Clinical Brief

Pseudocyst in Pulmonary Acute Respiratory Distress Syndrome (ARDS)

Arun K. Baranwal, Sunit C. Singhi, M. Jayashree and Akshay K. Saxena[1]

Pediatric Emergency and Intensive Care Units, Departments of Pediatrics and [1]Radiodiagnosis, Postgraduate Institute of Medical Education and Research, Chandigarh, India

ABSTRACT

Childhood ARDS is mostly caused by pneumonia. Pulmonary pseudocysts are reported in adults recovering from ARDS, usually in non-dependent lung regions. The authors present a 1.5-year-old boy, who survived severe pulmonary ARDS with development of pulmonary giant pseudocysts and other structural abnormalities in dependent lung region. To the best of authors knowledge, it is the first follow up report of pulmonary abnormality in a toddler with ARDS of extreme severity. **[Indian J Pediatr 2010; 77 (5) : 569-572]** *E-mail: sunit.singhi@gmail.com*

Key words: *Pneumonia; ARDS; Pulmonary pseudocyst; Children*

Progress in pathological understanding of ARDS led to evolution of concepts of 'barotrauma,' 'volutrauma' and now 'cellular biotrauma'[1] to explain air-leaks with high pressure ventilation. Air leaks usually present as pneumothorax and pneumomediastinum in patients with severe ARDS. Of late, covert injury as pseudocyst formation has been reported on CT scans.[2,3] We report development of giant pseudocyst in a young toddler, who survived severe protracted ARDS.

REPORT OF CASE

A 1.5-yr-old boy presented with fever for 7 days, recurrent vomiting and 3 brief tonic seizure episodes on day 6-7 of illness with loss of sensorium. He developed fast breathing after first episode of seizure. Examination revealed tachycardia (114/min), tachypnea (44/min), hypotension (60/44 mm Hg), petechiae and ecchymosis, palpable splenomegaly (2cm), hepatomegaly (span; 10cm), altered sensorium (GCS score-6; $E_1M_4V_1$), neck rigidity, exaggerated tendon jerks, extensor plantars, normal pupils and fundus. PRISM III score was 5. He was intubated for airway instability. Chest radiograph showed bilateral non-homogeneous alveolar opacities. He had anemia (Hb 71g/L), relative neutrophillia (TLC, $13X10^9$/L, $P_{80}L_{17}M_{02}E_{01}$), thrombocytopenia ($42X10^9$/L), coagulopathy (PTI 53%, PTTK 36"{control 30"}, negative D-dimer), normal serum electrolytes and renal functions. CSF analysis showed 20 cells (50% PMNs), elevated protein (60 mg/dL) and hypoglycorrhachia (CSF sugar, 60mg/dL; blood sugar, 134mg/dL). Initial cultures were sterile. He was managed with antibiotics (Ceftriaxone, Amikacin and Metronidazole), CVP-guided fluid, inotropes and other supportive care as per our Pediatric Intensive Care Unit (PICU)'s protocol.

On day 3 of admission, he was mechanically ventilated for rising $PaCO_2$ with initial settings of Positive End-Expiratory Pressure (PEEP) 5 cmH_2O, ΔP of 10 cmH_2O, FiO_2 0.4 and tidal volume 6-8 ml/Kg. At the outset, PaO_2/FiO_2 ratio and oxygenation index were 282 and 2.8 respectively. Over next 2 days, there was gradual worsening of radiological opacities, PaO_2/FiO_2 ratio (187) and oxygenation index (7.5). Central venous pressure and right ventricular function were normal. Management strategy included fluid intake titrated to maintain urine flow of $\simeq$1ml/Kg/hour, $FiO_2 \leq 0.6$, optimal PEEP to achieve adequate oxygenation (SpO_2 90-95% and PaO_2 55-60 torr), optimal ΔP to achieve pH of 7.20-7.25 (with $PaCO_2$ 45-55 torr) and tidal volume of 6-8 ml/Kg. Initially tidal volume could be maintained at 6-8 ml/Kg level, however with nosocomial polymicrobial sepsis and associated metabolic acidosis, higher tidal volume (up to 10-14 ml/Kg) was required to optimize pH. During acute phase, high PEEP (maximum; 13 cmH_2O) and high ΔP (maximum; 22-23 cmH_2O) were needed to achieve the goals. During recovery, ventilatory support was gradually reduced; by day 57, he was on ΔP of 7 cmH_2O and PEEP

Correspondence and Reprint requests : Prof. S.C. Singhi, Pediatric Emergency & Intensive Care Units, Advanced Pediatrics Center, PGIMER, Chandigarh-160012, India.

