

# PNEUMONIA

## Facilitators Guide

Author **Ellis Collins & Michelle Alisio**

(Edits by the DFTB Team)

[fellows@dontforgetthebubbles.com](mailto:fellows@dontforgetthebubbles.com)

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Duration **1- 2 hrs**

# OUTLINE

- Basics (10 mins)
- Main session: (2 x 15 minute) case discussions covering the key points and evidence
- Advanced session: (2 x 20 minutes) case discussions covering grey areas, diagnostic dilemmas; advanced management and escalation
- Sim scenario (30-60 mins)
- Quiz (10 mins)
- Infographic sharing (5 mins): 5 take home learning points

## PRE-READING FOR LEARNERS

Khan Academy: [What is pneumonia?](#) (9 mins) OR

Khan Academy: [Classification of lung diseases.](#) (restrictive, obstructive, ventilation and perfusion lung problems 11mins)

[GPpaedstips](#): Diagnosing a lower respiratory tract infection (LRTI)

[LITFL](#): Pneumonia in the ED

[Paediatric clinical examinations- The respiratory system](#) (7mins)

[DFTB](#): Respiratory infections

[RCH](#): Community Acquired Pneumonia

[DFTB](#): The Mire of Mycoplasma

[DFTB](#): POCUS and Pneumonia

[ALiEM](#): Lung Ultrasound for diagnosing pneumonia

[Substituting POCUS for CXR Podcast on using lung USS](#) (11 mins)

### **Pathophysiology and background**

According to WHO Pneumonia kills more children than any other illness - more than AIDS, malaria and measles combined. In 2017 pneumonia accounted for 15% of all deaths of children under 5 years old, killing 808 694 children and it accounts for nearly one in five child deaths globally. It should also be noted that pneumonia is one of the leading causes of deaths for children under the age of 5.

Pneumonia is an invasion of the lower respiratory tract, below the larynx by pathogens either by inhalation, aspiration, respiratory epithelium invasion, or hematogenous spread. There are barriers to infection that include anatomical structures (nasal hairs, turbinates, epiglottis, cilia), and humoral and cellular immunity. Once these barriers are breached, infection, either by fomite/droplet spread (mostly viruses) or nasopharyngeal colonization (mostly bacterial), results in inflammation and injury or death of surrounding epithelium and alveoli. This is ultimately accompanied by a migration of inflammatory cells to the site of infection, causing an exudative process, which in turn impairs oxygenation. In the majority of cases, the microbe is not identified, and the most common cause is of viral aetiology.

There are four stages of lobar pneumonia. The first stage occurs within 24 hours and is characterized by alveolar oedema and vascular congestion.

Both bacteria and neutrophils are present.

Red hepatization is the second stage, and it has the consistency of the liver. The stage is characterized by neutrophils, red blood cells, and desquamated epithelial cells. Fibrin deposits in the alveoli are common.

The third of the grey hepatization stage occurs 2-3 days later, and the lung appears dark brown. There is an accumulation of hemosiderin and haemolysis of red cells.

The fourth stage is the resolution stage, where the cellular infiltrates are resorbed, and the pulmonary architecture is restored. If the healing is not ideal, then it may lead to parapneumonic effusions and pleural adhesions.

In bronchopneumonia, there is often patch consolidation of one or more lobes. The neutrophilic infiltrate is chiefly around the centre of the bronchi.

The WHO reclassified pneumonia in children into two categories; pneumonia with fast breathing and/or chest in-drawing, which requires home therapy with oral amoxicillin, and severe pneumonia, which is pneumonia with any general danger sign (i.e. hypoxaemia), which requires referral and injectable therapy.

The presentation of children with pneumonia can be very varied and may include cough, fever, tachypnea, and difficulty breathing. Young children may even present with abdominal pain only.

### Features from the history and what they might mean.

Sign/History	Implication	Complication
Prolonged duration of cough	Secondary infection, abscess or empyema formation	Longer admission, tertiary referral
Choking	Aspiration of FB or food	Bronchiole/lower airway obstruction, pneumonitis
Birth complications- e.g. meconium or prematurity	Chronic lung disease for the newborn	More susceptible to infections/ severe infections
Immunisation	Incomplete immunization/ no immunisation	At risk of acquiring bacterial infections, severe infections or viral complications from measles, chickenpox
Travel and exposure	Contact with unwell relative, contact with other children Exposure to different pathogens with travel	Contact with older/unwell children, or adults may be exposed to pathogens not yet immunized against, or atypical ones

## CASE SCENARIO 1: NON-SEVERE PNEUMONIA

Mary is 3yrs old and was referred to hospital from the GP with a 2 day history of coryzal symptoms, cough, fever and saturations of 91%. She is not eating but still drinking fluids well. On assessment in triage she is crying; her respiratory rate is 45, saturations are 96% and temperature is 37.8°. The play therapist distracts her while you examine her chest on mum's lap. You don't see any use of accessory muscles or intercostal recessions at rest; you think you heard crackles but it could also be transmitted sounds.

**What is the probability that Mary has pneumonia?**

**Should you do a Chest X-ray?**

**Mary's mother says the GP frightened her by referring her to hospital. She asks you whether Mary needs antibiotics. Should you prescribe antibiotics?**

### Discussion points:

- **The value of clinical signs**
- **When to do a CXR**
- **Severity of pneumonia to direct treatment**
- **Safety netting**

Mary is a well grown, fully immunised and a previously well child who now displays mild signs and symptoms of pneumonia. She does not need a CXR nor does she need antibiotics. The family requires reassurance that the child is safe, can be managed at home as well as be provided with illness specific information and when to return.

The value of clinical signs in diagnosing pneumonia

<https://gppaedstips.blogspot.com/2018/11/making-diagnosis-of-lower-respiratory.html>

Children with pneumonia may present with fever, tachypnoea, breathlessness or difficulty in breathing, cough, wheeze or chest pain. They may also present with abdominal pain and/or vomiting and may have headache. Cough and fever are non-specific symptoms and are not grounds for diagnosing LRTI on their own.

Tachypnoea is also a non-specific sign in children. It may present in fever, when a child cries or is in pain and in many non-respiratory cases.

