VENOUS HYPERTENSION**—left-sided atrial or ventricular heart disease, left-sided valvular heart disease

WHO CLASSIFICATION OF PULMONARY HYPERTENSION (CONT'D)

GROUP III. PULMONARY HYPERTENSION ASSOCIATED WITH HYPOXEMIA—COPD, interstitial lung disease, sleep-disordered breathing, alveolar hypoventilation disorders, chronic exposure to high altitude, developmental abnormalities

GROUP IV. PULMONARY HYPERTENSION DUE TO CHRONIC THROMBOTIC DISEASE, EMBOLIC DISEASE, OR BOTH—thromboembolic obstruction of proximal pulmonary arteries, thromboembolic obstruction of distal pulmonary arteries, pulmonary embolism (tumor, parasites, foreign material)

GROUP V. MISCELLANEOUS—sarcoidosis, pulmonary Langerhans cell histiocytosis, lymphangiomatosis, compression of pulmonary vessels (adenopathy, tumor, fibrosing mediastinitis)

PATHOPHYSIOLOGY

DEFINITION OF PULMONARY HYPERTENSION—mean pulmonary arterial pressure (PAP) >25 mmHg at rest or mean PAP >30 mmHg with exercise measured with right heart catheterization

CLINICAL FEATURES

HISTORY—unexplained dyspnea on exertion, cough, chest pain, hemoptysis, dizziness, syncope, hoarseness, past medical history (cardiac and respiratory diseases, thromboembolic diseases, HIV, cirrhosis, autoimmune and rheumatologic disorders), medications (amphetamines, diet pill such as dexfenfluramine)

PHYSICAL—vitals (tachypnea, tachycardia, atrial fibrillation, hypoxemia), peripheral cyanosis, small pulse volume, elevated JVP (prominent a wave or absent if atrial fibrillation, large v wave), right ventricular heave, palpable P2, narrowly split or paradoxically split S2, right-sided S4, tricuspid regurgitation

CLINICAL FEATURES (CONT'D)

murmur, Graham Steell murmur (high-pitched, decrescendo diastolic rumble over LUSB), crackles, congestive liver, ascites, ankle edema

INVESTIGATIONS**BASIC**

- **LABS**—CBCD, lytes, urea, Cr, AST, ALT, ALP, bilirubin, INR, albumin, ANA, RF, anti-CCP, anti-SCL 70, anticentromere antibody, ESR, HIV serology, TSH
- **IMAGING**—CXR, CT chest, V/Q scan or CT chest PE protocol, echocardiogram
- **EKG**
- **OVERNIGHT POLYSOMNOGRAPHY**—if suspect OSA

ABG**PFT****SPECIAL**

- **RIGHT HEART CATHETERIZATION**

MANAGEMENT

SYMPTOM CONTROL—O₂, **calcium channel blockers** if positive vasoreactivity test (high doses), **vasodilators** (prostacyclin, sildenafil, bosentan, NO), **anticoagulation**

TREAT UNDERLYING CAUSE**ATRIAL SEPTOSTOMY****LUNG TRANSPLANT****SPECIFIC ENTITIES**

EISENMENGER SYNDROME—left-to-right shunt leading to pulmonary hypertension and eventually right-to-left shunt

THYROTOXIC-ASSOCIATED PULMONARY HYPERTENSION—pulmonary artery hypertension and isolated right-sided heart failure are associated with hyperthyroidism. Restoration to a euthyroid state may reverse pulmonary hypertension

Interstitial Lung Disease**DIFFERENTIAL DIAGNOSIS**

PRIMARY (idiopathic)—usual interstitial pneumonia (UIP), respiratory bronchiolitis-associated interstitial lung disease (RBILD), desquamative interstitial pneumonia (DIP), acute interstitial pneumonia (AIP), non-specific interstitial pneumonia (NSIP), lymphoid interstitial pneumonia (LIP), cryptogenic organizing pneumonia (COP)

SECONDARY ★DICE★

- **DRUGS**—chemotherapy (bleomycin), sulfa, penicillin, sulfonyleurea, gold, penicillamine, phenytoin, amiodarone, nitrofurantoin

DIFFERENTIAL DIAGNOSIS (CONT'D)

