

An approach to the child in respiratory distress

Jeena PM, MBChB, FCPaed(SA)

Department of Paediatrics and Child Health, University of KwaZulu-Natal, Durban, South Africa

Correspondence to: Prof Prakash M Jeena, e-mail: jeena@ukzn.ac.za

Abstract

Respiratory distress (RD), a term utilised to summate a conglomeration of clinical features, including tachypnoea, use of accessory muscles of respiratory, lower chest wall indrawing, grunting, hypoxaemia and cyanosis, is useful in determining severity of illness in childhood. While these features commonly reflect pathology in the respiratory system, a condition accounting for the vast majority of the 10.8 million under-five childhood deaths occurring globally each year, dysfunction in other organ systems may also present with features of respiratory distress. The World Health Organization (WHO) has utilised some of these clinical findings to classify the severity of pneumonia and to advocate management under its programme of integrated management of childhood illness. The WHO has identified the following three essential steps that would help reduce mortality from pneumonia: (1) recognition of a sick child, (2) appropriate seeking of care, and (3) management of the underlying condition. Despite the WHO's acknowledgement that appropriate implementation of these steps would have a significant impact on reaching the target of Millennium Development Goal 4 (a two-thirds reduction in the global under-five mortality rates between 1990 and 2015), only about one in five health caregivers knows the danger signs of severe respiratory distress, inappropriate behaviour in seeking care is often seen in the impoverished, poorly educated communities, and effective interventions are inconsistently applied.

 This article has been peer reviewed. Full text available at www.safpj.co.za

SA Fam Pract 2008;50(3):32-37

Introduction

Respiratory distress is the term utilised to denote a composition of clinical features that reflects ill health. The term was coined primarily to describe varying degrees of ill health in the respiratory system due to high morbidity and mortality from these conditions. For every four to nine episodes of acute respiratory infection per child occurring in developing countries, one-fifth results in a lower respiratory tract infection that causes between 11 and 20 million hospitalisations and 2 million childhood deaths globally each year.^{1,2} The lastmentioned statistic represents 20% of the 10.8 million under-five childhood deaths occurring globally each year.² These data do not take into consideration deaths occurring in the neonatal period, in which 26% of all neonatal deaths are related to severe infections.³

Pneumonia, the commonest of these respiratory diseases, kills more children than the combined total of those dying from AIDS, malaria and measles. The clinical features utilised to describe respiratory distress are however of a protean nature and also reflect ill health within other body systems. Cardiac abnormalities such as shock; metabolic abnormalities such as acute diarrhoea, acute renal dysfunction, drug toxicity and diabetes mellitus; infectious conditions such as sepsis and urinary tract infections; and neurological conditions such as meningitis, brain stem insults-infarcts, haemorrhage and infection may present with clinical manifestations described as respiratory distress. Consequently, these features in isolation or combination are utilised as an entry point for the common conditions in the integrated management of childhood illnesses such as diarrhoea, malaria, and HIV disease.

Definition of respiratory distress

The principle features of the respiratory distress syndrome (RDS) are:

- 1. Tachypnoea:** The respiratory rate is the most reliable of the clinical features in denoting respiratory ill health. It is measured in a restful state and has a sensitivity of 62–81% and specificity of 54–70% for pneumonia.^{4–7} Rates of > 60 breaths/min, > 50 breaths/min and > 40 breaths/min for young infants (0–59 days), infants (60–365 days) and childhood (1–5 years) are regarded as being symptomatic of tachypnoea. The higher the respiratory rate above the cutoff rate, the greater the degree of respiratory distress, i.e. up to 10 above the cutoff threshold is regarded as mild, up to 30 above the cutoff threshold is regarded as moderate RDS and > 30 above the cutoff value is regarded as severe RDS.^{7–9} It must, however, be noted that young infants often respond to ill health with apnoea and hence care must be taken with evaluation of the respiratory rate at this age.¹⁰
- 2. Use of accessory muscles for respiration:** Features include use of sternocleidomastoid muscles, nasal alar flare and tracheal tug. These features are more frequently seen in children with upper airway disease – due to intraluminal, intramural and/or extraluminal upper airway obstruction, e.g. by a foreign body.
- 3. Use of intercostal or subcostal muscles** for respiration resulting in intercostal or subcostal recession – lower chest wall indrawing. These features suggest lower airway pathology and in the long term result in a Harrison's sulcus.