Hearing crepitations on auscultation is also a common finding that should not be given too much weight. The infant or child with an upper respiratory tract infection (URTI) will often have crepitations that can be heard in one or more places in the chest. These may be transmitted sounds or due to secretions. Often, these noises go away or move around if re-examined, especially after a cough. In the absence of abnormal breathing, these crackles are not good evidence for LRTI. Also, auscultation and percussion in infants and small children is difficult. Chests are small and there is always the possibility that the area of abnormality will be missed.

### **What clinical findings are of value in diagnosing Pneumonia?**

[The Rational Clinical Examination Systematic Review](#) concludes that more important than tachypnoea and auscultatory findings are

Hypoxia (Saturations  $\leq$  96%) and  
Increased work of breathing/ abnormal breathing

#### **Signs of abnormal breathing in children**

- **Fast breathing (tachypnoea) which is not transiently due to a spike in temperature**
- **Intercostal recession, subcostal recession or tracheal tug**
- **Use of accessory muscles for breathing**
- **Grunting (a brief grunting noise made on expiration)**
- **Difficulty feeding in babies**

*gppaedstips.blogspot.co.uk*

Image courtesy of [gppaedstips.blogspot.co.uk](http://gppaedstips.blogspot.co.uk)

### **When to do a Chest X-ray?**

There are no absolute rules about when to Xray but we shouldn't rely on CXR's to make the decision for us. The sensitivity and specificity of a CXR as a way to diagnose pneumonia in children is too poor to justify using radiation when the diagnosis should be made clinically.

[The BTS guidelines for community acquired pneumonia in children](#) and the Clinical Practice Guidelines by the Pediatric Infectious Diseases Society and the Infectious Diseases Society of America both recommend that CXR is routinely avoided.

Special circumstances where a CXR should be considered include:

### **Small infants and babies**

This age group tend to have a higher probability of serious bacterial infection whenever they present.

### **The child with complex medical problems**

They may not demonstrate abnormal breathing or unwellness in the way that normal children do.

### **Chronic symptoms in a child that does not appear unwell, red flags (such as weight loss), known exposure to Tuberculosis**

Daily cough for several weeks should be taken seriously. Underlying causes including bronchiectasis and simply unresolved LRTI may need to be ruled out in which case referral will be necessary. **Unilateral findings** to evaluate for a foreign body.

Chest radiography should also be done when a child fails to improve clinically after 48-72 hours of appropriate antibiotic therapy, in patients with severe or unexplained respiratory distress, and those who require hospitalisation.

### **Severity assessment to direct treatment**

A clinical examination cannot distinguish between a viral or bacterial pneumonia, neither can a CXR. More important than distinguishing whether a pneumonia is viral or bacterial is to adopt a severity-based approach to guide your treatment. Even if mild to moderate disease is caused by bacteria, these infections still resolve on their own and antibiotics make little to no difference anyway.

There is no single validated severity scoring system to identify children at risk from a severe infection. A global assessment of clinical severity and risk factors is crucial in identifying the child likely to require hospital admission.

One key indication for admission to hospital is hypoxaemia.

[British Thoracic Society Guidelines](#)' features of severe disease in an infant and

older child include oxygen saturations < 92% together with other features of abnormal breathing listed below.

**Table 6** Severity assessment

	<b>Mild to moderate</b>	<b>Severe</b>
<b>Infants</b>	Temperature <38.5°C Respiratory rate <50 breaths/min Mild recession Taking full feeds	Temperature >38.5°C Respiratory rate >70 breaths/min Moderate to severe recession Nasal flaring Cyanosis Intermittent apnoea Grunting respiration Not feeding Tachycardia* Capillary refill time ≥2 s
<b>Older children</b>	Temperature <38.5°C Respiratory rate <50 breaths/min Mild breathlessness No vomiting	Temperature >38.5°C Respiratory rate >50 breaths/min Severe difficulty in breathing Nasal flaring Cyanosis Grunting respiration Signs of dehydration Tachycardia* Capillary refill time ≥2 s

\*Values to define tachycardia vary with age and with temperature.<sup>67[III]</sup>

Bringing all these things together shows that there are two key features. The first of these is abnormal breathing in the context of an unwell child with cough. The presence of abnormal breathing almost immediately makes it likely that the problem is LRTI, bronchiolitis or viral wheeze. If there is a wheeze, this largely rules out LRTI. It's almost that simple.