- **INFILTRATIVE**—lymphangitic carcinomatosis, sarcoidosis
- **INFECTIONS**—TB, histoplasmosis, coccidioidomycosis
- **INFLAMMATORY**—rheumatoid arthritis, SLE, scleroderma, ankylosing spondylitis, myositis
- **CONGESTIVE HEART FAILURE**
- **ENVIRONMENT**—**organic dust** (hypersensitivity pneumonitis), **inorganic dust** (asbestos, silica, beryllium, coal worker's pneumoconiosis)
- **EOSINOPHILIA-ASSOCIATED PULMONARY INFILTRATES**—allergic bronchopulmonary aspergillosis (ABPA), parasitic, drugs

DIFFERENTIAL DIAGNOSIS (CONT'D)

- **ETC**—pulmonary histiocytosis X, idiopathic pulmonary hemosiderosis, lymphangioleiomyomatosis, radiation

CLINICAL FEATURES

HISTORY—dyspnea (duration, progression), cough, hemoptysis, wheezes, chest pain, impaired exercise tolerance, occupational history (details of all previous jobs, exposure to gases or chemicals particularly important), environmental exposure (home setting, air-conditioning, pets, hobbies), rash, joint swelling, past medical history (smoking), medications, family history

PHYSICAL—vitals (tachypnea, hypoxemia), cyanosis, clubbing (idiopathic pulmonary fibrosis, asbestosis, rheumatoid lung, fibrosing NSIP), decreased chest expansion, crackles (fine), wheezes, cor pulmonale. Note that sarcoidosis and silicosis may have a normal lung examination

Related Topics

Allergic Bronchopulmonary Aspergillosis (p. 43)
 Restrictive Lung Disease (p. 21)
 Rheumatoid Arthritis (p. 277)
 Sarcoidosis (p. 420)
 Tuberculosis (p. 250)

INVESTIGATIONS

BASIC

- **LABS**—CBCD, ANA, RF, anti-CCP antibody, anti-SCL antibody, anticentromere antibody, anti-Jo antibody
- **IMAGING**—CXR, CT chest (high resolution), echocardiogram (if suspect pulmonary hypertension)
- **ABG**
- **PFT**

SPECIAL

- **BIOPSY**—bronchoscopy (transbronchial biopsy), open lung biopsy

DIAGNOSTIC ISSUES

CHARACTERISTIC CXR PATTERNS FOR INTERSTITIAL LUNG DISEASE

- **UPPER LOBE PREDOMINANCE**—sarcoidosis, hypersensitivity pneumonitis, pneumoconiosis, silicosis, histiocytosis X, PJP, ankylosing spondylitis, ABPA, TB
- **LOWER LOBE PREDOMINANCE**—idiopathic pulmonary fibrosis, asbestosis, rheumatoid arthritis, scleroderma, drugs

DIAGNOSTIC ISSUES (CONT'D)

- **BILATERAL HILAR/MEDIASTINAL ADENOPATHY WITH INTERSTITIAL INFILTRATES**—sarcoidosis, berylliosis, lymphangitic carcinomatosis, TB, fungal, lymphoma
- **EGGSHELL CALCIFICATION OF HILAR/MEDIASTINAL LYMPH NODES**—silicosis (other pneumoconiosis), TB, fungal
- **CALCIFIED PLEURAL PLAQUES**—asbestos
- **PLEURAL EFFUSIONS WITH INTERSTITIAL INFILTRATES**—HF, lymphangitic carcinomatosis, rheumatoid arthritis, SLE

MANAGEMENT

TREAT UNDERLYING CAUSE—steroids in most cases. **Idiopathic pulmonary fibrosis** (steroids plus either azathioprine or cyclophosphamide). **Sarcoidosis** (if \geq stage II or symptomatic, give steroids for at least 6 months, even with improvement of symptoms. See p. 420 for details)

LUNG TRANSPLANT

SPECIFIC ENTITIES

IDIOPATHIC PULMONARY FIBROSIS (IPF), ALSO KNOWN AS USUAL INTERSTITIAL PNEUMONIA (UIP)

