Complications of Pneumonia in Children

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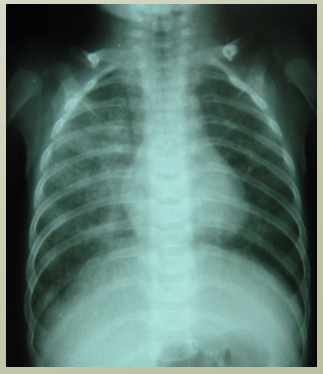
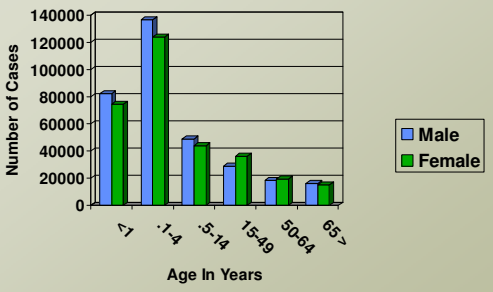
CL, a 5-year-old girl, has been highly febrile for 5 days. Her aunt claims that her niece has been coughing for nearly 3 weeks despite intake of Ambroxol syrup.

PE: HR 112/min, RR 35/min, T 38.4°C; decreased breath sounds and increased vocal fremiti on the right lung field.





In 2005, ALRI and Pneumonia leads in morbidity with 692,305 reported case or a rate of 830.1 per 100,000 population.

The etiology of pneumonia is difficult to determine and initial choice of therapy is based on:

- **frequency of pathogens in various age groups**
- **local antibiotic resistance patterns of the organisms**
- **clinical presentation**
- **epidemiological data**

Most common pathogens based on presentation

Typical
- Streptococcus
- Hemophilus
- Staphylococcus

Atypical
- Chlamydia
- Mycoplasma
- Legionella
- Viral

Nosocomial
- Pseudomonas
- Klebsiella
- E. coli
- Enterobacter

Immunocompromised
- Pneumocystis

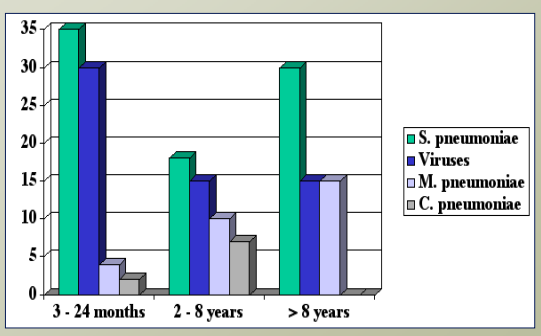
Spectrum of pathogens in PCAP

Bacterial Pathogens
- S pneumoniae
- Moraxella catarrhalis
- Haemophilus influenzae

Atypical Pathogens
- Mycoplasma pneumoniae (non-typable)
- Chlamydia pneumoniae

Viral Pathogens
- Respiratory syncitial virus
- Influenza A and B
- Adenovirus
- Rhinovirus, Enterovirus, Human Metapneumovirus

PCAP: Incidence of Etiologic Agents by Age



Wubble L, et al. Pediatr Infect Dis J 1999; 18:98–104.

Adolescents may demonstrate the classic adult presentation of pneumonia, including:
1. abrupt onset of symptoms
2. high fever
3. productive cough
4. pleuritic chest pain, and
5. possible toxic appearance.

The presentation of the younger child with PCAP is often subtle:
1. Fever
2. Lethargy
3. Tachypnea
4. Irritability
5. Vomiting, diarrhea and poor feeding.