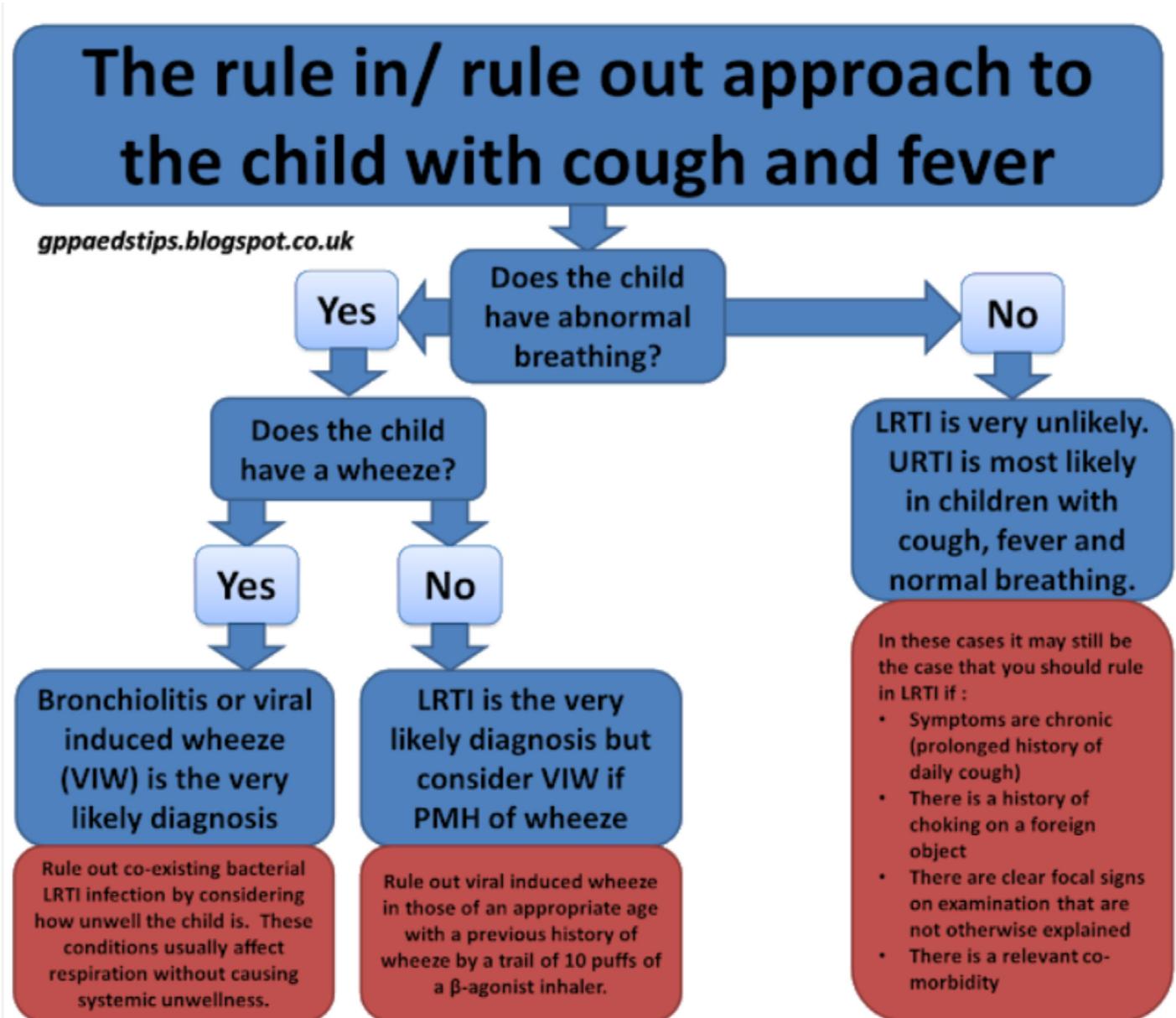


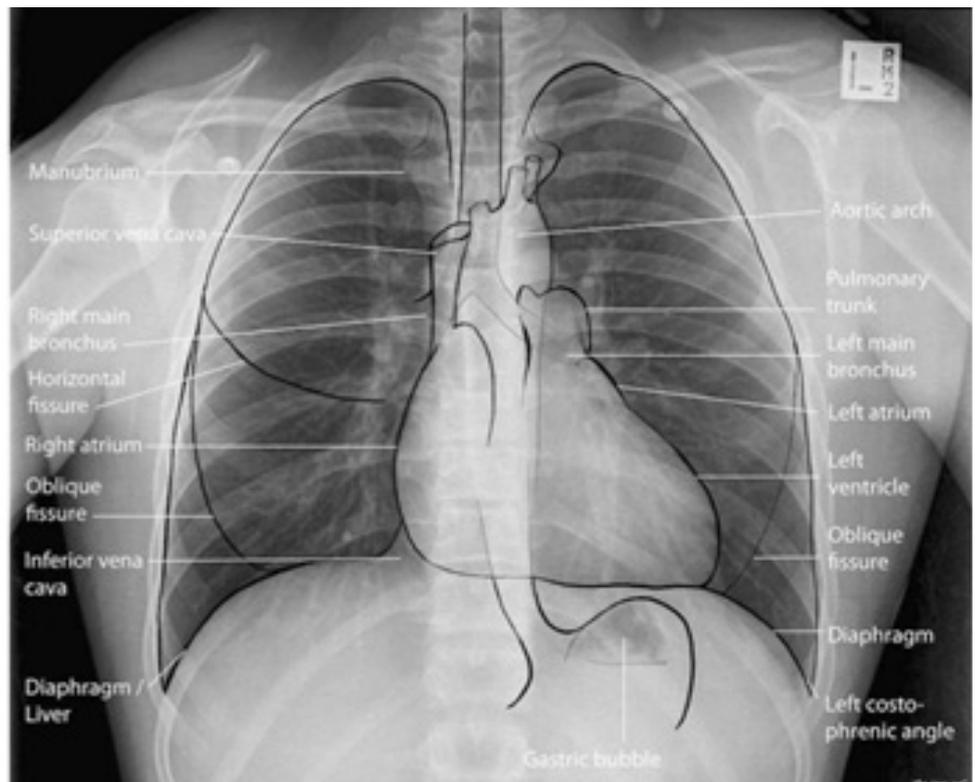
Image courtesy of [gppaedstips.blogspot.co.uk](http://gppaedstips.blogspot.co.uk)

## Safety-netting advice is key.

For the majority of encounters, parents bring their child to medical attention because they are uncertain as to the severity of their child's illness, and they are frightened. Not because they seek antibiotics. [DFTB](#) lists reassurance steps to take in your discussion:

- Acknowledge their child feels poorly.
- Acknowledge this is difficult for their child, and for them as parents.
- Reassure them their child is safe, and there are no 'red flags'; – remember what we consider severe (physiological derangement) is not the same as parents (behavioural impact).
- Explain that medical treatment is supportive and offer symptom management.
- If you need to, confirm antibiotics are neither necessary nor helpful, as it will not speed up recovery and only expose the child to unnecessary risk.
- Most importantly – provide illness specific information and [safety net advice](#) (ideally written information/leaflet).

Normal CXR  
for your reference



[Life in the Fast Lane – Paediatric CXR](#) (some of the CXR start with CT images)

## CASE SCENARIO 2: MYCOPLASMA PNEUMONIA

Martin is an 8-year-old fit and healthy young boy who was brought in by his dad with three days of fever, a dry cough, shortness of breath, and abdominal pain, initially seen by the GP and started on amoxicillin. Today he was sent home from school because of breathing difficulties. On assessment Martin is lying in bed, alert with a tracheal tug, use of accessory muscles, a respiratory rate of 37 breaths per minute, and oxygen saturations of 89% in room air. You also note that Martin has a rash on his lower legs.

**Why is Martin not improving on appropriate antibiotics?**

**How should Martin be investigated and managed?**

**Discussion points:**

- **When a child with pneumonia fails to respond to initial therapy**
- **Severe Mycoplasma pneumonia**

**Why is this pneumonia not getting better?**

**Perhaps it's a viral pneumonia**

One could consider whether antibiotics were appropriate in the first place. Martin could be dealing with a viral infection, which could explain why there is no change in symptoms. Inappropriate antibiotic prescribing drives antibiotic resistance and drives future medicalised health behaviour.

**Perhaps it's the wrong antibiotics**

NICE recommends amoxicillin as the first choice of oral antibiotic for a low severity pneumonia in children and adults less than 18 years of age and high dose oral amoxicillin (30mg/kg TDS) is as effective as IV benzylpenicillin.

