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REVIEW ARTICLE

Review of supplemental oxygen and respiratory support for paediatric emergency care in sub-Saharan Africa

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ABSTRACT

Introduction: In African countries, respiratory infections and severe sepsis are common causes of respiratory failure and mortality in children under five years of age. Mortality and morbidity in these children could be reduced with adequate respiratory support in the emergency care setting. The purpose of this review is to describe management priorities in the emergency care of critically ill children presenting with respiratory problems. Basic and advanced respiratory support measures are described for implementation according to available resources, work load and skill-levels.

Methods: We did a focused search of respiratory support for critically ill children in resource-limited settings over the past ten years, using the search tools PubMed and Google Scholar, the latest WHO guidelines, international 'Advanced Paediatric Life Support' guidelines and paediatric critical care textbooks.

Results: The implementation of triage and rapid recognition of respiratory distress and hypoxia with pulse oximetry is important to correctly identify critically ill children with increased risk of mortality in all health facilities in resource constrained settings. Basic, effective airway management and respiratory support are essential elements of emergency care. Correct provision of supplemental oxygen is safe and its application alone can significantly improve the outcome of critically ill children. Non-invasive ventilatory support is cost-effective and feasible, with the potential to improve emergency care packages for children with respiratory failure and other organ dysfunctions. Non-invasive ventilation is particularly important in severely under-resourced regions unable to provide intubation and invasive mechanical ventilation support. Malnutrition and HIV-infection are important co-morbid conditions, associated with increased mortality in children with respiratory dysfunction.

Discussion: A multi-disciplinary approach is required to optimise emergency care for critically ill children in low-resource settings. In this context, it is important to consider aspects of training of staff, technical support and pragmatic research.

African relevance

- The burden of disease from respiratory failure is high in critically ill children.
- This article reviews respiratory support options feasible in African emergency centres.
- Pulse oximetry and a reliable oxygen supply are a priority in the care for critically ill children.
- Continuous positive airway pressure (CPAP) is a simple non-invasive ventilation option feasible in many low-resource settings.

Introduction

In 2013, 6.3 million children died before the age of five years. Approximately 50% of these deaths occurred in sub-Saharan Africa (SSA), where severe pneumonia remains a leading cause of child mortality [1].

A review from Malawi reported a considerable decline in paediatric hospital mortality from pneumonia between 2000 and 2012. However, mortality remained high in critical sub-groups including those with very severe pneumonia, suspected *Pneumocystis jirovecii* pneumonia and malnutrition [2].

Respiratory failure is also a common feature of critically ill children

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with severe sepsis. Kissoon et al. suggest that the global burden of severe sepsis as a cause of death and disability is under-estimated [3]. Severe infections such as pneumonia, bacteraemia and malaria can co-exist and can lead to a complex systemic inflammatory response [4]. Without rapid, efficient management, significant organ dysfunction, including respiratory failure, can occur [3]. Respiratory support is as essential in the management of these critically ill children as in respiratory disease [5,6].

Improvement of living conditions, preventative public health measures (e.g. vaccinations, malaria control programs) and community-based care can have a major impact on child health in low resource settings. However, strengthening of paediatric emergency care in peripheral health facilities and paediatric hospital departments also has the potential to significantly contribute to improvements of child survival [7]. Improvement of oxygen systems and respiratory support plays an important role in this context. A review of first level referral health facilities in twelve African countries showed that a large percentage of these facilities were not adequately equipped to provide basic supplemental oxygen [8].

A World Health Organisation (WHO) expert committee recently reviewed aspects of oxygen administration and peripheral oxygen saturation (SpO2) targets for paediatric emergency care [9]. This review did not include non-invasive or invasive respiratory support.

In well-resourced settings, non-invasive ventilation (NIV) is used routinely in neonatal care and together with application of surfactant has significantly reduced the need for mechanical ventilation, especially in pre-term newborns [10]. Adapted forms of NIV such as bubble continuous positive airway pressure (bCPAP) were introduced successfully in several low- and middle-income countries (LMICs) [11].