Sensitivity and Specificity of Symptoms for PCAP

Symptom	Sensitivity	Specificity
Tachypnea	92%	15%
Cough	92%	19%
Toxic appearance	81%	60%
Crackles	44%	80%
Retractions	35%	82%
Flaring	35%	82%
Pallor	35%	87%
Grunting	19%	94%

Leventhal JM. Clin Pediatr 1982

A chest radiograph should be obtained if

(1) the diagnosis is questionable

(2) this is a repeated episode

(3) the patient is ill enough to be admitted

(4) the child is younger than 3 years and
- has a fever > 39°C without a source and
- leukocytosis > 15,000 mm^3

(5) a complicated pneumonia is suspected

Indications for Admission in PCAP

Signs and symptoms

- Dyspnea
- Hypoxemia
- Lethargy
- Tachypnea
- Vomiting
- Grunting
- Irritability
- Retractions
- Toxic appearance

Social factors

- Poor follow-up
- Poor home care
- Neonate

Progression

- Rapid progression
- Failed outpatient therapy
- Complications

Latham-Sadler, et al. Prim Care 1996

Initial Empirical Treatment of PCAP Based on Age and Severity of Pneumonia

Age	Outpatients (Mild to Moderate)	Inpatients (Moderate)	Inpatients (Severe)
3–6 mo	Amoxicillin with or without clavulanate Erythromycin	Ceftriaxone or cefotaxime	Ceftriaxone or Cefotaxime ± vancomycin
6 mo to 5 yr	Amoxicillin with or without clavulanate Macrolide	Ceftriaxone, Cefotaxime, or Cefuroxime ± macrolide	Ceftriaxone or Cefotaxime ± macrolide ± vancomycin
5–18 yr	Macrolide	Ceftriaxone or Cefotaxime ± macrolide	Ceftriaxone or Cefotaxime ± macrolide ± vancomycin

Hsiao G, PCCU 2001

Pediatric CAP

	Possible Pathogen	Empiric Therapy
Mild, Nontoxic pharyngitis, rhinorrhea or diarrhea	Probably viral	*None*
Moderate toxicity no hospitalization Lobar or segmental consolidation, mild	S pneumoniae S pyogenes H influenzae M pneumoniae Influenza A and B	Amoxicillin Co-amoxiclav Cefprozil, Cefdinir, Cefpodoxime, Cefuroxime, Ceftriaxone Macrolide

Bradley JS. Pediatr Infec Dis J 2002;21(6):592-598.

Pediatric CAP

	Possible Pathogen	Empiric Therapy
Bilateral, severe Lobar or segmental consolidation, moderate - severe	S pneumoniae S pyogenes S aureus M pneumoniae	Cefuroxime, ceftriaxone, cefotaxime Nafcillin, oxacillin, cefazolin, clindamycin Macrolide
With pleural fluid, empyema or necrotizing	S pneumoniae S pyogenes S aureus H influenzae Anaerobe	Ceftriaxone, cefotaxime Nafcilllin, oxacillin, cefazolin, clindamycin Vancomycin Meropenem, imipenem BL-BI

Bradley JS. Pediatr Infec Dis J 2002;21(6):592-598.

Predictors of Mortality in Community Acquired Pneumonia in Children

Maria Liza B. Zabala and Alexander O. Tuazon. UP-PGH 2001

Variable	Survivor	Mortality	*p*	OR	95% CI
Pre-existing illness	27/74	32/46	0.0004	3.98	1.68-9.54
Temp 38.5	27/74	26/46	0.009	2.26	1-5.15
Altered mental status	60/74	45/46	0.007	10.5	1.47-453.64
Mechanical ventilation	20/74	46/46	0.0000		
O2 supplementation	46/74	46/46	0.0000		

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Variable	Survivor	Mortality	*p*	OR	95% CI
Hemoglobin (m$\pm$SD)	111$\pm$20	94$\pm$28	0.0002		
WBC< 5 x 10^9/L	1/74	7/43	0.002	15.37	1.9-690.98
WBC> 28 x 10^9L	6/74	7/43	0.033	3.15	0.94-11.33
Platelet < 150x10^6/mm^3	5/70	15/43	0.0003	6.5	1.98-24.6

Predictors of Mortality in Community Acquired Pneumonia in Children

Maria Liza B. Zabala and Alexander O. Tuazon. UP-PGH 2001

Variable	Survivor	Mortality	*p*	OR	95% CI
≥3 lobes with infiltrates	9/74	19/46	0.0003	5.08	1.86-14.16
Bilateral infiltrates	12/74	20/46	0.002	3.97	1.56-10.27
Alveolar type of infiltrate	29/74	36/46	0.0000	5.59	2.22-14.34

