ORIGINAL ARTICLE

Acute Respiratory Distress Syndrome in a Paediatric Intensive Care Unit

A W Norrashidah, MMed*, B H O Azizi, FRCP**, M A Zulfiqar, MMed***, *Paediatric Department, Institute Paediatric, Hospital Kuala Lumpur, Jalan Pahang, Kuala Lumpur, **Paediatric Department, ***Radiology Department, Hospital Universiti Kebangsaan Malaysia, Jalan Tenteram, Cheras, 56000 Kuala Lumpur

Summary

Acute respiratory distress syndrome (ARDS) is the final outcome of a common pathway of a variety of unrelated but massive insults to the lung. It is commonly seen in adults but also occurs in the paediatric age group. A prospective study was carried out to determine the incidence, predisposing conditions, clinical course and outcome of children with ARDS admitted to a paediatric intensive care unit (PICU). Six patients (aged 0.8 to 11 years) who fulfilled the strict criteria for ARDS were identified prospectively during a one year study period. The incidence was 1.7% of all PICU admission. The most common underlying conditions were septicemia and pneumonia. The mortality rate was 83%. Death most often occurred during the early phase of the disease. Treatment of ARDS included elimination of the cause of ARDS, early institution of mechanical ventilation with PEEP, prompt recognition and treatment of superimposed infection and careful management of additional organ failure.

Key Words: Acute respiratory distress syndrome, Children, Paediatric intensive care

Introduction

The term acute respiratory distress syndrome (ARDS) in adult patients was first coined by Ashbaugh et al in 1967[1] and Petty and Ashbaugh et al[2] in 1971. They observed the parallel between the syndrome and the idiopathic respiratory distress syndrome or hyaline membrane disease in preterm infants. ARDS is the final common pathway of a variety of unrelated but massive insults to the lung with resultant injury of the gas-exchange interfaces (terminal-capillary units). It is characterised by physical signs of pulmonary insufficiency and impairment of gas-exchange (acute respiratory distress that needs mechanical ventilation with PEEP), decreased lung compliance, decreased lung volume and capacities, increased alveolar arterial oxygen gradient and diffuse alveolar infiltrates on chest radiograph. This disease was initially described only in adults and was referred to as traumatic wet lung, Da Nang lung and white lung syndrome. The characteristics of the syndrome in children have not been described even though occasional paediatric cases have been reported[3]. Cases involving children less than 18 years of age were first reported in 1968 following cardiopulmonary by-pass[4]. Despite the diversity of the presenting illness, the clinical pattern of respiratory involvement is remarkably stereotyped. Severe tachypnoea, arterial oxygen desaturation, decreased lung compliance and radiologic evidence of diffuse alveolar infiltrate were consistently observed. Published data reported the mortality rate for children with ARDS to be in excess of 50%[5]. It varies from 0.8% to 4.8% among all admission to PICU[6]. Davis et al reported that ARDS was an important disease for the paediatric intensivist amounting for 8% of total PICU days and 33% of all deaths[7]. However the incidence of ARDS is still controversial and studies need to be done to

determine the true incidence by utilising PICU, hospital, regional and national databases. The present study was carried out to determine the incidence of this syndrome in paediatric intensive care unit, to identify the predisposing factors and to indicate the mortality associated with this syndrome in children.

Materials and Methods

Patients included in this study were identified by prospectively reviewing all admissions to the PICU of the Paediatric Institute, Hospital Kuala Lumpur, in a one year period from 1st January 1994 to 31st December 1994. The PICU is a multidisciplinary unit and takes care of both neonates and children. The patients with ARDS were identified based on the inclusion and exclusion criteria as well as using the lung injury score by Murray et al[8] (Table I). The ARDS cases were reviewed everyday for the progression of the disease and serial chest radiographs were reviewed by the same paediatric radiologist. The changes in the ventilator settings and arterial blood gases were recorded. The inclusion criteria in this study were as follows:

- previously normal lung
- all ages, both sexes and races
- need for mechanical ventilation
- presence of an acute triggering illness or injury
- lung injury score of more than 2.5