[DOI-10.1007/s12098-010-0067-4]

[Received July 8, 2009; Accepted January 6, 2010]

of 5 cmH_2O. Subsequent weaning was slow for development of critical illness neuropathy. CPAP could be initiated on 95th day and was required for another 36 days. Ventilatory and blood gas parameters at 0800 everyday for initial 60 days are shown in fig. 1. His PICU stay was complicated by polymicrobial sepsis and nosocomial pneumonia. Growth of coagulase-negative *Staphylococcus* (blood, day 13), *Candida tropicalis* (blood, day 9 and urine, day 15) and *Klebsiella pneumoniae* (blood, day 37 and 55) were obtained at different points of PICU-stay. The clinically significant cultures were treated as per sensitivity. His total hospital stay was 5 months.

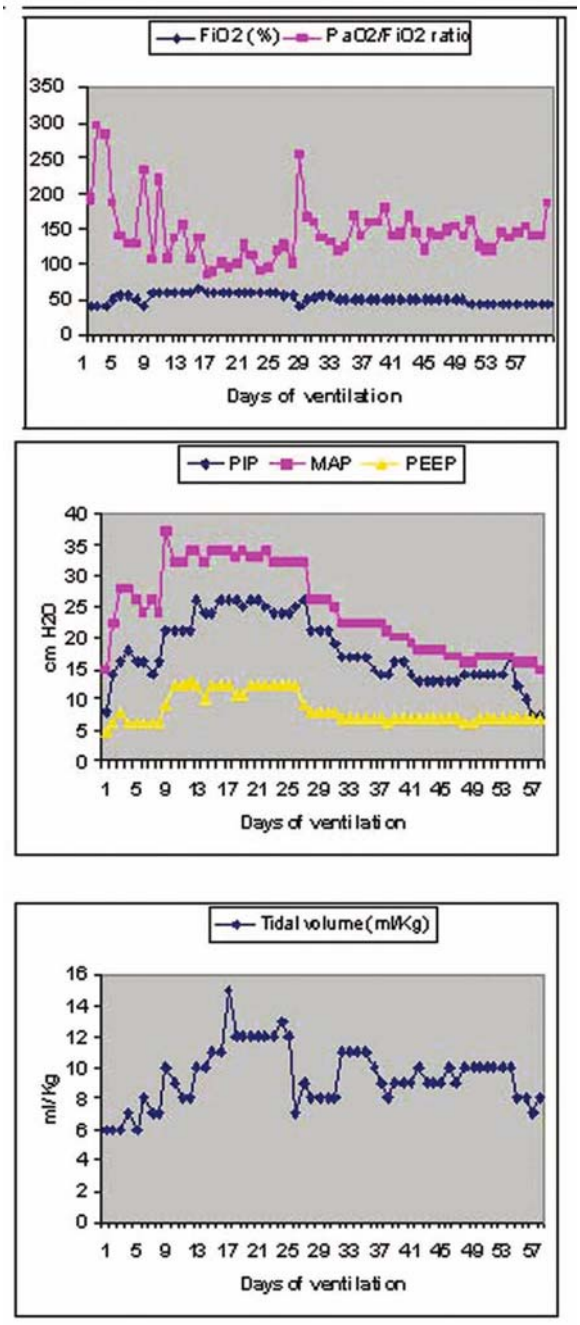

Fig. 1. Line diagram showing daily (0800) ventilatory and oxygenation parameters.

On day 24 of PICU admission, chest radiograph revealed pneumomediastinum and pneumopericardium, and next day he developed subcutaneous emphysema, which improved with conservative management. Chest radiograph obtained on day 73 revealed a large thin walled pneumocyst on left side. CT chest on day 112 revealed patchy areas of consolidation and ground glass densities in both the lungs. Multiple small thin walled pneumocystic lesions were seen in left lower lobe, largest measuring 49mm × 38mm (Fig. 2a). At 8 months of ARDS onset, there was persistence of the large thin walled left sided pneumocyst on chest radiograph (Fig. 2c); and of consolidation, ground glass densities and thin walled multiple cysts were persisting on CT chest (Fig. 2c). Patchy areas of fibrosis had appeared bilaterally.

During follow up (fortnightly visits for initial 3 months and then monthly visits), he continued to have cough, tachypnea (RR, 35-40/min), nasal flaring, chest retractions, bilateral fine crepts, right sided bronchial breathing, and reduced air entry in left hemithorax. His critical illness neuropathy gradually improved and he became ambulatory by 10 months. At 10 months of ARDS onset, he was prescribed high dose oral ambroxol (12 mg/Kg/day for one month) for its potential mucolytic expectorant effects. With ambroxol, cough had disappeared within 2 weeks. He was last seen at 18 months with slow but continued improvement in exercise tolerance. Chest examination revealed improved but reduced air entry and fine crepts at infrascapular and inferior axillary areas in left hemithorax. The repeat chest radiograph revealed bilateral multiple thin-walled cysts (Fig. 2d).