Complications of PCAP

Viral PCAP

- Focal necrosis and airway plugging
- Atelectasis
- Bronchospasm
- Apnea spells
- Respiratory failure
- ARDS
- Reactive airway disease
- Bronchiectasis
- Bronchiolitis obliterans
- Pulmonary fibrosis

Complications of PCAP

Bacterial PCAP

- Most commonly associated with S pneumoniae in children younger than 2 years
  - Meningitis
  - Purpura fulminans
  - Arthritis
  - Parapneumonic effusions
  - Empyema
  - Abscess formation
  - Endocarditis
  - Pericarditis

Comparison of children admitted for Pneumococcal Pneumonia (Jerusalem)

Characteristic	Pulmonary complications (n=43)	No pulmonary complications (n=68)	P value
Age (years)	3.4 ± 3.2	4.0 ± 4.0	NS
M/F ratio	1.47	1.76	NS
Background disease (%)	50.0	46.5	NS
Respiratory distress (%)	52.3	21.7	<0.001
Weight ≤10% for age (%)	56.4	32.8	0.018
Hemoglobin, admission (g/dl)	10.72 ± 1.26	11.12 ± 1.60	0.012
Hemoglobin, lowest (g/dl)	9.78 ± 1.32	10.63 ± 1.63	0.002
Anemia, age-adjusted (%)	69.0	47.1	0.024
Abnormal platelet count (%)	36.3	29.1	NS
Admission WBC <15,000 (%)	43.9	20.6	0.007
Days to defervescence (mean)	9.2 ± 7.0	2.3 ± 1.8	<0.0001
Hospitalization days (mean)	13.2 ± 11.3	5.3 ± 2.7	<0.0001
Resistant S pneumoniae (%)	18.4	14.5	NS

Wexler ID, et al. Pediatr Pulmonol 2006

Comparison of children admitted for Pneumococcal Pneumonia (USA)

(Complications rose from 14% (1994) to 27% (1999), mostly with strain 1)

Characteristic	Pulmonary complications (n=133)	No pulmonary complications (n=235)	P value
Age (mos)	45	27	0.008
White race (%)	58	85	<0.0001
Background disease (%)	22.6	48.5	<0.0001
Antibiotics before diagnosis (%)	19	12.8	NS
Chest pain (%)	29.3	7.7	<0.0001
Fever before diagnosis >3d (%)	65.1	31.4	<0.0001
CXR findings ≥ 2 lobes (%)	65	37	<0.0001
CXR consolidation (%)	90.2	41.3	<0.0001
Defervescence >2d (%)	86.1	26.4	<0.0001
Hospitalization days (mean)	17.7	6.45	<0.0001
Resistant S pneumoniae (%)	11.3	9.4	NS

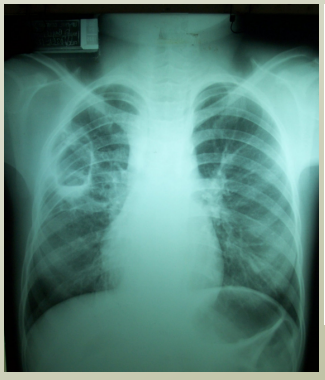
Tan TQ, et al. Pediatrics 2002

Complications Of Pneumonia Practical Management

- Prompt diagnosis and treatment of lung infections are necessary to prevent complications.
- Patient education enhances early medical consult.
- Compliance to treatment of lung infections is crucial in the prevention of complications.
- In the absence of these elements, complications of lung infections eventually develops.

Complications Of Pneumonia Practical Management

- Lung Abscess
- Pleural Effusion and Empyema
- Pneumothorax



SB 12 y/o female with cough and low grade fever for 2 weeks.Consulted given Amoxicillin. Came to you for consultation because she developed high grade fever and cough productive of purulent foul-smelling sputum 2 days ago.