- **PATHOPHYSIOLOGY**—unknown. Fibrotic rather than inflammatory process
- **DIAGNOSIS**—CT chest (honeycombing, interlobular septal thickening, traction bronchiectasis, peripheral, sub-pleural, lack of ground glass pattern), bronchoscopy (to rule out other causes, mostly infectious); consider open lung biopsy if CT is not consistent with above
- **TREATMENTS**—steroid monotherapy usually ineffective. For patients <50 with early disease and minimal fibrosis, consider steroids plus either azathioprine or cyclophosphamide. Lung transplant referral should be done early

CCM 2004 171:2

HYPERSENSITIVITY PNEUMONITIS

- **PATHOPHYSIOLOGY**—inhaled organic antigens \rightarrow immune response \rightarrow acute, subacute, or chronic granulomatous pneumonia
 - **DIAGNOSIS**—**major criteria** (compatible symptoms, antigen exposure, imaging findings, lavage lymphocytosis, histologic findings (poorly formed granulomas), reexposure triggers symptoms); **minor criteria** (bilateral crackles, \downarrow DLCO, hypoxemia). Combination of major and minor criteria will help raise suspicion of hypersensitivity pneumonitis. Serology may be helpful
 - **TREATMENTS**—cessation of exposure, steroids
- CRYPTOGENIC ORGANIZING PNEUMONIA (COP)**—previously known as bronchiolitis obliterans organizing pneumonia (BOOP)
- **CAUSES**—**idiopathic** (80%), **post-infectious** (CMV, influenza, adenovirus, Chlamydia), **drugs**

SPECIFIC ENTITIES (CONT'D)

(amiodarone, bleomycin, gold, sulfasalazine, cephalosporin, cocaine), **connective tissue disease** (RA, SLE, scleroderma, Sjogren's, dermatomyositis), **immunologic** (essential mixed cryoglobulinemia), **transplantation** (bone marrow, lung, kidney), **malignancy** (MDS, lymphoproliferative diseases, radiation)

- **CLINICAL FEATURES**—about 50% of cases preceded by viral-like respiratory infection. Symptoms

SPECIFIC ENTITIES (CONT'D)

include dyspnea on exertion, persistent non-productive cough, and weight loss

- **DIAGNOSIS**—characteristic findings on CXR and CT chest include bilateral, diffuse, ill-defined alveolar opacities distributed peripherally. PFT shows mainly restrictive lung disease pattern
- **TREATMENTS**—prednisone 1 mg/kg PO daily

Obstructive Sleep Apnea

NEJM 2007 356:17

DIFFERENTIAL DIAGNOSIS OF SLEEP DISORDERS

HYPERSONNOLENCE

- **SLEEP DISRUPTION**—obstructive sleep apnea (OSA), periodic limb movement disorder
- **INADEQUATE SLEEP TIME**—medicine residents, shift workers
- **INCREASED SLEEP DRIVE**—narcolepsy, primary CNS hypersomnolence, head injury, severe depression, medications

INSOMNIA

- **ACUTE**—stress, travel through time zones, illness, medications (steroids), illicit drugs (stimulants)
- **CHRONIC**—conditioned, psychiatric disorders, poor sleep hygiene, medical disorders, pain, restless leg syndrome, circadian rhythm disorder

PARASOMNIA—sleep walking, sleep terrors, nocturnal seizures, rapid eye movement behavior disorder

PATHOPHYSIOLOGY

ABNORMAL PHARYNX ANATOMY—decreased upper airway muscle tone and reduced reflexes protecting pharynx from collapse, increased hypercapnic set point → airway collapse with hypoxemia and hypercapnia → partial collapse leads to snoring and hypopnea, full collapse leads to apnea → terminated with arousal → repeated arousals lead to hypersomnolence. Severe chronic hypoxemia leads to pulmonary hypertension

ASSOCIATIONS—obesity, hypothyroidism, acromegaly, amyloidosis, neuromuscular disease, vocal cord paralysis, nasopharyngeal carcinoma, Down syndrome (macroglossia)

COMPLICATIONS—hypertension, pulmonary hypertension, CAD, CVA, increased motor vehicle accidents

Related Topics

CPAP (p. 94)

Hypertension (p. 57)

Pulmonary Hypertension (p. 14)

CLINICAL FEATURES

HISTORY—daytime sleepiness, habitual snoring, witnessed apneic episodes, poor sleep hygiene, morning headaches, fall asleep while driving, dyspnea, cough, exercise capacity, short-term memory loss, excessive caffeine intake, alcohol intake, past medical history (weight gain, thyroid disease, neurological disease), and medications. The Epworth Sleepiness Scale may be used as a screening questionnaire

