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INCIDENCE, RISK FACTORS, AND OUTCOME OF PEDIATRIC ARDS: A SINGLE-CENTER EXPERIENCE

Paediatrics

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ABSTRACT

Background: Acute respiratory distress syndrome (ARDS) is a major source of morbidity and mortality. It accounts for 1–4% of all PICU admissions, and an estimated mortality of 20–75% despite advances in management. **Patients and Methods:** 61 Children between ١ month to ١٢ years of age who were admitted to PICU with the diagnosis of ARDS were included in the study. Clinical history and examination were done for the diagnosis and assessment of the severity. X-ray chest and arterial blood gas analysis was done for every patient and HRCT was done for the selected patients. Outcomes were measured in terms of mortality and survival. **Results:** 61 ARDS patients fulfilling the criteria were included. The incidence of pediatric ARDS is 8.09% and mortality is high i.e. 80.32%, in our study. The median age of the subjects was 38 (4-96) months. No significant difference was noted in vital parameters and respiratory system findings between dead and alive patients. The ESR, frequency of need for invasive ventilation, as well as PCV mode of ventilation, and OI/OSI ratio were significantly higher, while haemoglobin, PaO2, and SpO2 levels were significantly lower in subjects with adverse outcomes. **Conclusions:** There is a very high incidence and mortality of ARDS in the present study, maybe because most patients are being referred from distant rural areas with poor conditions.

KEYWORDS

ARDS, Pediatric, Respiratory failure, Incidence, Outcome

INTRODUCTION

Adult respiratory distress syndrome (ARDS) is characterized by acute respiratory distress, refractory hypoxemia, and pulmonary hypertension and remains a challenge for the intensivist.[1] It is a major source of morbidity and mortality in people who are critically ill.[2,3] The first consensus definition for ARDS was given by the American-European Consensus Conference with well-defined criteria for ARDS and Acute Lung Injury (ALI).[4] It has been estimated that ARDS accounts for 1–4% of all Pediatric Intensive Care Unit (PICU) admissions, 8–10% of patients requiring mechanical ventilation, and an estimated mortality of 20–75% despite advances in management.[5,6]

Although only a few studies have been conducted to identify prognostic factors for mortality in pediatric ARDS, the currently available factors include the presence of multiple organ system failure, an increased Pediatric Risk of Mortality (PRISM) score[7], a lower PaO_2/FiO_2 ratio[8], and the presence of neurologic dysfunction. More recently, the driving pressure is defined as plateau inspiratory pressure minus positive end-expiratory pressure (PEEP) and is associated with increased mortality among adult patients with ARDS.[9]

As the criteria for pediatric acute respiratory distress syndrome (PARDS) have recently been framed, few studies have assessed the incidence of PARDS in the Indian population. Also, risk factors, prognostic factors, and the clinical picture in the Indian context remain to be explored. Knowledge of incidence, clinical presentation, and prognosis of PARDS in our scenario will be highly helpful to devise strategies for prevention, management, and designing of strategies for implementation of any public health strategies in India.

So this study was conducted to know the incidence, risk factors, and outcome of pediatric ARDS at tertiary care centers in India.

MATERIAL AND METHODS

This is a prospective observational study conducted in a tertiary care center. Sixty-one Children between 1 month to 12 years of age who were admitted to the PICU with the diagnosis of ARDS according to the Paediatric Acute Lung Injury Consensus Conference (PALICC) definition 2015 were included in the study.

Clinical history was taken with particular emphasis on the presence of risk factors. Clinical examination, including vital parameters, and general and systemic examination was done for the establishment of diagnosis and assessment of the severity of the disease. X-ray chest and arterial blood gas analysis were done for every patient. HRCT was done for the selected patients. Biochemical parameters, including renal function test and liver function test, were performed on a clinical chemistry analyzer using the manufacturer's protocol. The clinical diagnosis at the time of satisfying the study criteria was considered a risk factor for the development of ARDS. Outcomes were measured concerning mortality and survival.