PE: HR 120 RR 32 T 39.5 C; Equal chest expansion, (+) subcostal retractions; (+) crackles over both lung fields

Lung Abscess

- A circumscribed, thick-walled cavity in the lung that contains purulent material resulting from suppuration and necrosis of the involved lung parenchyma.
- An unresolved area of pneumonia is the site in which an abscess develops most frequently.
- Pulmonary aspiration, diminished clearance mechanisms, embolic phenomena, hematogenous spread from septicemia, or local extension from oropharyngeal or abdominal processes contribute to abscess development.
- Abscess may develop indolently over a few weeks with tachypnea, cough and fever.

Patradoon-Ho 2007

Lung Abscess: Organisms

Common anaerobes:

- *Fusobacterium nucleatum*
- *Prevotella melaninogenica*
- *Bacteroides fragilis* group
- *Bacteroides urealyticus* group
- *Peptostreptococcus* species
- *Veilonella* species
- Microaerophilis streptococci
- *Porphyromonas*
- *Prevotella oralis* group

Lung Abscess: Organisms

Common aerobes:

- S.*aureus*
- *E. coli*
- *Klebsiella pneumoniae*
- *Pseudomonas aeruginosa*
- *S. pyogenes*
- Group B *Streptococcus*

Lung Abscess: Evaluation

- Common Signs and Symptoms:

  Fever, pleuritic chest pain, cough, hemoptysis, dyspnea, sputum production, weight loss, malaise

- Physical Examination:

  Tachypnea, tachycardia, retractions,decreased chest movement, decreased breath sounds, dullness to percussion, crackles, bronchial breathing

Lung abscess in children.

Patradoon-Ho P, et al. Paediatr Respir Rev 2007

Symptoms (%)	Children' s Hosp, Sydney (n=23)	Tan, et al (n=25)	Chan et al (n=27)	Yen et al (n+23)
Fever	83	84	100	91
Cough	65	53	67	87
Dyspnea	36	35	19	35
Chest pain	31	24	22	9
Anorexia/ Nausea and Vomiting	24	20	4	26
Malaise and Lethargy	31	11	NR	22

Lung Abscess: Evaluation

Diagnosis:

Chest X-Ray: solitary, thick-walled cavity in the lung with or without air fluid level

Ultrasonography and CT scan: to localize the lesion and guide drainage or needle aspiration.

Direct percutaneous aspiration is the most reliable mode of identification of the etiologic agent.

Lung Abscess: Antimicrobial Treatment

- **Overall outcome is good, with mortality rates lower than those in adults.**
- **Up to 90% of patients with lung abscess may be adequately treated with intravenous antibiotic therapy.**
- **The choice of antibiotic is usually empiric based on the underlying condition of the patient and the presumed etiologic agent(s).**
- **The duration of parenteral treatment varies from 5 days** (Patradoon-Ho 2007) **to 3 weeks** (Tan 1995), **followed by oral therapy.**

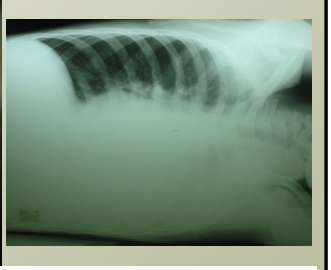
Patradoon-Ho 2007

Lung Abscess: Surgical Treatment

- **Surgical management is considered in cases of large lung abscess especially when associated with hemoptysis.**
- **Surgical management is indicated if there is clinical deterioration despite appropriate antibiotic therapy.**

1. **Drainage via bronchoscopy**
2. **Percutaneous tube drainage**
3. **Percutaneous needle aspiration**
4. **Lobectomy**

Lobectomy or wedge resection should be reserved for massive expansion of the abscess associated with mediastinal shift and attendant symptoms.