Is Martin allergic to penicillin? Perhaps the amoxicillin has caused the rash and worsening respiratory symptoms, so amoxicillin should be discontinued immediately and replaced with a macrolide. NICE recommends doxycycline or clarithromycin in penicillin allergy.

**Perhaps it is the wrong diagnosis**

Here we come to the crux of any child that fails to respond to initial treatment: always go back to the drawing board. Retake a detailed history and do a thorough examination. Draw out any red flags, allergies, previous medical history, a significant family history. On examination it is clear that Martin has a severe pneumonia –

he is hypoxic with obvious work of breathing and will require oxygen therapy, further work up and admission.

### What other differentials would one think about?

Pneumonia can occur at any age but tends to occur in younger children and become less common as they get older.

In neonates respiratory distress can be a sign of underlying pathology and such things as congenital abnormalities, laryngeal injury, pulmonary haemorrhage/ birth trauma and these must be considered in the differential.

In older children respiratory distress can be present in asthma, bronchiolitis, chronic anaemia, cystic fibrosis, heart disease, haematological malignancies and even foreign body inhalation.

Also important to consider whether this is a complicated pneumonia (pneumothorax, effusion, empyema) or sepsis.

Some differentials are demonstrated below

Sign/History	Differential	Investigation
Sudden onset or precipitating trigger of dust/hay/animal	Allergy or anaphylaxis Acute exacerbation of asthma Trigger/sudden onset more likely asthma/ anaphylaxis than pneumonia	If anaphylaxis then IgE levels Peak flow in Asthma pre and post bronchodilators, response and improvement- more likely asthma over pneumonia
Nocturnal cough or sx of cough and SOB when well (interval symptoms)	Undiagnosed or under treated asthma	Peak flow
Fatigue, easy bruising, pallor	Anaemia, leukemia	Full blood count with film- low Hb, high WBC or pancytopenia
Failure to thrive in neonate/infant	Cystic fibrosis	Sweat test and specialist referral

Sweat test and specialist referral	Congenital cardiac defect	ECG, CXR, echocardiogram and specialist referral
Hx of sickle cell disease	Acute chest crisis	Severe chest pain and bilateral CXR changes, pain in regions outside of chest, or previous presentations
History of choking, unilateral chest signs	Foreign body inhalation	CXR, bronchoscopy and specialist referral
Previous streptococcal infection, fever, erythema marginatum, carditis	Rheumatic fever	ESR, WCC, Blood Culture, ECG, echocardiogram, antibiotics
Immunocompromised (primary immunodeficiency, HIV)	Fungal pneumonia, tuberculosis (if exposure to known contact)	Antifungals and anti-tuberculous therapy and specialist referral to Infectious Diseases.

Martin has deteriorated over the 3 days so bacterial infection is more likely, as most 8year old boys will tolerate a viral URTI without deterioration. When a child fails to respond to initial treatment it is important to consider differentials, complications and in this case atypical pneumonias.

### **What is atypical pneumonia?**

Pneumonias have a variety of classifications, such as community acquired pneumonia (CAP), aspiration pneumonia, hospital acquired pneumonia, and pneumonia classified by age group or causative pathogen.

Atypical pneumonia refers predominantly to an uncommon pathogen causing pneumonia. Below is a classification of pneumonia typical for certain age groups of children.

# Etiology

AGE GROUP	FREQUENT PATHOGENS (IN ORDER OF FREQUENCY)
Neonates (<3 wk)	Group B streptococcus, Escherichia coli, other gram-negative bacilli, Streptococcus pneumoniae, Haemophilus influenzae (type b,* nontypable)
3 wk-3 mo	Respiratory syncytial virus, other respiratory viruses (parainfluenza viruses, influenza viruses, adenovirus), S. pneumoniae, H. influenzae (type b,* nontypable); if patient is afebrile, consider Chlamydia trachomatis
4 mo-4 yr	Respiratory syncytial virus, other respiratory viruses (parainfluenza viruses, influenza viruses, adenovirus), S. pneumoniae, H. influenzae (type b,* nontypable), Mycoplasma pneumoniae, group A streptococcus
≥5 yr	M. pneumoniae, S. pneumoniae, Chlamydia pneumoniae, H. influenzae (type b,* nontypable), influenza viruses, adenovirus, other respiratory viruses, Legionella pneumophila

Image courtesy of slideshare

<https://www.slideshare.net/azadhaleem/pneumonia-in-children-55490255>

Respiratory tract problems, cough and fever, are the most common presentations to the Paediatric Emergency Department (PED). Most of these children do not have pneumonia, and most who do have pneumonia can be discharged from the PED with oral antibiotics and careful safety netting.

Refer children under the age of 1 year, if they have comorbidities (i.e. immunodeficiency, cardiac disease), poor oral intake or urine output and most certainly if there is laboured breathing, hypoxaemia and signs of sepsis. RCEMLearning has a simplified (and useful) summary of how to differentiate the common respiratory problems in PED.

Condition	Fever	Unwell	Recession/ tachypnoea	Usual age range*	Cough	Wheeze
Viral URTI	Yes	With fever only	No	Any but uncommon under 3/12	Dry or productive	No
Bronchiolitis	Usually low grade	Only if severe	Yes	Birth -12 months	High pitched	Yes
Viral Wheeze	Usually low grade	No	Yes	1-7 years	Tight	Yes
Asthma	No	No	Yes	Over 5 yrs old	Yes	Yes
Croup	Usually low grade	Only if severe	If moderate	6 months to 6 years	Barking	No (may have stridor)
Pneumonia	Yes	Yes	Yes	Any age	Variable	No

[RCEMLearning](#): Coughing, Wheezy and Stridulous children

There is also fungal pneumonia which in addition to common bacterial and viral pathogens are considered uncommon and opportunistic microorganisms in a 'poly-microbial mix' seen mainly in immunocompromised children such as in HIV-exposed or infected children. Pneumocystis jiroveci (PJP) is a common fungal infection of the lung in immunocompromised infants from 2-6 months of age. They present with an acute onset of respiratory distress, minimal/absent chest signs in a child who is HIV exposed or infected. Hypoxaemia and cyanosis are common features in severe disease and CXR shows a range of abnormalities including bilateral perihilar interstitial changes.