The variables used in the PALICC criteria were—
Duration of onset of acute illness to ARDS of less than ٧ days, the origin of pulmonary edema (cardiogenic or non-cardiogenic), any new infiltrate on Chest X-ray (unilateral or bilateral), and oxygenation defect based on PaO_2/FiO_2 (P/F) or SaO_2/FiO_2 (S/F) ratio if on non-invasive mechanical ventilation, and OI or OSI if on conventional mechanical ventilation (CMV). Using the following formulas, variables OI, OSI, and MAP were calculated.

$OI = [\text{mean airway pressure (MAP)} \times FiO_2 \times 100[/PaO_2$

$OSI = [MAP \times FiO_2 \times 100[/SpO_2$

$MAP = [(PIP\text{-}PEEP)(T_I)/T_I + T_E]$

The study was approved by the Institutional Ethics Committee dated 07/12/2018, memo no.- BCH/ME/PR/3736.

Statistical Analysis

Data was expressed as a percentage and mean ± S.D. Kolmogorov-Smirnov analysis was performed to check the linearity of the data. Student's t-test was used to check the significance of the difference between two parameters in parametric data. Fischer's exact test or the Chi-square test was used to analyze the significance of the difference between the frequency distribution of the data. P value <0.05 was considered statistically significant. SPSS© for windows™ Vs 17, IBM™ Corp, NY, and Microsoft excel™ 2007, Microsoft® Inc, USA were used to perform the statistical analysis.

RESULTS

We recruited 61 subjects who reported ARDS as per PALICC criteria after screening 754 subjects being admitted to our hospital (Incidence of ARDS 8.09%). Out of 61 subjects, the maximum subjects (50.8%) were >36 months of age. Median age was found to be 38 (4-96) months. Eighteen subjects were female (29.5%) while 43 subjects were male (70.5%).

Pulse, Respiratory rate, Systolic blood pressure, and diastolic blood pressure were compared between subjects with different outcomes. All these vital parameters were found to be matched between the two groups. SPO2 between ARDS subjects with different outcomes was compared using t t-test, and a significant difference was observed ($p<0.0001$) (Table 1).

Table 1: Comparison of Vital Parameters Between ARDS Subjects with Different Outcomes

Vital parameter	Outcome	N	Mean	S.D.	S.E.	T	P value
Pulse	Dead	49	123.67	22.32	3.19	0.583	0.568
	Alive	12	119.33	23.28	6.72		
RR	Dead	49	45.18	11.64	1.66	0.136	0.894
	Alive	12	44.58	14.22	4.11		
SBP	Dead	49	92.02	10.32	1.47	0.189	0.852
	Alive	12	91.50	8.05	2.32		
DBP	Dead	49	52.61	10.02	1.43	-0.417	0.681
	Alive	12	53.75	8.04	2.32		
SpO2	Dead	49	91.51	2.27	0.32	-5.539	<0.0001
	Alive	12	95.33	1.44	0.41		

RR- Respiratory rate, SBP- Systolic blood pressure, DBP- Diastolic blood pressure.

Comparison of the requirement of respiratory support between ARDS subjects with different outcomes assessed using Fisher's exact test. A significant difference was observed between invasive (p<0.0001), noninvasive (p<0.0001), and mode of ventilation (p<0.0001) support and the outcomes in ARDS subjects, while no significant difference was observed between the duration of ventilation and the outcomes (p=411) (Table 2).

Table 2: Comparison of the Requirement of Respiratory Support Between ARDS Subjects with Different Outcomes

Ventilation parameters		Outcome		Total	P value
		Dead	Alive		
Requirement of respiratory support	Invasive	49	4	53	<0.0001
		100.0%	33.3%	86.9%	
	Non-invasive	0	8	8	<0.0001
		.0%	66.7%	13.1%	
Mode of ventilation	HFNC	0	5	5	<0.0001
		.0%	41.7%	8.2%	
	NHFO	0	1	1	
		.0%	8.3%	1.6%	
	NIVPS	0	2	2	
		.0%	16.7%	3.3%	
	PCV	45	4	49	
		91.8%	33.3%	80.3%	
	SIMV	3	0	3	
		6.1%	.0%	4.9%	
	VC	1	0	1	
		2.0%	.0%	1.6%	