PHYSICAL—vitals (hypertension, hypoxia). Obtain weight and height (BMI often >30 kg/m²). Asterixis and plethora secondary to hypercapnia. Check for low-hanging soft palate, large uvula, enlarged tonsils, retrognathia, micrognathia, ↑ neck circumference (>42 cm [>16.5 in.] for ♂, >39 cm [>15.4 in.] for ♀), and acanthosis nigricans. Perform respiratory and cardiac examination (hypertension and pulmonary hypertension, restrictive lung disease). Inspect for potential causes such as nasopharyngeal carcinoma, hypothyroidism (goiter), acromegaly (course facial structures), and amyloidosis (periocular infiltrate, shoulder pad sign)

INVESTIGATIONS

POLYSOMNOGRAPHY

ABG

PFT

MANAGEMENT

LIFESTYLE CHANGES—sleep hygiene (avoid daytime napping, avoid caffeine, reduce alcohol intake, exercise regularly but not immediately before sleep, maintain regular sleep schedule, ensure comfortable sleep environment without noises or bright light), restrict body position during sleep

TREAT UNDERLYING CAUSE—for patients with obstructive sleep apnea, consider weight loss through exercise and dieting, avoidance of alcohol/sedatives. CPAP is the gold standard for therapy. Other options include orthodontic devices to hold lower jaw forward and surgical procedures such as tracheostomy,

MANAGEMENT (CONT'D)

tonsillectomy, nasal surgery, uvulopalatopharyngoplasty; however, therapies other than CPAP are not generalizable. Thus, every effort should be made to treat with CPAP

TREATMENT ISSUES

PATIENTS WITH OBSTRUCTIVE SLEEP APNEA AND HF—CPAP can ↑ ventilation during sleep, ↓ hypoxemia, ↑ sleep quality, and ↑ cardiac function (↓ LV transmural pressure and improves cardiac output)

SPECIFIC ENTITIES

OBESITY HYPOVENTILATION SYNDROME (OHS)—also known as Pickwickian syndrome. Defined by hypoventilation (awake PaCO₂ >45 mmHg) in the absence of other causes of hypoventilation. OHS patients have sleep disordered breathing, and most have OSA. BMI is usually >35 kg/m². Treatment options include respiratory stimulants, ventilatory support, oxygen therapy, and weight loss

SPECIFIC ENTITIES (CONT'D)

NARCOLEPSY—severe daytime hypersomnolence, cataplexy (loss of postural tone, usually with emotions), sleep paralysis (usually happens after sleep-wake transition), hypnagogic hallucinations (visual or auditory hallucinations during drowsiness)

RESTLESS LEG SYNDROME

- **PATHOPHYSIOLOGY**—associated with iron deficiency, hypoparathyroidism, uremic neuropathy, diabetic neuropathy, rheumatoid arthritis, and fibromyalgia
- **CLINICAL FEATURES**—desire to move extremities, associated with paresthesias, dysesthesias, and motor restlessness (floor pacing, leg rubbing). Symptoms tend to be worse at rest, particularly in the evenings and at night. Relieved by activity
- **TREATMENTS**—dopamine agonists (pergolide, pramipexole, or ropinirole), levodopa/carbidopa, gabapentin, clonazepam, and oxycodone if precipitated by pain. A trial of iron therapy is indicated in all patients even in the absence of overt iron deficiency

NEJM 2003 348:21

Respiratory Acidosis: Hypoventilation**DIFFERENTIAL DIAGNOSIS**

CNS (respiratory center depression)—brain stem injury (tumor, stroke), sleep apnea, obesity, medications (opioids)

RESPIRATORY

- **UPPER AIRWAY OBSTRUCTION**—epiglottitis, laryngospasm
- **LOWER AIRWAY OBSTRUCTION**—COPD, asthma, sleep apnea
- **DEAD SPACE VENTILATION**—infection, pleural effusion
- **MUSCULAR**—myasthenia gravis, Guillain-Barre syndrome, myopathy, ALS, hypophosphatemia, hypokalemia
- **CHEST WALL RESTRICTION**—kyphosis, scoliosis, ankylosing spondylitis