Table I
Lung Injury Score by Murray et al[8]

	Components		Score
Chest X-ray score:	No alveolar consolidation		0
	Consolidation confined to 1 quadrant		1
	Consolidation confined to 2 quadrants		2
	Consolidation confined to 3 quadrants		3
	Consolidation confined to 4 quadrants		4
Hypoxic score:	PaO_2 / FiO_2	> 300	0
	PaO_2 / FiO_2	225 - 299	1
	PaO_2 / FiO_2	175 - 224	2
	PaO_2 / FiO_2	100 - 174	3
	PaO_2 / FiO_2	< 100	4
PEEP score:	PEEP	< 5cm H_2O	0
	PEEP	6 - 8cm H_2O	1
	PEEP	9 - 11cm H_2O	2
	PEEP	12 - 14cm H_2O	3
	PEEP	> 15cm H_2O	4
Respiratory compliance:	Compliance	> 80ml/cm H_2O	0
	Compliance	60-79ml/cm H_2O	1
	Compliance	40-59ml/cm H_2O	2
	Compliance	20-39ml/cm H_2O	3
	Compliance	<19ml/cm H_2O	4

The severity of lung injury was defined by using the modified lung injury score by Murray et al[8]. The respiratory compliance score was excluded from the scoring system as the compliance measurement was not available. Furthermore, the lung compliance was not essential for scoring. The lung injury score was obtained by dividing the aggregate sum by the number of components that were used. The exclusion criteria were as follows:

- pre-existing lung disease or chronic pulmonary disease
- congenital heart disease such as left ventricular failure
- rapidly fatal course

Information on the past medical history, details of triggering events for ARDS, other organs failure or dysfunction, duration of IPPV, values of PEEP used, peak inspiratory pressure, time of death after ARDS developed and the outcome were obtained and analysed. The chest radiographs were reviewed by the same paediatric radiologist for evidence of diffuse alveolar infiltrate at the onset of the illness and for interstitial changes later in the course of the disease. Autopsy was not done as consent was not available in all patients.

Results

During the one year study period, there were 354 patients admitted to PICU and six patients fulfilled our inclusion criteria of ARDS, giving an incidence rate of 1.7%. The mean age was 4.68 years, with a range of 0.8 to 11 years (Table II). There was no sex predominance. The syndrome developed in previously healthy children except for one patient who was newly diagnosed to have acute myeloid leukemia. Ventilatory support was instituted because of progressive respiratory distress in three, cardiorespiratory arrest in two and need for post-operative respiratory support in one. Sepsis was the predisposing event in five patients. Two cases had bacteriologically proven septicaemia and 3 cases was diagnosed clinically to have septicaemia. One patient had post-measles pneumonia. Five patients had associated renal failure with shock and three had disseminated intravascular coagulation (DIVC). Additional organ failure was very common and most of the non-survivors had more than one organ failure. The interval to death after developing ARDS varied in the non-survivors. Four patients died during the early phase of the disease and one patient died later secondary to brain death. All patients with ARDS required fractional inspired oxygen (FiO_2) of more than 0.5, and the positive end expiratory pressure (PEEP) levels applied during the acute stage of ARDS were between 5 to 8cm of H_2O. None of the patients had any pulmonary air leak complication. All children received either a course of antibiotic or several courses of antibiotics for proven or suspected bacterial infections. The only survivor had no residual pulmonary abnormality. The overall mortality of ARDS was 83%. In all five non-survivors, no autopsy was done as consent was not given.