Perinatally acquired cytomegalovirus associated pneumonia in HIV infected infants presents as an interstitial pneumonitis with acute hypoxic respiratory failure and tuberculosis in HIV infected children occurs at all ages. The diagnosis is difficult to confirm, one needs to have a high index of suspicion if exposure to a contact has been elicited from the history and a Mantoux test of  $\geq 5$ mm induration is indicative of tuberculosis disease.

Those children with chronic lung diseases such as in immunocompromised children or those with cystic fibrosis (CF) are typically colonised with uncommon organisms such as Pseudomonas aeruginosa and Klebsiella pneumoniae.

## What is *Mycoplasma pneumoniae*? (DFTB: Mire of *Mycoplasma*)

*Mycoplasmas* are distinguished from other bacteria by their lack of a cell wall, which has implications for its treatment – as most antibiotic classes, which act on the cell wall, will be ineffective in treating *Mycoplasma* species. While LRTI decreases with age, the prevalence of atypical infections increases, with a median age of about 7. They most commonly present with respiratory symptoms such as pneumonia, however they also have a range of extrapulmonary symptoms. CXR manifestations in this group are also wide and varied as are laboratory findings. Some CXR features can involve reticulonodular patterns confined to one lobe, segmental and lobar consolidations, or diffuse interstitial and bilateral perihilar peribronchial patterns. Below is an example of left lower lobe consolidation complicated by a pleural effusion in a patient with confirmed *Mycoplasma pneumoniae*.



Image courtesy of paper titled 'Increased risk of refractory *Mycoplasma pneumoniae* pneumonia in children with atopic sensitization and asthma'

<https://doi.org/10.3345/kjp.2014.57.6.271>

Atypical pneumonias, such as those caused by mycoplasma, are generally treated with oral macrolides, fluoroquinolones or tetracycline.

There is no need to target extrapulmonary symptoms such as in this case, as it is likely immune mediated but supportive therapy may be considered.

Skin manifestations are the most common of the extra-pulmonary manifestations and range from erythema nodosum (as depicted in the diagram) to Stevens-Johnson Syndrome. These are raised and tender nodules. Part of Martin's management should include adequate analgesia not only for erythema nodosum but also for his referred abdominal pain.



### **When to admit?**

When considering admission there is no one clinical factor for admission, it is based on a combination of clinical signs, but most importantly on severity of pneumonia. Compliance with medication and parental anxiety can be a valid reason.

Admission does not necessarily need to mean further investigation and can be trial of PO antibiotics in hospital, switching to IV/ambulatory IV if a trial of oral is not tolerated, and importantly supporting the parents.

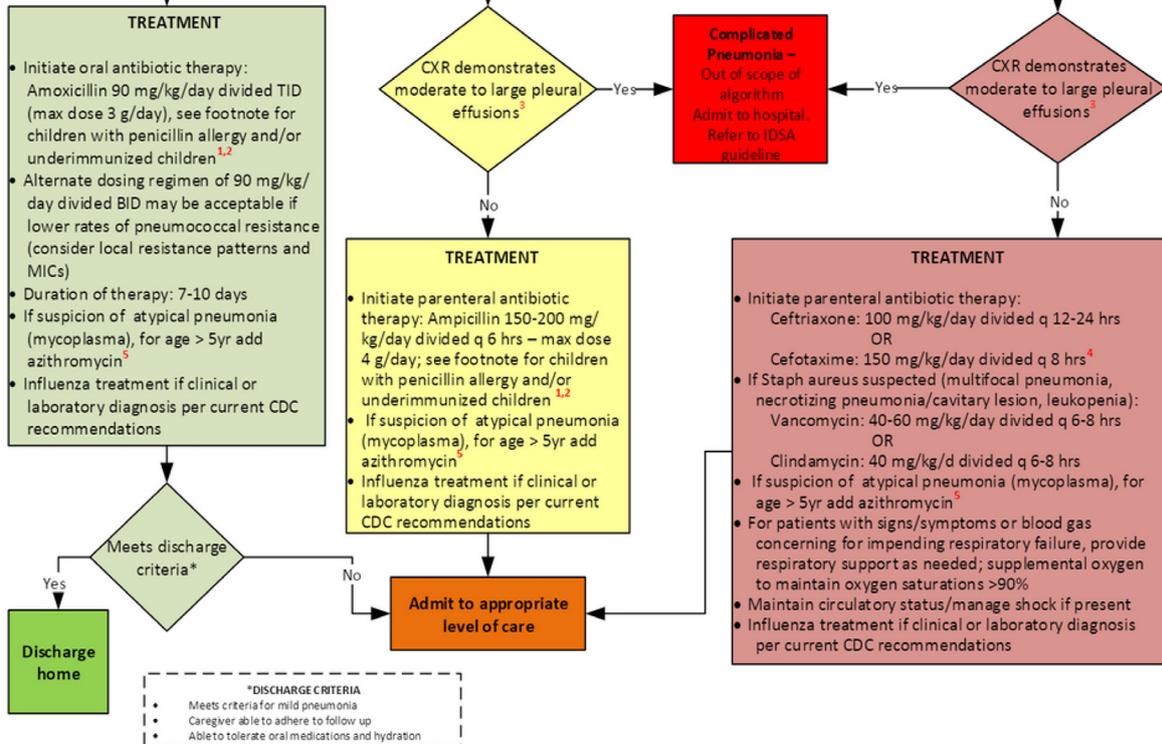
# EmDocs: Paediatric Pneumonia Management Algorithm

## AAP Section on Emergency Medicine Committee on Quality Transformation Clinical Algorithm for Emergency Department Evaluation and Management of Pediatric Community Acquired Pneumonia

<b>Overview</b>	
Definition of community acquired pneumonia (CAP) is complicated by lack of gold standard as clinical and radiographic findings may be discordant. This algorithm applies to children whom the clinician has diagnosed uncomplicated CAP by clinical or imaging findings. Base antibiotic choice and dosing on local resistance patterns and MICs of prevalent bacterial organisms causing pneumonia ( <i>S. pneumoniae</i> , Group A <i>Streptococcus</i> , <i>S. aureus</i> , <i>H. influenzae</i> , <i>M. pneumoniae</i> , <i>C. pneumoniae</i> ). This algorithm was developed through the efforts of the American Academy of Pediatrics Section on Emergency Medicine in the interest of advancing pediatric healthcare. Ultimately, the patient's physician must determine the most appropriate care.	
<b>Scope</b>	Emergency Department (ED) Setting
<b>Includes</b>	Patients 3-months to 18-years of age with community acquired pneumonia (include patients with asthma or reactive airways disease)
<b>Excludes</b>	Immunocompromised, tracheostomy/ventilator dependent, or children with chronic conditions such as cystic fibrosis Suspected hospital-acquired pneumonia or aspiration pneumonia