MT a 5 y/o male with high-grade fever and dyspnea. 1 month PTA, he developed cough with low grade fever on-and –off. 2 weeks PTA, consulted with a private physician and was given Amoxicillin and carbocisteine with no relief. 2 days PTA, fever became high grade w/ progressive dyspnea.
PE: HR 120 RR 48 T 39.1 C; (+) multiple CLAD
(+) chest lag on the left, (+) decreased breath sounds and vocal fremitus ,left
(+) dullness to percussion left, (-) crackles, (-) wheezing

Pleural Effusion and Empyema

- Collection of fluid or pus in the pleural space
- Can occur as a complication of pneumonia, tuberculosis or surgical procedures (post-surgical empyema)
- ***Staphylococcus aureus*** is the single most common pathogen of empyema in infants < 2 years of age
- Other common nontuberculous causes of empyema include ***H. influenzae*** type B, ***S. pyogenes, D. pneumoniae, E. coli, Klebsiella*** sp, ***Pseudomonas aeruginosa***.

Pleural Effusion and Empyema

- The diagnosis of empyema include CXR, ultrasound and examination of pleural fluid
- Obliteration of the costophrenic sulcus is the earliest radiologic sign of pleural fluid accumulation
- Failure of the liquid to shift from upright to decubitus view indicates loculation as commonly seen in staphylococcal empyema

Pleural Effusion and Empyema

Physical examination findings:

- Tachypnea
- Fever
- Chills, Cough
- Irritability, Anorexia, Lethargy
- Chest pain, Chest tightness
- Diminished thoracic excursion
- Fullness of the intercostal spaces, Dull or flat percussion
- Decreased tactile and vocal fremiti
- Displaced trachea and cardiac apex

Pleural Effusion and Empyema

- Expectoration of an increasing amount of purulent sputum with or without hemoptysis may herald the onset of bronchopleural fistula and pyopneumothorax
- Bronchopleural fistula may be due to rupture of neglected empyema into the lung or rupture of pulmonary suppuration into the pleura
- Muffling of the heart tones and pericardial rub indicate extension into the pericardium

Pleural Effusion and Empyema: Treatment

- Outcome is uniformly good, regardless of treatment option
- Treatment is aimed at specific management of the underlying cause and relief of functional disturbances caused by the existing clinical disorder, pleural involvement and concurrent complications
- The basic principle for treatment is to drain the infected pleural space and allow lung re-expansion
- Treatment is medical (high dose intravenous antibiotics) and surgical

Pleural Effusion and Empyema: Treatment

- General supportive measures:
  1. Bed rest
  2. Analgesia
  3. Fluid replacement
  4. Supplemental oxygen
  5. Lying on the affected side
- Choice of antimicrobial is based on bacterial epidemiology in the community, clinical data, pharmacologic properties of the drug.
- Repeated thoracentesis and eventually continuous chest tube drainage are indicated if rapid re-accumulation of effusion induces dyspnea.

Pleural Effusion and Empyema: Antibiotics

Little difference in penetration of penicillins and cephalosporins into empyemas and uninfected parapneumonic fluids.

Drugs with excellent pleural penetration include aztreonam, clindamycin, ciprofloxacin, cephalothin and penicillin

Aminoglycosides may be inactivated or have poor penetration into empyemas than uncomplicated parapneumonic effusions.

Pleural Effusion and Empyema: Treatment

Indications for tube thoracostomy:

1. Identification of an organism by gram stain
2. Positive pleural fluid culture
3. Pleural fluid glucose < 40 mg/dl
4. Pleural fluid LDH >1000 IU
5. Pleural fluid pH <7.10
6. Frank pus

An advanced stage empyema is suspected with pleural fluid that has:

1. Pure pus
2. pH <7.0
3. LDH >1000 U/mL
4. Glucose <40 mg/dL
5. Bacteria on gram stain

Pleural Effusion and Empyema: Treatment

- Therapy includes high dose intravenous antibiotics and drainage. Other modalities include fibrinolytic therapy, surgical debridement (including VATS).
- Surgical intervention may be considered in patients with evidence of treatment failure manifest as persistent leukocytosis, elevated ESR or C-reactive protein, persistence of significant pleural fluid on radiographic chest imaging.
- Decortication represents the primary surgical intervention.