HFNC-High flow nasal canula, NHFO-Noninvasive high-frequency oscillation, NIVPS-Noninvasive ventilation pressure support, PCV-Pressure controlled ventilation, SIMV- Synchronised intermittent mandatory ventilation, VC- Volume control

No significant difference was observed between the duration of ventilation and MAP and the outcomes in ARDS subjects (p>0.05), while a significant difference was found between PaO2 (p=0.033) and OI/OSI (p=0.008) for the outcomes. PF/SF ratio could not be compared as the values were not available for the death of group subjects (Table 3).

Table 3: Comparison of Ventilator Parameters Between ARDS Subjects with Different Outcomes

	Outcome	N	Mean	S.D.	S.E.	t	P value
Duration of ventilation (days)	Dead	49	7.38	1.02	0.15		
	Alive	12	6.92	1.16	0.34	1.248	0.23
PaO2	Dead	49	85.90	24.40	3.49	-3.509	0.033
	Alive	4	140.75	30.48	15.24		
MAP	Dead	49	8.28	1.53	0.22	1.003	0.365
	Alive	4	7.46	1.76	0.79		
OI/OSI	Dead	49	10.23	2.74	0.39	4.90	0.008
	Alive	4	5.13	1.93	0.97		
PF/SF ratio	Dead	8	205.00	30.22	10.68	-	-
	Alive						

MAP- Mean airway pressure, OI/OSI- Oxygenation index/ Oxygen saturation index, PF- PaO_2/FiO_2 ratio, SF- SpO_2/FiO_2 ratio.

On comparison of laboratory findings between ARDS subjects, a significant difference was observed between Hb (0.001) and ESR (0.01) concerning the outcomes. While TLC (0.933), platelets (0.129), and RBS (0.302) were found to be matched for the outcomes (Table 4).

Table 4: Comparison of Laboratory Findings Between ARDS Subjects with Different Outcomes

	Outcome	Mean	S.D.	S.E.	T	P value
Hb	Dead	10.59	1.57	0.22	-3.85	0.001
	Alive	12.43	1.46	0.42		
TLC	Dead	15500.00	8548.30	1221.19	-0.09	0.933
	Alive	15700.00	8690.17	2508.64		
Platelets	Dead	190000.00	93075.04	13296.43	-1.58	0.129
	Alive	229000.00	74130.67	21399.68		
ESR	Dead	51.45	16.18	2.31	2.96	0.01
	Alive	34.08	18.72	5.40		
RBS	Dead	76.65	16.88	2.41	-1.06	0.302
	Alive	81.92	14.99	4.33		

HB- Hemoglobin, ESR- Erythrocyte sedimentation rate, TLC- Total leukocyte count, RBS- Random blood sugar

The outcomes in ARDS subjects were found to be matched for pneumonia (p=0.112), Bronchiolitis (p=0.170), sepsis (p=0.170), and other risk factors (p=0.305). Mortality in our study was 80.32%.

DISCUSSION

In this study, the incidence, risk factor, and outcome of ARDS in children between 1 month to 12 years of age, admitted to an intensive care unit in a tertiary care center in Eastern India were evaluated.

We recruited 61 subjects who reported ARDS as per PALICC criteria after screening 754 subjects being admitted to the PICU of our hospital (Incidence of ARDS 8.09%). In a similar study, Das et al[10] reported an incidence of 19.42/1000 admissions. Also, reported high mortality of 87.8%, like our study. Chetan G et al[11] reported 22.7 cases of ARDS per 1000 admissions in their study. The overall mortality was 70%. In a case series of ARDS patients from New Delhi, Lodha R et al had a similar incidence of 20 per 1000 PICU admissions. [13]

Incidence in our study was almost similar to the study by Yadav B et al[12] and Li et al[14] but higher compared to other studies that reported it between 2-20/1000 PICU admissions.[15-18] Being a tertiary referral center, we often receive patients at an advanced stage of illness due to poor medical facilities in the peripheries. That may account for the higher incidence rate.