Assessment			
	MILD (meets ALL criteria below)	MODERATE (meets ANY criteria below)	SEVERE (meets ANY criteria below)
<b>Oxygenation</b>	Oxygen saturation $\geq 90\%$ on room air	Oxygen saturation persistently $< 90\%$ on room air	Oxygen saturation $\leq 92\%$ despite supplemental oxygen on 50% FiO <sub>2</sub> ; apnea, bradypnea or hypercarbia
<b>Work of Breathing</b>	None or minimal (i.e., no grunting, flaring, retractions, apnea)	Increased /moderate respiratory distress (i.e., grunting, retractions, nasal flaring)	Need for mechanical ventilation or non-invasive positive pressure ventilation; severe respiratory distress or concern for impending respiratory failure
<b>Hydration</b>	Able to tolerate fluids and medication	Signs of dehydration; persistent vomiting; inability to take oral medications	Systemic signs of inadequate perfusion, including fluid refractory shock, hypotension, sustained tachycardia, need for pharmacologic support of blood pressure or perfusion
<b>Appearance</b>	Not significantly ill or toxic appearing	Ill-appearing	Toxic or septic appearing and/or altered mental status

Diagnostics			
	MILD	MODERATE	SEVERE
<b>Labs</b>	CBC and inflammatory markers NOT routinely indicated	CBC and inflammatory markers NOT routinely indicated	Obtain CBC/differential Consider inflammatory markers (ESR, CRP), lactate, VBG, and BMP
<b>Cultures</b>	Blood cultures NOT routinely indicated	Blood culture NOT routinely indicated unless complicated pneumonia or underimmunized child	Obtain blood and sputum culture (if able to expectorate)
<b>Imaging</b>	Not routinely indicated; consider CXR in those with diagnostic uncertainty or concern for complications.	Obtain AP and lateral chest x-ray; consider bedside ultrasound as adjunct diagnostic tool if ultrasound credentialed provider is present.	Obtain AP and lateral chest x-ray; consider bedside ultrasound as adjunct diagnostic tool if ultrasound credentialed provider is present.
<b>Viral testing</b>	Influenza treatment if clinical or laboratory diagnosis per current CDC recommendations- <a href="http://www.cdc.gov/flu/professionals/">www.cdc.gov/flu/professionals/</a>		



**Footnotes:**

- 1 - If penicillin allergy, administer cephalosporin (oral cefpodoxime, cefuroxime, or cefprozil; parenteral ceftriaxone or cefotaxime)  
If severe penicillin allergy: oral levofloxacin (16-20 mg/kg/day divided q 12 hr (age 6 mos- 5 yrs) or 8-10 mg/kg/day (age 5-16 yrs) once daily (max daily dose 750 mg); clindamycin (40 mg/kg/day divided q 8 hr- max dose 600 mg), or linezolid
- 2 - In underimmunized children: oral amoxicillin-clavulanate or parenteral 3rd generation cephalosporin (ceftriaxone, cefotaxime)
- 3 - Effusion  $> 10$  mm rim or  $> 1/4$  hemi-thorax opacified
- 4 - If severe penicillin allergy: Levofloxacin OR Clindamycin OR Linezolid
- 5 - Azithromycin: IV--10 mg/kg (max dose 500 mg) day 1 and 2, then transition to oral; Oral--10 mg/kg (max dose 500 mg) once on day 1, then 5 mg/kg (max dose 250 mg) once daily on days 2-5

Individual risk factors for the child e.g prematurity, immunocompromise, congenital abnormalities or previous complications from CAP must also be considered. Children who are ex-premature may have chronic lung disease of the newborn and are likely to be more susceptible to severe pneumonias and infections. The same applies for children with congenital abnormalities and immunocompromised.

It can also be secondary to chemotherapy or as a result of HIV. Being immunocompromised may mean they are more likely to require IV antibiotics or a longer period of observation.

Martin has severe mycoplasma pneumonia and requires humidified high flow nasal cannula oxygen (HHNC) therapy to start. He also needs a CXR, so we can make sure we are not dealing with a complicated pneumonia.

It's probably advisable to get intravenous access in case of further deterioration and a set of baseline bloods (FBC, CEU) and a baseline blood gas to determine how well (or poorly) Martin is oxygenating (PaO<sub>2</sub>). Septic markers are controversial here as they would probably not change the initial management in the paediatric emergency department but seeing that Martin is unwell and needing admission, it would be reasonable in this situation to do a CRP and/or procalcitonin (PCT). If tolerating oral medication, he would continue on oral Azithromycin.

Mycoplasma pneumonia's are usually diagnosed retrospectively so depending on local guidelines a viral pharyngeal polymerase chain reaction (PCR) swab or sputum and/or antibody test to Mycoplasma pneumonia can be done. Martin is admitted to the Paediatric high care isolation ward and PICU is also made aware of Martin's condition.

## ADVANCED CASE SCENARIO 1: SEVERE PNEUMONIA MANAGEMENT

Mimi is well known to the department. She has Trisomy 21 and had her VSD repaired at 3 months of age. She is now 10 months old and is brought in with a 2 day history of coryzal symptoms, cough and fever. Today her parents have noticed fast breathing, she is much more lethargic and off food. She is normally a very bright bubbly child. On examination Mimi is tiring, she is cyanosed with oxygen saturations of 82%.

**Which patients are at increased risk of a severe pneumonia?**

**Should we CPAP 'trial' or immediately intubate?**

### **At risk groups**

As previously discussed children with other comorbidities or congenital abnormalities are at increased risk of lower respiratory tract infection and complications.

Those with underlying or previous cardiac abnormalities can deteriorate more rapidly with fewer precipitating symptoms.

Similarly, ex-premature infants are at increased risk of severe pneumonia's (typically RSV pneumonia) and remember the child with complex medical problems may not demonstrate severe clinical signs as would a normal child. One should always have a low threshold for investigating further.