PHYSIOLOGIC COMPENSATION—secondary to metabolic alkalosis

PATHOPHYSIOLOGY

DEFINITION OF RESPIRATORY ACIDOSIS—PaCO₂ >40 mmHg (or upper limit of normal), which is synonymous with hypoventilation

INVESTIGATIONS**BASIC**

- **LABS**—CBCD, lytes, urea, Cr, CK
- **IMAGING**—CXR
- **ABG**

MANAGEMENT

ACUTE—ABC, O₂, IV, BIPAP, intubation

TREAT UNDERLYING CAUSE**Related Topics**

Approach to ABG (p. 77)

Metabolic Acidosis (p. 77)

Metabolic Alkalosis (p. 78)

Respiratory Alkalosis: Hyperventilation

DIFFERENTIAL DIAGNOSIS

CARDIOPULMONARY—hypoxia, pneumonia, early restrictive disease, mild HF, pulmonary embolism, mechanical ventilation

NON-CARDIOPULMONARY—fever, sepsis, CNS, anxiety, hyperthyroidism, drugs, pregnancy, liver failure

PHYSIOLOGIC COMPENSATION—secondary to metabolic acidosis

PATHOPHYSIOLOGY

DEFINITION OF RESPIRATORY ALKALOSIS— $\text{PaCO}_2 < 40$ mmHg (or lower limit of normal), which is synonymous with hyperventilation

INVESTIGATIONS

BASIC

- **LABS**—CBC/D, lytes, urea, Cr, AST, ALT, ALP, bilirubin, TSH, urinalysis, βhCG in women of reproductive age
- **IMAGING**—CXR, CT chest

ABG SPECIAL

- **SEPTIC WORKUP**—blood C&S, urine C&S
- **D-DIMER**—if suspect PE but low probability

MANAGEMENT

ACUTE—ABC, O_2 , IV, sedation (use with great caution as patients may experience respiratory decompensation)

TREAT UNDERLYING CAUSE

Hypoxemia

See HYPOXEMIA (p. 92)

Ventilation Issues

See VENTILATION ISSUES (p. 94)

Approach to Chest Imaging

APPROACH TO CHEST X-RAY INTERPRETATION

1. **ID**—note patient's name, date/time, technique (PA + lateral, or AP); if not stated, assume PA + lateral by default
2. **QUALITY OF CXR**
 - **ROTATION**—equi-distance between clavicular heads and spinous process
 - **PENETRATION**—intervertebral space seen behind cardiac silhouette
 - **INSPIRATION**—at least 6–8 ribs anteriorly, or 9–11 ribs posteriorly
 - **FIELD**—ensure the entire thorax is captured on film
3. **DEVICES**—previous sternotomy, mechanical valves, pacemaker, central lines (tip at level of carina), PICC line, Swan Ganz, endotracheal tube (two vertebral spaces above carina or aortic

APPROACH TO CHEST X-RAY INTERPRETATION (CONT'D)

notch), NG tube, ECG leads, pacer wires, O_2 tubing, nipple markers (used to differentiate nipple shadows from pulmonary nodules)

4. MSK

- **SOFT TISSUES**—fat, muscle, breast shadow
 - **BONES**—rib or clavicle #, osteoporosis
5. **MEDIASTINUM WIDENING**—right paratracheal stripe >4 mm, azygous region >4 mm, hilar involvement, AP window, tracheal deviation, carina angle widening
 6. **HEART**
 - **CARDIOTHORACIC RATIO**—heart to thorax ratio of $>30\%$ on PA film or $>50\%$ on AP suggests cardiomegaly
 - **CHAMBER ENLARGEMENT**—see table below

CHAMBER ENLARGEMENT

	PA film	Lateral film
Left ventricular hypertrophy	Enlargement of left heart border inferiorly and laterally	Enlargement of inferior and posterior aspects of heart (start where left diaphragm intersects IVC, go up 2 cm [0.8 in.] and then posteriorly 1.8 cm [0.7 in.], LVH is likely if still in heart shadow)
Left atrial enlargement	Prominence of left atrial appendage	Enlargement of posterior border of heart
Right atrial enlargement	Bulging right heart border	Enlargement of anterior and superior aspects of heart
Right ventricular hypertrophy	Enlargement of left heart border laterally	Enlargement of anterior and superior aspects of heart