Discussion

Our findings indicate that although ARDS is an uncommon disease in paediatric intensive care unit, (with incidence rate of 1.7% of all total PICU admissions) it is important as it carries a high mortality despite modern management technique. Although the inclusion criteria and data reported vary significantly among the earlier studies, the six subjects of this report were similar in many ways to the 53 children in the earlier report[9]. In the present study, the incidence of 1.7% is consistent with those the previously reported rates of 0.8% to 4.4% among all admission to PICU[5]. The age range in our study was from 10 months to 11 years with a mean age of 4.68 years. In the two series reported by Davis et al and Lyrene et al, the age range was two months to 21 years with mean age of 4.8[7,10]. Septicaemia, septic shock and pneumonia were the most common predisposing events in our patients in contrast to the two paediatric series reported in the literature in which sepsis and hypovolaemic shock[4], near drowning and near strangulation[5] were the leading causes of ARDS. One patient had viral (post-measles) pneumonia. However, in two patients who were suspected to have septicaemia, there were no organisms isolated from blood culture. Fein et al[11] concluded in his study that ARDS frequently complicated all forms of septicaemia and he also stated that the age, gender, white cell count

Table II
Clinical parameters ventilatory requirement and outcome of patients studied

Cases	Age(yr) Sex	Lung Injury score	Triggering Events	Duration of ventilation	Mean PEEP (cm H_2O)	PIP (cm H_2O)	Outcome	Time to death after ARDS developed	Organ failure noted
1	1.3 F	2.66	Meningococcus septicaemia	3 hours	6	35	Died	3 hours	CNS, DIVC
2	0.8 M	2.66	MRSA septicaemia	7 days	8	38	Survived		CNS,GIT Renal
3	1.0 M	3.00	Septicaemic shock	30 days	7	40	Died	30 hours	CNS, Renal
4	4.0 M	2.66	Septicaemia with gut perforation	30 days	5	38	Died	10 days	CNS,GIT, CVS, Renal
5	11 F	3.00	AML with septicaemia	3 days	8	45	Died	3 days	CNS, DIVC Renal
6	10 F	3.00	Measle pneumonia	3 days	6	40	Died	3 days	CVS, Renal

PEEP = Positive end expiratory pressure
PIP = Peak inspiratory pressure
AML = Acute myeloid leukemia
MRSA = Methicillin resistant Staphalococcus aureus
CNS = Central nervous system
CVS = cardiovascular system
GIT = Gastrointestinal tract
DIVC = Disseminated intravascular coagulation

and type of organism had no significant association with development of ARDS. Effmann et al[12] reported that the most common predisposing factors for development of ARDS were septic shock, septicaemia, pneumonia and near drowning. The mortality rate in the present study was 83%. It is comparable to the mortality rate published in the literature during the past decade[13]. This discouraging mortality figure is not different from those reported in the original description of this disease in adult 29 years ago.

Early recognition of patients who have the risk factors of developing ARDS is important. The use of high PEEP in managing these patients were implemented as there were no other measures such as high frequency ventilator or extracorporal membrane oxygenation (ECMO) in our unit. The use of steroid gives no benefit. PEEP has been proven to have beneficial effects in lowering the mortality of ARDS[1,14,15] by preventing the airway pressure from falling below the alveolar closing pressure, limiting the repetitive expansion and collapse of the terminal airways and redistributing pulmonary oedema from alveolar to interstitium, thereby improving compliance and ventilation to perfusion mismatch. One approach consists of oxygen limited, pressure control, square-pressure-wave ventilation with sufficient mean air pressure, to achieve minimally acceptable PaO_2 values (55 to 75mmHg) while limiting the peak pressure and tidal volume. Based on this approach, the mean airway pressure is determined

mainly by PEEP and not PIP. Permissive hypercarbia (45 to 60mmHg) enables the paediatrician to further reduce the PIP and tidal volume of the ventilator setting. In the present study, the highest PEEP used was 8cm of H_2O and 45cm of H_2O for peak inspiratory pressure (PIP). These values were the lowest compared with the other studies[12,16-18]. Even though ventilatory support and PEEP levels were recognised as the hallmark of therapy in ARDS, there were other factors contributing to the high mortality in children with ARDS, such as infections and multiorgan failure. The radiographic diagnosis of ARDS must be made in the context of clinical presentation and the course of the disease because a large number of differential diagnoses have to be considered during the initial phase of the syndrome. The overall outcome in adults seems to be better than in children. In children, the mortality is estimated to be between 60% to 94% and in adults, it ranges from 25% to 60%[19]. In this study, the survival from ARDS is still dismal despite the use of modern techniques of therapy, support and monitoring.

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