Mortality in ARDS was reported in various series to range from 22% to 83%.[15-18] Schouten LR , reported a pooled weighted mortality of 33.7% (95% CI, 28.6-39.7), and there were no trends over time, but mortality was significantly associated with study location.[3] A very high mortality of 80.32% in the present study may be because most patients are being referred from distant rural areas with poorly managed conditions, and most developed shock as a co-morbid condition.

Gupta S et al[19] reported that they failed to report any difference in key clinical outcomes such as duration of ventilation, inotropes, PICU stay, the proportion with air leaks, the proportion with shock, and use of adjuvant therapy or mortality. Das et al[10] didn't find a significantly low min PaO2/FiO2 amongst non-survivors in their study cohort, like that by Schene KM et al.[20] However, Flori H et al. and Flori HR et al. found PaO2/FiO2 to be a robust predictor and independently associated with mortality.[3,20-22] Yehya N et al.[23] found PaO2/FiO2 not to be associated with mortality at onset but associated with mortality at 24 hours. Desai AR et al. suggest that ventilation with low tidal volume and low plateau pressure are associated with decreased mortality. [24]

Chetan G et al[11] reported that Shock followed by sepsis was the most common accompanying feature and was associated with high mortality. This may be due to the involvement of other organ systems as part of a more serious multi-organ dysfunction syndrome (MODS). Children with acute renal failure and disseminated intravascular coagulation had 100% mortality in this study. Available literature suggests that the presence of sepsis, the initial severity of arterial hypoxemia, non-pulmonary organ dysfunction, and chronic diseases increases the risk of mortality significantly.[7,25,26] The mortality of ARDS has decreased over the years as a result of better ventilator strategies and improvements in supportive care. [27,28]

Study by Li et al[14], showed an incidence of 7.8% (44/562), which was

similar to our study. The mortality rate of ARDS was 24.1% (7/29) and that of ALI/ARDS was 18.2% (8/44). At a 3-month follow-up, 12 patients died after being discharged from the PICU, and the total mortality rate was 45.5% (20/44). ALI/ARDS patients with pulmonary disease had better outcomes than those with extra-pulmonary involvement (P<0.05). Discharge against medical advice, low PaO2/FiO2 during hospital stay, and high PaCO2 on PICU admission were risk factors for mortality.

In our study age, gender, and vital parameters were not found to be influencing the mortality in study subjects suffering from pediatric ARDS. Similarly, respiratory findings were found to be matched between subjects with different outcomes. However, mean SPO2 and PaO2 were noted to be significantly lower, and the frequency of need for Invasive ventilation, PCV, and the OI/OSI ratio was found to be significantly higher in subjects with death as an outcome. No significant difference was observed in the duration of ventilation between the two groups (death and survival). Hemoglobin was significantly lower, and ESR was significantly higher in subjects with adverse outcomes. Pneumonia (68.9%) was found to be the most common risk factor followed by Sepsis which accounted for 23% of children but the difference failed to reach statistical significance.

CONCLUSION

This study provides valuable insight into the incidence, risk factors, and clinical outcomes of pediatric ARDS in a tertiary care setting in Eastern India. Despite optimal intensive care, the overall mortality remained substantial, underscoring the need for early identification and aggressive management of high-risk cases.

Strengths

- This study is one of the few from Eastern India that systematically evaluates pediatric ARDS using standardized definitions and clinical scoring systems.(PRISM III)

Limitations

- The single-center design may limit the generalizability of the results to other settings with different case mixes or resources.
- Long-term outcomes post-discharge were not assessed, which may have provided a more complete picture of ARDS sequelae in children.

Future multicenter studies with larger cohorts and longitudinal follow-up are recommended to validate these findings and develop region-specific clinical management protocols for paediatric ARDS.

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