APPROACH TO CHEST X-RAY INTERPRETATION (CONT'D)

7. LUNGS

- **DIAPHRAGM**—right diaphragm is usually higher on lateral, left diaphragm touches heart border
 - **COSTOPHRENIC ANGLE**—blunting suggests effusion
 - **PLEURA**—convex lesion, thickening, calcifications, pneumothorax (veil-like pleural margin over lung edge with no lung markings extending beyond darker zone)
 - **PARENCHYMA CONSOLIDATION SIGNS**—fluffy density, air bronchograms, silhouette signs (right heart border = RML, left heart border = lingular, right diaphragm = RLL, left diaphragm = LLL)
 - **PARENCHYMA RETICULAR NODULAR PATTERN**
8. **BLIND SPOTS**—behind heart, below diaphragm, spine, paraspinous lines, lung apices, peripheral bones

LUNG CAVITIES

INFECTIONS—**bacterial** (*Staphylococcus*, β -hemolytic *Streptococcus*, *Klebsiella*, Enterobacteriaceae, *Nocardia* [multiple cavities], anaerobes), **mycobacteria** (TB, non-TB), **fungal** (histoplasmosis, coccidioidomycosis), **parasites** (echinococcus or hydatid infection), **seeding from another site** (septic emboli from right-sided endocarditis, multiple cavities)

NEOPLASMS—**bronchogenic cancer** (squamous cell), **metastatic seeding** (usually multiple cavities; squamous cell carcinomas such as nasopharynx, esophagus, or cervix; adenocarcinomas such as lung, breast, and GI tract tumors; melanoma)

VASCULAR—**Wegener's granulomatosis** (multiple cavities with airspace disease), **necrotic rheumatoid nodules** (multiple cavities), **pulmonary embolus** (infarction)

FOCAL INFILTRATE

LOBAR PNEUMONIA

LUNG INFARCTION OR HEMORRHAGE

FOCAL INFILTRATE (CONT'D)

NEOPLASM (less likely)—bronchoalveolar carcinoma is commonly mistaken as pneumonia initially, with radiographic appearance of focal consolidation in 30%, lymphoma

DIFFUSE AIRSPACE DISEASE

PULMONARY EDEMA (fluid)—**cardiogenic** (left ventricular failure, valvular disease), **non-cardiogenic** (toxic inhalation, drug reaction, aspiration, fat embolism, ARDS)

INFECTIONS (pus)—bacterial, viral, atypical (TB), fungal

HEMORRHAGE (blood)—**bleeding diathesis, DIC, anticoagulation, vasculitis** (Wegener's granulomatosis, Goodpasture's, SLE)

INFLAMMATORY—cryptogenic organizing pneumonia, eosinophilic pneumonia, pulmonary alveolar proteinosis

MALIGNANCY—bronchoalveolar carcinoma, lymphoma

RETICULAR PATTERN

PULMONARY EDEMA

INFECTIONS—bacterial, viral, PJP

INTERSTITIAL LUNG DISEASE—idiopathic pulmonary fibrosis, drug-induced fibrosis, pneumoconiosis, hypersensitivity pneumonitis, connective tissue disease-related fibrosis, asbestosis, ankylosing spondylitis, sarcoidosis, ABPA, opportunistic infections

TUMOR—lymphangitic carcinomatosis (subacute)

NODULAR OR RETICULONODULAR PATTERN

INFECTIONS—TB (miliary), viral, fungal

INFLAMMATORY GRANULOMAS—sarcoidosis, silicosis, histiocytosis X, hypersensitivity pneumonitis

METASTASES—melanoma, lung cancer, breast cancer, renal cell carcinoma, germ cell tumors (in young men), thyroid

PLEURAL-BASED DISEASE

THICKENING (obtuse angle, linear)—tumor, edema/post-radiation thickening, fibrosis, consolidation
CALCIFICATIONS—asbestos, TB, empyema, hemothorax

HILAR ENLARGEMENT

LARGE PULMONARY ARTERIES—see PULMONARY HYPERTENSION (p. 57)

BILATERAL HILAR ADENOPATHY—**neoplasm** (lymphoma, metastases), **infections** (viral, TB, fungal), **non-specific inflammation** (sarcoidosis, silicosis, Berylliosis, connective tissue disease)