### **CPAP trial vs intubation**

Recognising the child at risk and the deteriorating child early means appropriate early intervention and escalation of care, but sometimes there isn't the time and a child may need an emergent intubation

It is important to recognise when a child is deteriorating by looking at response to treatments given, work of breathing, RR, SPO<sub>2</sub> and general appearance.

In the hypoxic child the simple administration of oxygen may not always be sufficient. This is where continuous positive airway pressure (CPAP) which delivers constant positive end expiratory pressure (PEEP). Normally a mask or nasal prongs are sealed against the nostrils and are connected to a pressure generator and an airflow source. Options are where the mask is connected to a mechanical

ventilator, which provides airflow and PEEP. Alternatively an oxygen concentrator or cylinder provides airflow, and the depth of expiratory tubing within a fluid reservoir generates PEEP and this is referred to as bubble CPAP (bCPAP).

There are several studies looking at CPAP particularly in low resource settings and if it reduces mortality in childhood pneumonia. The difficulty in low resource settings (or indeed a small DGH) is access to equipment and a balance of providing highly concentrated/pressurised O<sub>2</sub> to a small number of children vs being able to provide low flow to several. Hopefully this is a highly unlikely scenario but was what was recognised in some of the studies conducted to very rural areas.

Generally the studies suggested that CPAP reduced respiratory distress and improved oxygenation, but rate of mortality was unchanged particularly with associated comorbidities.

<https://onlinelibrary.wiley.com/doi/full/10.1111/apa.14796>

CPAP is useful particularly for respiratory distress regardless of SPO<sub>2</sub> and is often better tolerated than a face mask as the nasal prongs are less intrusive and the humidified oxygen less distressing. It can eliminate the need for intubation and along with distraction technique calm a child down. However some models you cannot transfer on easily and this need to be taken into consideration when setting it up (e.g if they are in ED and not a ward)

If a child does not respond to CPAP then the next definitive step is to perform an emergency intubation, or a rapid sequence induction.

If the child is in respiratory failure then it may be that intubation is the first step. CPAP is only indicated as a method of pre oxygenation if pre oxygenation is not possible via normal face-mask (but this will take time to set up and may delay intubation)

This [podcast discusses](#) some different situations and nuances around RSI

Any child who you are considering CPAP/RSI should have a PICU involvement as this is the area they will need to be transferred to after the interventions. Ideally PICU should be present at the time of intubation or a paediatric anaesthetist as these will be the best placed clinician to intubate and with a child in respiratory distress the goal is to secure the airway and provide adequate oxygenation as quickly and safely as possible.

## ADVANCED CASE SCENARIO 2: PNEUMONIA COMPLICATED BY EMPYEMA

A 4yr child, Hannah was diagnosed with pneumonia and admitted to the children wards on oxygen and commenced on IV antibiotics. After 48hr of initial therapy her oxygen requirements have increased, and she is still spiking fevers. You have been called to review Hannah as the nursing staff are concerned that she is febrile again despite paracetamol. Her initial CXR showed a dense left lower lobe consolidation.

**Would you repeat a Chest xray? Or are their alternative investigations? Hannah has developed an empyema. Discuss your approach to inserting a chest drain.**

### **POCUS in Pneumonia**

Point of care ultrasound is becoming an increasingly utilised tool for clinicians in the emergency field, by specialist and emergency physicians. Several studies have started looking to lung ultrasound for diagnosing pneumonia and this has been expanded into the paediatric cohort.

Several studies have now shown that lung ultrasound (LUS) is as sensitive in diagnosing pneumonia as CXR. However it is noted that this may be user and locality dependent, e.g. clinicians on shift being able to perform and interpret USS, or having access to this modality out of hours.

[One meta analysis](#) comparing LUS vs CXR showed that LUS had a sensitivity of 95.5% and specificity of 95.3% whereas CXR had a sensitivity of 86.8% and specificity of 98.2%. We know that CXR is currently the gold standard Yet some [studies](#) have demonstrated LUS may pick up even smaller areas of consolidation that can be missed on CXR. Ultrasound is something that is being used more and more and can be readily taught to physicians to achieve basic competence. Utilising US provides rapid insight into the pathology of the lungs and can identify, monitor and assess changes at regular intervals without the need for repeated CXR. It may be easier to have access to an USS rather than a CXR especially in a critical emergency.

However if LUS is not immediately available then CXR should not be delayed if indicated.

If a child has not responded to Abx after 48hr then the clinician must think why and assess what has changed. The incidence of parapneumonic effusion and empyema in children is 3.3 per 100 000 children. If effusion is suspected on CXR then an US must be used to confirm the presence of fluid.

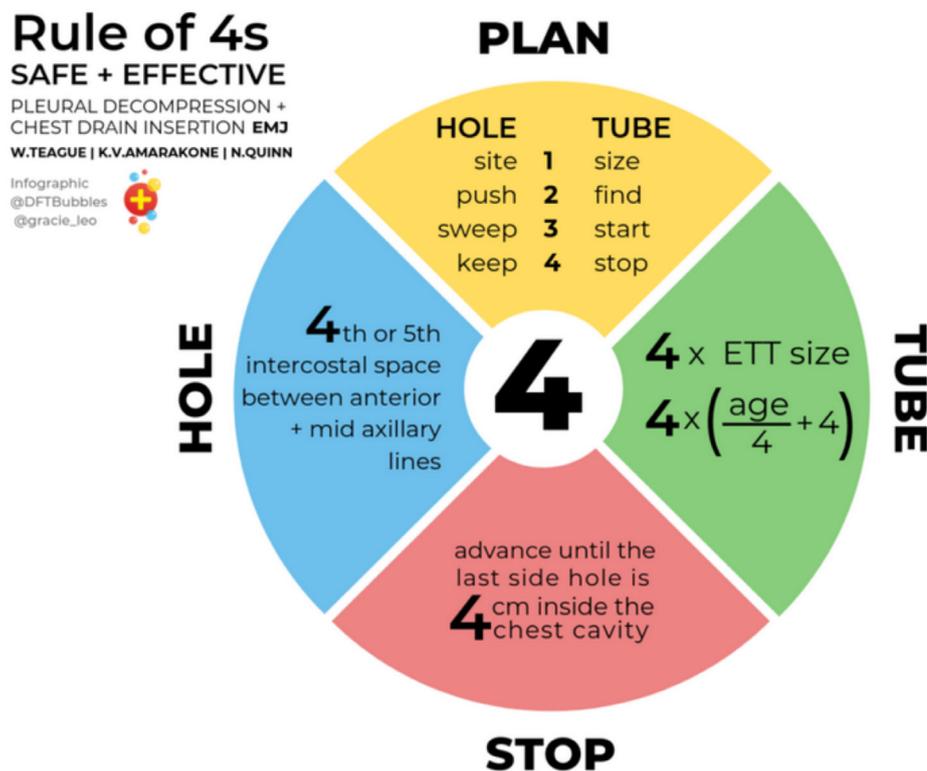
All children with effusion/empyema must be admitted for IV antibiotics.