ACCP classification of parapneumonic effusions

Pleural space anatomy	Pleural fluid bacteriology	Pleural fluid chemistry	Category	Risk of Poor Outcome	Drainage	Additional fibrinolytic, VATS or surgery
Minimal, free-flowing effusion (<10 mm on lateral decubitus CXR)	Unknown	pH unknown	1	Very Low	No	No
Small-moderate free-flowing effusion (>10mm, <1/2 hemithorax)	Negative	pH ≥7.2	2	Low	No	No
Large, free-flowing(≥1/2 hemithorax(, loculated effusion or effusion with thickened pleura	Positive culture and gram stain	Ph<7.2	3	Moderate	Yes	Yes
	Pus		4	High	Yes	Yes

Complicated parapneumonic effusion and empyema in children. Shen YH, et al. J Microbiol Immunol Infect 2006 (Taiwan)

Classification	Characteristics	Treatment
Acute	Clear, slightly cloudy, serous Sterile fluid Has at least one of the following: pH <7.20 Glucose <40 mg/dL LDH >1000 IU/dL Protein >2.5 g/dL Specific gravity >1.018 WBC >500/mm^3	Antibiotics with or without chest tube drainage
Fibropurulent	Fluid is thicker and opaque, or Positive culture	Antibiotics with chest tube drainage
Chronic	A peel forms around the lung	Decortication

Classification	Success	Decorti-cation	Hospitali-zation	Fever after drainage	Tube insertion
Acute	34/42 (81%)	8/42 (19%)	22.4 ± 6.6 d	9.2 ± 6.6 d	7.6 ± 5.6 d
Fibropurulent	15/17 (88%)	2/17 (12%)	30.1 ± 11.5 d	10.0 ± 4.0 d	12.8 ± 9.3 d
Chronic					

Complicated parapneumonic effusion and empyema in children. Shen YH. et al. J Microbiol Immunol Infect 2006

FC, 3 y/o male w/ 2-week-history of cough & low-grade fever productive of whitish phlegm. 9 days ago consulted at a local hospital, chest x-ray done showed pleural effusion left. Given oral Cefuroxime. Few hours PTA suddenly became dyspneic and was rushed to the ER.
PE: HR 140 RR 50 T 37.9 C
Trachea deviated to the right
(+) chest lag, left (+)decreased breath sounds left lung field, hyperresonant on percussion, left chest;
Apical heart sounds heard on the right

Pneumothorax

- An accumulation of air in the pleural spaces due to secondary to free communication of the pleural space with the atmosphere either from a chest wall defect through the parietal pleura or from alveolar rupture
- Can be secondary to infection with gas-producing microorganisms.

3 factors that determine the extent of alveolar rupture:

1. *Degree of transpulmonary pressure exerted*
2. *Duration of pressure applied*
3. *Ratio of inexpansible to expansible portion of the lung*

Pneumothorax

- Signs and symptoms may vary according to the extent of lung collapse, degree of intrapleural pressure, rapidity of onset and age and respiratory reserve of the patient
- PE includes chest bulging on the affected side if one side is involved, shift of cardiac impulse away from the site of the pneumothorax, tachypnea, decreased breath sounds on the affected side,tachycardia
- Grunting,retraction and cyanosis occur late in the progression of the complication

Pneumothorax

- Differential diagnosis include lung cyst, lobar emphysema, bullae,diaphragmatic hernia
- CXR is crucial in the confirmation of diagnosis
- Effective management requires early clinical recognition and prompt radiologic investigation
- Therapeutic management should take into account clinical severity, presence and nature of the underlying lung disease, precipitating event and history of recurrence

Pneumothorax

- Direct mechanical evacuation of intrapleural air should be performed unless the size of the pneumothorax is very small, the underlying disorder is mild and the clinical status is stable
- Close clinical and blood gas monitoring are integral parts of the management in all situations.

Summary

Complications of lung infections such as lung abscess, empyema and pneumothorax require a high index of clinical suspicion and confirmation by employing the appropriate diagnostic testing.

Management of these infections includes prescription of appropriate antimicrobials and may require specific drainage procedures and the judicial use of surgical interventions.