LUNG MASS ABUTTING THE HILUM**MEDIASTINAL MASSES**

SUPERIOR MEDIASTINUM (above horizontal line drawn between sternomanubrial joint and T4 vertebra)—thyroid goiters, cystic hygromas, adenopathy, aneurysm

ANTERIOR MEDIASTINUM (in front of heart border)

★5T's★

- Thymoma
- Thyroid retrosternal
- Teratoma
- Terrible lymphoma
- Tumor—bronchogenic carcinoma

MIDDLE MEDIASTINUM (between anterior heart border and vertebral bodies)—**infections** (TB, fungal), **neoplastic** (bronchogenic, lymphoma, metastases, neurogenic, mesothelioma), **sarcoidosis**, **aneurysm**, **cysts** (bronchogenic, pericardial, esophageal), **Castleman's disease** (giant LN hyperplasia)

POSTERIOR MEDIASTINUM—**neural tumors** (sheath tumors [schwannomas, neurofibromas], ganglion cell tumors [neuroblastoma, ganglioneur-

MEDIASTINAL MASSES (CONT'D)

oma)), **non-neural tumors** (mesenchymal, vertebral, lymphoma), **Bochdalek's hernia**

SIGNS FOR DISEASE PROCESSES

HEART FAILURE—vascular redistribution/bat wings, cardiomegaly, peribronchial cuffing, Kerley B lines, pulmonary edema, pleural effusion

COPD—hyperinflation, hemidiaphragm height <1 cm on lateral film, large retrosternal airspace, peripheral vessels end bluntly

CYSTIC FIBROSIS—hyperinflation (flattened diaphragms, large retrosternal airspace), prominent **interstitial markings** (upper lobes progressing to the lower lobes), **bronchiectasis** (peribronchial cuffing, "tram tracks," ring shadows), **cysts**, **scarring** (retraction of hilar regions), **pulmonary arterial hypertension** (pulmonary arteries dilatation), **pneumothorax**

CT CHEST PROTOCOLS

HIGH RESOLUTION—1 mm cut every 1 cm (10% of chest only). Non-contrast. Best for pulmonary fibrosis

LUNG CANCER PROTOCOL—7–10 mm cut of entire chest. Also scans adrenals and liver. Contrast enhanced. Best for nodules and mediastinal and pleural structures

PULMONARY EMBOLISM PROTOCOL—contrast bolus timed for optimal imaging of pulmonary arteries. Best for vascular structures, reasonable for nodules and mediastinal and pleural structures

Related Topics

Interstitial Lung Disease (p. 15)

Solitary Pulmonary Nodule (p. 13)

Approach to Pulmonary Function Tests**OVERALL APPROACH TO PFT INTERPRETATION**

1. **ID AND DEMOGRAPHICS**—name, date/time, age, height, weight, BMI, smoking history
2. **ANALYZE FLOW VOLUME LOOP AND SPIROMETRY**—identify obstructive or restrictive pattern
3. **ANALYZE SPIROMETRY**—identify obstructive defect, reversibility, and severity. Note that restrictive defect cannot be diagnosed without knowledge of lung volumes
4. **ANALYZE LUNG VOLUMES**—identify restrictive defect, severity
5. **ANALYZE DLCO AND DLCO ADJUSTED FOR ALVEOLAR VOLUME (VA)**—a measure of gas exchange; if abnormal, suggests disease even if spirometry and lung volumes are normal

CLASSIFICATION OF PULMONARY DISEASES

OBSTRUCTIVE—asthma, COPD, bronchiectasis, cystic fibrosis, bronchiolitis obliterans

RESTRICTIVE

- **PARENCHYMAL**—sarcoidosis, idiopathic pulmonary fibrosis, pneumoconiosis, other interstitial lung diseases
- **EXTRAPARENCHYMAL**—neuromuscular (diaphragmatic paralysis, myasthenia gravis, Guillain-Barré syndrome, muscular dystrophies), chest wall (kyphoscoliosis, obesity, ankylosing spondylitis)