### **What next?**

If confirmed on LUS then a CT scan with contrast enhancement can be used as a definitive investigation. Effusions that are enlarging or causing respiratory embarrassment should be considered for invasive intervention. Conservative management alone can be appropriate but can prolong the overall hospital admission. As per the [British Thoracic Society \(BTS\) guidelines for the management of pleural infection in children](#) a chest drain should be considered and placed by an appropriately trained member of staff and with the aid of LUS.

Repeated aspirations are not recommended as they are less efficacious, and more likely to cause distress and involve repeated invasion into the pleural cavity. Whereas an appropriately placed drain (and not necessarily the biggest!) when inserted under appropriate procedural sedation (or GA) can shorten the illness and resolve the effusion faster. Different types of chest drain are available; one small study compared pigtail with large bore surgical drains and found no significant difference in outcome, but did find that the smaller pigtail drains were better tolerated. If a child has a complicating fibrinopurulent empyema then the drain can also be used to administer intrapleural fibrinolytics e.g. urokinase. This can also allow continued drainage with reduced risk of purulent blockage, and help re-establish normal pleural flow.

## Inserting the chest drain- [DFTB rule of 4s](#)



### Then when to remove/ when to clamp?

Clamp the drain for 1 hour once 10 ml/kg are initially removed.

Remove the drain when they no longer swing/bubble and LUS shows resolution of effusion/empyema and importantly the child is clinically improving.

However if the drain stops swinging- check why, has the effusion been drained or has the tube become kinked or blocked, attempts at repositioning or flushing the drain should be undertaken and assessment of the clinical picture.

If the effusion has not drained or the child has not improved then it would be appropriate to refer to the paediatric surgeons for consideration of a replacement drain or potentially a VATS procedure if a particular viscous or loculated effusion remains.

Removal of drains should be based on resolution of effusions and clinical improvement. Antibiotics should be continued for 1-4 weeks after removal, all children should have routine follow up and underlying comorbidities should be considered e.g undiagnosed CF, immunocompromise, malignancy.

Even with effusion/empyema most children should recover without any long-term complications of adverse reduction in lung function.

## SIMULATION (30-60 MINS)

### [Optimus Bonus Simulation Package PDF](#) – Paediatric sepsis

This simulation focuses on management of sepsis so would follow on from recognising complications or deteriorations in children with LRTI, recognising shock and when to escalate care.

## QUIZ QUESTIONS (10-15 MINS)

A 5yr is brought in with 3day history of fever, lethargy and complaints of left sided abdominal pain. Normally fit and well, immunisations are up to date and they attend school. In triage he is noted to have subcostal and intercostal recession, with SpO<sub>2</sub> of 90% in air, the triage nurse moves him to a bay and asks for your urgent review.

### Question 1.

**What on examination/initial investigation would make the diagnosis of pneumonia more likely?**

- A - Fever and cough
- B - Low sats and fever
- C - Focal crackles on chest auscultation
- D - Hypoxaemia and increased work of breathing**
- E - Coryzal and increased work of breathing

### Answer D

Hypoxaemia and increased work of breathing were most clinically significant in diagnosis of pneumonia. Chest signs can be misleading and it is often difficult to tell upper airway noises from focal signs. Even viral pneumonias can lead to focal signs on auscultation and on chest x-ray. Upper airway noises can be distinguished as they tend to change on positioning/after coughing as upper airway secretions move and are expelled whereas focal signs will be less affected by this. A viral pneumonia may have a history of coryzal symptoms and would be similar to that of bronchiolitis

## Question 2.

On examination the child has consistently reduced air entry at the right, persistently low sats of 91%. CXR shows a right lower lobe pneumonia.

**What is the most likely causative pathogen?**

**A - Streptococcus Pneumoniae**

**B - Staphylococcus aureus**

**C - Haemophilus influenza (type B)**

**D - Mycoplasma pneumonia**

**E - Respiratory Syncytial Virus (RSV)**

### Answer A

The infective agents that commonly cause pneumonia will vary by age. Pathogens will vary from neonates, to infants to preschool to school age children, think of the vaccination schedule, maternal swabs in pregnancy and maternal fever in labour and atypical pathogens in immunocompromised children. Remember atypical e.g. mycoplasma's become more common in the older child. Haemophilus influenza B- rates overall reduced due to vaccinations

### Question 3.

You insert an IV cannula and take bloods. Results show a white cell count of  $24.3 \times 10^9/L$  (with neutrophils 92%), a CRP 283 mg/L and a sodium (Na) 126 mmol/L. The rest of his full blood count and renal function are normal.

**Which of the following is the most likely cause for his hyponatraemia?**

- A - Low sodium intake
- B - Increased renal excretion
- C - Hyponatraemic dehydration
- D - Increased sodium dilution**
- E - High sweat sodium concentrations

#### Answer D

Hyponatremia has frequently been ascribed to the syndrome of inappropriate antidiuretic hormone (SIADH) in the past, but the existence of this entity in children with pneumonia is now being questioned. SIADH leads to hyponatremia by increasing the total body water causing a dilutional effect.

## Take home tips

- 1** Pneumonia can present in a number of ways but abnormal signs of breathing, fever and low saturation would make a pneumonia more likely
- 2** There are no absolute rules about when to do a Chest X-ray – consider doing it in infants, those with complex medical backgrounds and those with chronic symptoms.
- 3** A clinical examination cannot distinguish between a viral or bacterial pneumonia, neither can a CXR. Use a severity assessment to direct your treatment.
- 4** Consider using POCUS over CXR if the resource and technicians are available- it can give a more sensitive result without Xray exposure
- 5** If there is no response to antibiotics after 48hours consider development of an effusion or empyema. If continued deterioration then a trial of CPAP/PICU may be required

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 fellows@dontforgetthebubbles.com