4. **Hypoxaemia:** This is measured by a low oxygen saturation of < 90%. This feature is affected by altitude but for all areas in South Africa a cutoff of < 90% saturation is pathological and requires supplementary oxygen therapy. It should be noted that this feature is affected by haemoglobin concentration, degree of acidosis, temperature, and 2,3 DPG, and correction of these factors are essential for optimising the oxygen-carrying capacity of blood. Saturation monitoring is an essential cost-effective part of monitoring any ill child and should be widely available at all levels of health care. Normal oxygen saturations are over 92%.
5. **Grunting:** This clinical sign is generated by a patient in severe distress in an effort to raise the peak end expiratory pressure to avoid collapse of the alveoli during expiration.
6. **Cyanosis:** This is a feature of severe respiratory distress and denotes > 5 g/dl of deoxygenated (reduced) haemoglobin. It is often identified centrally but occasionally peripheral cyanosis is recognised.

In young infants (< 2 months of age), the presence of the abovementioned clinical features are less reliable in predicting the degree of respiratory distress and therefore the presence of non-specific signs are recommended for making such predictions. These signs include the inability to feed, variable temperature control (both hypothermia and hyperthermia), decreased level of activity and level of consciousness, convulsions, increased sleepiness, apnoea, increased chest retraction (chest wall is more compliant), hypoxaemia and cyanosis. In a recent multicentre study of young infants conducted in seven countries, history of difficult feeding, history of convulsions, movement only when stimulated, respiratory rate > 60 breaths/min, severe chest indrawing and temperature instability were most predictive with a sensitivity of 85% and specificity of 75% for severity of illness.¹¹

Features suggestive of severe respiratory distress (danger signs according to IMCI) include¹²:

1. Inability to feed or drink and vomiting everything
2. Convulsions
3. Abnormal sleepiness
4. Stridor in a calm child
5. Severe malnutrition

Clinical signs (other than the abovementioned signs) of respiratory failure have been found to be most useful in detecting severe illnesses. Features of hypercapnia, i.e. bounding pulses and warm peripheries, and of hypoxaemia, i.e. initial irritability, restlessness and later progressing to decreased level of consciousness and convulsions, should be recognised immediately and elicit a rapid response which includes use of oxygen and possibly mechanical ventilation. Adventitious breath sounds such as crackles (fluid in alveoli), wheezes (lower airway obstruction), and bronchial breathing (parenchymal consolidation) are useful for determining the site and nature of the lesion but are poorly predictive of severity of respiratory illness and have a low sensitivity of 40–50%.^{13,14}

The work of breathing as detected by chest wall compliance and elastic recoil is useful for detecting severity but requires greater training for accurate evaluation.

Risk factors for determining severity of respiratory distress

Apart from the clinical features utilised to determine respiratory distress, certain associated abnormalities increase the risk for

adverse outcomes. These conditions include primary or secondary immune deficiencies, including HIV; severe malnutrition; structural abnormalities, e.g. bronchiectasis; and socio-economic characteristics, e.g. overcrowding, smoking and indoor pollutants (burning of wood fire and kerosene). Impoverished living conditions in rural environments place children at risk of acquiring illness and limit their access to care.

Differential diagnosis of children with respiratory distress

As mentioned above, other non-respiratory conditions must be considered and excluded prior to labelling a child with RDS as having a respiratory illness.

Cardiac illness, especially shock that is hypovolaemic, septic, cardiogenic, distributive or congestive, will present with abnormalities in pulse rates, blood pressure and perfusion. There may be fluid overload or dehydration. Blood tests such as those used to determine a lactate level or ESR may assist in clarifying the situation, although a chest radiograph, electrocardiograph, echocardiograph and catheterisation with measurements of CVP and cardiac pressure may be more helpful.

Metabolic diseases, including acute diarrhoea, would be best assessed clinically by history and features of the degree of dehydration. Urea and electrolytes and arterial blood gases evaluations are useful for confirming the clinical severity of the disease. Diabetes mellitus would be assessed through consideration of clinical history, acidotic breathing, urine dipsticks for glucose and ketones, serum glucose, arterial blood gas and urea and electrolytes. Renal dysfunction will be evaluated by consideration of urine and serum electrolytes, calcium, phosphate and magnesium evaluations, and appropriate urinary tract imaging. Overdose or drug toxicity such as salicylate toxicity would be excluded by consideration of a drug history and by measurement of drug (salicylate) levels.

Severe infections, including severe sepsis, septicaemia and multi-organ dysfunction, could also present with features of respiratory distress. Exclusion of such diagnosis is achieved through the consideration of clinical features, and supportive or confirmatory laboratory evidence of infection including coagulation screens, acute phase reactants and relevant culture evaluations.