TERMINOLOGIES

DLCO—carbon monoxide diffusion capacity

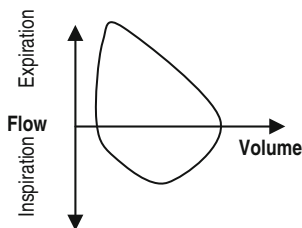
FEF25–75%—forced expiratory flow during the middle of a FVC maneuver, represents flow of small airways

TERMINOLOGIES (CONT'D)

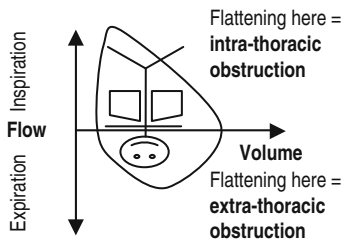
- FEV1**—forced expiratory volume during the first second of a FVC maneuver
- FVC**—forced vital capacity, maximum volume exhaled after maximum inhalation
- MEP**—maximum expiratory pressure
- MIP**—maximum inspiratory pressure
- TLC**—total lung capacity at maximal inhalation

FLOW-VOLUME LOOP PATTERNS

NORMAL

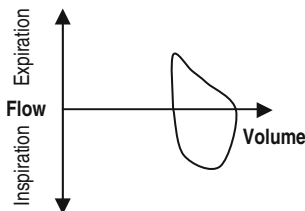


OBSTRUCTIVE DISEASE—scooped appearance of expiratory curve seen in COPD. Variable extrathoracic obstruction (e.g. paralyzed vocal cords) appears as flattening of inspiratory curve. Variable intrathoracic obstruction (e.g. tracheal tumor) appears as flattening of expiratory curve. As illustrated by the man below, scooping of the inspiratory curve (i.e. negative portion of the flow-volume loop) represents extrathoracic obstruction, compared to intrathoracic obstruction, affecting the expiratory curve (i.e. positive portion of the flow-volume loop)



FLOW-VOLUME LOOP PATTERNS (CONT'D)

RESTRICTIVE DISEASE—expiratory portion of curve appears relatively tall (preserved flow rates), but narrow (↓ lung volumes)



SPIROMETRY AND LUNG VOLUME PATTERNS

OBSTRUCTIVE DISEASE—↓ FEV1/FVC ratio (↓ FEV1 out of proportion to ↓ FVC); definitions vary but GOLD criteria define ↓ FEV1/FVC as <70%. If improvement >12% and 200 mL post-bronchodilator, consider diagnosis of asthma (reversibility). Note that mild obstructive (small airways) disease may have normal FEV1/FVC with ↓ FEF 25–75%

RESTRICTIVE DISEASE—↓ TLC, defined as <80% predicted (only applies to plethysmography); 70–79%=mild; 60–69%=moderate; <60%=severe. Note that patients may have both obstructive and restrictive disease

Note: general rule for the lower limit of normal for most PFT results is 80% of predicted (FEV1, FVC, DLCO, TLC) but less accurate for FEV1/FVC ratio and for patients of extremes of age

OVERALL APPROACH

	TLC	FEV1/FVC	MIP	MEP
Obstructive	N/↑	↓	N	N
Restrictive				
• Parenchymal	↓	N/↑	N	N
• Extraparenchymal (inspiratory)	↓	N	N/↓	N
• Extraparenchymal (in+expiratory)	↓	↓/N/↑	N/↓	N/↓

ANALYZING DLCO**REFERENCE VALUES FOR DLCO**

	% predicted
High	>140%
Normal	81–140%
Borderline low	76–80%
Mild decrease	61–75%
Moderate decrease	41–60%
Severe decrease	<40%

OBSTRUCTIVE DISEASE PRESENT—DLCO usually normal in asthma and chronic bronchitis but ↓ in emphysema

ANALYZING DLCO (CONT'D)

RESTRICTIVE DISEASE PRESENT—DLCO adjusted for alveolar volume usually ↓ in interstitial lung diseases and atelectasis and normal in neuromuscular diseases, chest wall abnormalities, and obesity

ISOLATED DLCO ABNORMALITY (WITHOUT OBVIOUS OBSTRUCTIVE OR RESTRICTIVE DISEASE)—↓ DLCO may result from anemia, increased carboxyhemoglobinemia, PE, and pulmonary hypertension; ↑ DLCO may result from pulmonary hemorrhage, obesity, left-to-right shunts, and polycythemia

Notes