This review will focus on respiratory care in critically ill children beyond the neonatal age. We outline the importance of oxygen supply and non-invasive respiratory support as integral to paediatric emergency care. Priorities in the care of critically ill children are described and suggestions for when to consider mechanical ventilation in the emergency centre are provided.

Methods

A comprehensive literature search was conducted, using electronic search engines and databases (PubMed, Google Scholar) as well as references in review articles, focusing on articles published within the past ten years. No limitations in terms of scientific methodology were implemented. The following guidelines were reviewed:

- Emergency Triage Assessment and Treatment/ETAT [12]
- Updated guidelines for ETAT 2016 [9]
- Oxygen Therapy for Children 2016 [1]
- Pocket Book of Hospital Care for Children 2013; Technical Specifications for Oxygen Concentrators 2015 [14,15]
- International Advanced Paediatric Life Support manuals e.g. APLS, EPALS/PALS [16,17]
- Critical care training manuals (Paediatric BASIC [18]
- The latest editions of paediatric critical care and anaesthetic textbooks [5]

The following main topics were included in the review:

- Causes of child mortality; respiratory illnesses in the context of single and multi-organ-dysfunction.
- Paediatric emergency care; basic to advanced respiratory support modalities.
- Supportive care in paediatric respiratory illness including airway support, monitoring, fluids and nutrition.

The selection of evidence and clinical recommendations were discussed among authors and peers with experience in paediatric emergency and critical care in low- and middle-income countries, to be appropriate to this context. The authors were guided by the recommendations for resource tiered reviews [19].

Oxygen and respiratory support

Critically ill children are at risk of tissue hypoxia due to increased oxygen demand, impaired oxygen delivery or a combination of both. Inadequate oxygen delivery to tissues can lead to cell death and multi-organ failure (MOF). Hypoxaemia, the reduced percentage of oxygen-saturated haemoglobin in blood, contributes to tissue hypoxia and is associated with increased mortality and severity of disease in patients with pneumonia [20].

Respiratory failure and hypoxaemia occur frequently with lung pathologies (e.g. pneumonia, bronchiolitis, tuberculosis, asthma) but are also associated with other organ-dysfunctions often seen in African emergency centres including coma, convulsions and shock, which can be caused by conditions like meningitis, bacterial sepsis, malaria and common neonatal pathologies. Critically ill children with HIV infection and malnutrition have an increased mortality risk.

Oxygen treatment

Hypoxaemia is related to increased mortality and severity of disease in children with pneumonia. In a meta-analysis of twelve studies, the presence of hypoxaemia increased the risk of dying by more than fivefold [2]. Yet oxygen, the standard treatment for hypoxaemia and included in the WHO List of Essential Medicines, is often lacking in many African district hospitals [8]. The introduction of routine SpO2 measurements on admission and the provision of oxygen to hypoxic children with pneumonia resulted in a 35% reduction in mortality in Papua New Guinea [21]. However there is insufficient evidence to suggest that oxygen delivery to normoxaemic patients with pneumonia prevents the later development of hypoxaemia [22].

Table 1
SpO2 oxygen targets.

SpO2 target level	Patient category
≥90%	Children with respiratory distress only (e.g. with bronchiolitis, pneumonia…)
≥94%	Children with potentially reduced oxygen delivery capacity and vulnerable to moderate hypoxia include those with ETAT emergency signs* from conditions like severe sepsis, anaemia, cardiac failure, etc. * Obstructed or absent breathing * Severe respiratory distress * Central cyanosis * Signs of shock, defined as cold extremities with capillary refill time > 3 s and weak and fast pulse * Coma (or seriously reduced level of consciousness) * Seizures * Signs of severe dehydration in a child with diarrhoea Patients with severe anaemia and evidence of oxygen tissue deficit will require blood transfusion to increase oxygen carrying capacity. When the emergency condition has resolved, aim for SpO2 ≥ 90%
Oxygen supplementation should be given continuously until the child maintains SpO2 reliably above these levels without support	

SpO2, peripheral capillary oxygen saturation; ETAT, Emergency Triage Assessment and Treatment.