Neurological conditions, including infections (meningitis, encephalitis) and conditions involving the brain stem, may present clinically with different patterns of respiration, e.g. neurogenic hyperventilation, Cheyne-Stokes breathing, and gasping respiration with associated signs of respiratory distress. Associated neurological features and laboratory investigations, including lumbar punctures, serum and urine osmolalities and electrolytes for Diabetes Insipidus or syndrome of inappropriate secretion of antidiuretic hormone (SIADH), and imaging, e.g. computerised tomography, will help to differentiate these conditions.

Investigations of respiratory causes of respiratory distress

After the other common conditions of RDS are rapidly clinically excluded, it would be prudent to consider a respiratory cause for the RDS. *Pneumonia* is the commonest cause of acute deterioration and should be considered early on. In children with sticky eyes and staccato cough with respiratory distress a diagnosis of *Chlamydia pneumoniae* should be considered while older children presenting with headaches and arthralgia and respiratory distress may have *Mycoplasma pneumoniae* infection.

A chest radiograph is useful in determining the site and nature of the lesion. It helps to recognise foreign bodies, identify opacifications in lung parenchyma or bronchial tree, identify pleural effusions or pneumothoraces, recognise pulmonary tuberculosis, and identify cystic, nodular or reticular changes suggestive of lymphoid interstitial pneumonitis. A high resolution CT more clearly delineates the site and nature of the lesion but is often not required. Neither of these tests helps to confirm an aetiological diagnosis, although a lobar opacification is suggestive of *Streptococcal pneumoniae* infection, bulging of the interlobar fissures is suggestive of a *Klebsiella pneumoniae* infection, and a pneumatocele is suggestive of *Staphylococcus aureus* infection. Other tests that would more clearly detect infection include full blood counts with white blood cell differential, C-reactive protein or procalcitonin levels. Tests utilised to confirm an aetiological diagnosis include culturing of fluid from a usually sterile site, e.g. pleural effusion, blood cultures, nasopharyngeal aspirates evaluated for viral cultures, tuberculin skin tests and endotracheal, gastric aspirates and induced sputum.

Aetiology of respiratory infections

As regards the aetiologies associated with pneumonia, *Streptococcus pneumoniae* is the commonest bacterial pathogen. There are 92 different serotypes of *Streptococcus pneumoniae*, but just a few are currently associated with causing pneumonia in children. Most of the serotypes associated with pathology in children are covered in the currently licensed seven-valent conjugated pneumococcal vaccine. The incidence of the other previously common bacteria, *Haemophilus influenzae*, has decreased substantially since the introduction of the Hib vaccine. Other commonly implicated bacteria include *Staphylococcus aureus* and *Klebsiella pneumoniae*. Common viruses associated with respiratory tract infections include the respiratory syncytial virus, adenovirus, herpes, measles, parainfluenza and influenza. Also, the incidence of measles has been substantially reduced through the active implementation of the Expanded Programme of Immunisation.

Atypical pathogens such as *Chlamydia trachomatis* and *Mycoplasma pneumoniae* are seen predominantly in early infancy or in children of school-going age. In HIV-infected infants, *Pneumocystis jirovecii*, cytomegalovirus and *Mycobacterium tuberculosis* are common opportunistic pathogens that are recognised in addition to the pathogens mentioned above. *Pneumocystis jirovecii* pneumonia accounts for one in four deaths in infancy amongst HIV-infected individuals, and the provision of co-trimoxazole (treatment and prophylaxis) and/or antiretroviral treatment could prevent these deaths.^{15,16} Tuberculosis occurs commonly in both HIV-infected and uninfected children.

Management of respiratory infections associated with respiratory distress

Effective interventions to reduce deaths associated with the clinical presentation of respiratory distress are available, but these interventions reach too few people. The WHO has utilised some of the clinical features of respiratory distress to classify children into different severities of pneumonia.^{17,18}

Children with just tachypnoea are classified as having pneumonia and treated with oral amoxicillin on an outpatient basis for five

days. Children with chest indrawing, in addition to tachypnoea, are classified as having severe pneumonia and treatment includes parenteral penicillin for 48–72 hours followed by oral amoxicillin for five days as inpatients.¹⁹ If the child does not improve after 48 hours on benzylpenicillin, or if she/he worsens while on therapy, antibiotic therapy should be switched to parenteral chloramphenicol given every six hours. For patients with cyanosis and/or inability to drink (very severe pneumonia) the acute respiratory infections (ARI) guidelines recommend injectable benzylpenicillin plus gentamicin (2.5 mg/kg/dose every 8 hours) for 10 days. The guidelines for the management of severely malnourished children recommend ampicillin plus gentamicin for the treatment of severe pneumonia with complications,²⁰ because there is a need to cover both Gram-positive and Gram-negative bacteria. Macrolides should be instituted where the presence of atypical pathogens is suspected.

In HIV-endemic areas parenteral co-trimoxazole should be administered to all infants, while oral co-trimoxazole as well as oral amoxicillin should be given to children with pneumonia treated as outpatients.²¹ Corticosteroids as well as oxygen should be given to hypoxaemic children with confirmed *Pneumocystis jirovecii* pneumonia. Ganciclovir should be considered for use in children with confirmed cytomegalovirus (CMV) in infection.²² As HIV-Infected children are predisposed to polymicrobial infections, early consideration should be given to cover for *Mycobacterium tuberculosis* or *Staphylococcus aureus* where evidence of its occurrence exists.²³ It is estimated that around 600 000 lives could be saved each year at a cost of US\$600 million if antibiotics were universally delivered to children suffering from pneumonia. This figure could double if preventative measures such as expansion of vaccination could be universally implemented.²⁴ Supportive measures utilised in the management of children with respiratory distress include blood transfusion if haemoglobin < 7 g/dl, antipyretic and analgesia – paracetamol 15mg/kg/dose 4–6 hourly if temperature > 38.5°C; nutritional support – 50 to 60 kcal/kg/day with adequate carbohydrates to prevent lactic acidosis; vitamin A if child has measles or malnutrition; and zinc at a dose of 20 mg/day for 7 to 14 days.²⁵ Intravenous fluids should only be administered if the child is shocked, having associated hyponatraemia or is too distressed to tolerate enterals. Mechanical ventilation should be considered if there is failure to maintain oxygen saturation above 90% on a polymask with an inspired oxygen concentration of > 70% or there is apnoea or hypercarbia with resultant acidosis or fatigue. Nebulisation with either beta agonists or anticholinergics should only be utilised in instances of reversible airway obstruction. There is no indication for the use of mucolytics, physiotherapy or postural drainage in these cases. In HIV-infected children, the use of high active antiretroviral therapy should be considered once control of acute infection is attained.

Antibiotic resistance

Over the past few decades a large body of literature has reported on penicillin resistance in *S pneumoniae* from many developing countries.^{26,27} Drug resistance in *S pneumoniae* has been recognised in over 25% of cases. Fortunately the effect of antimicrobial resistance has not translated into worse outcomes in pneumococcal bacterial pneumonia when compared with susceptible pneumococcal isolates.^{28,29} Treatment with high dose amoxicillin (90 mg/kg/day) has been found to be effective in these cases. Macrolide-resistant *Streptococci pneumoniae* are also seen in up to a third of cases. Resistance to other antimicrobials used in the management of infection also occurs and local sensitivity patterns must be evaluated when making antibiotic policies.

Conclusions

Severe/very severe pneumonia has a case fatality rate of 15–25% in developing countries with death usually occurring in the first three days of presentation, making early recognition by families and community health care workers a critical strategy in reducing mortality.³⁰ Effective treatment requires an understanding of the common pathogens causing pneumonia and of administration of effective antibiotics by family practitioners. Appropriate assessment and management of respiratory distress in children has been shown to reduce the adverse impact of respiratory illnesses in childhood. A meta-analysis completed by Szazawal and Black has indicated that implementation of simple interventions as advocated by the WHO ARI algorithm has reduced all cause- and pneumonia-related mortality in children less than five years of age.²⁸ The overall reduction in mortality rates among young infants, infants and children between one and five years of age was reduced by 42%, 36%, and 36% respectively while the pneumonia-related mortality was also decreased by 27%, 20% and 24% respectively.³¹ It is therefore imperative that health systems act urgently by undertaking training in the recognition of clinical features of respiratory distress and provide the tools for the implementation of planned interventions related to the recognition of the severely ill child. Such action would significantly reduce under-five mortality rates. South Africa, with its currently increasing childhood mortality rates, is unlikely to achieve the Millennium Development Goal 4 (of a two-thirds reduction in under-five mortality rates between 1990 and 2015) unless the government and private health systems urgently undertake to implement a programme that includes increased awareness of a recognised approach to a child suffering from respiratory distress. 🧑

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