DISCUSSION

Acute respiratory tract infections (ARTIs) are the commonest cause of ARDS in Pediatric Intensive Care Units of developed economies,[4] and should not be different in developing economies where ARTIs continue to cause alarming childhood mortality. The published data on changes in lung parenchyma during recovery from ARDS are scanty[2,3] and almost non-existent in children. Presence of fast breathing and bilateral non-homogeneous alveolar opacities in the index case at admission suggested direct acute lung injury, presumably caused either by community-acquired pneumonia or by aspiration pneumonitis, which might have been aggravated by septic shock. The patient progressed to severe protracted ARDS and later developed large pseudocyst in dependent lung region. Pneumatoceles/pseudocyst formation is commonly seen in staphylococcal

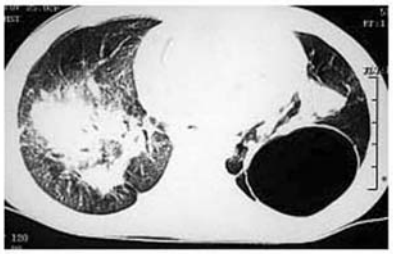

Fig. 2a

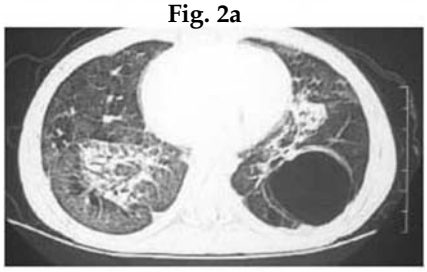

Fig. 2b

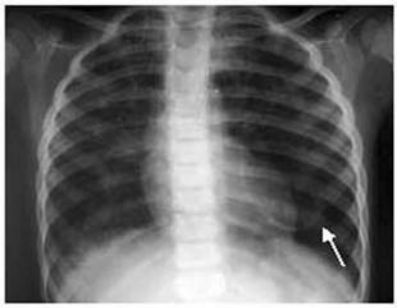

Fig. 2c

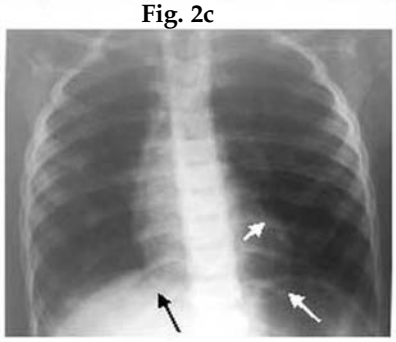

Fig. 2d

Fig. 2. Chest CT scans at the level of lower lobes showing **(a)** a large cystic lesion in left lower lobe, bilateral consolidation and ground glass densities at 3 months of ARDS onset, **(b)** additionally, appearance of fibrosis in the form of intralobular septal thickening at 8 months. Chest radiographs (AP view) showing **(c)** thin-walled cystic lesion in left lower lobe at 8 months and **(d)** bilateral multiple thin-walled cysts at 15 months.

pneumonia; other causes include pneumococcus, pneumocystis carinii and Job's Syndrome. However, these pneumonia-associated pneumatoceles usually appear early in the clinical course, mostly at the time of presentation or shortly thereafter.[5,6] In the index case, pseudocysts appeared two and half months after the onset of pneumonia, suggesting chronic ARDS and ventilation induced lung injury as likely explanation. Such large unresolving pseudocysts has been managed surgically if there is persistence of infection, >50% involvement of hemithorax with severe aletectasis, development of tension pneumothorax, bad tolerance to follow up[6] or ventilator dependence.[7] The index case is doing well on follow up until now and thus surgery has not been considered. Surgical options include image-guided[6] or VATS-guided[7] catheter drainage, or surgical excision if former fails due to thick wall or persistent infection.[6]

ARDS follows a variable course, varying from resolution within a week to a more protracted course. Beyond 2 weeks, there is dramatic increase in incidence of pseudocysts, varying in size from few millimeters to several centimeters.[8] Pseudocysts are shown to develop in non-dependent anterior lung regions in adult series of extrapulmonary ARDS.[2] Better aeration during early stages of ARDS, makes non-dependent regions more prone to baro- and/or volutrauma *vis-à-vis* poorly aerated dependent regions,[2] and so preponderance of pseudocysts in these regions. However, pulmonary ARDS (*p*ARDS) has different morphology. Gattinoni et al reported pseudocysts in dependent lung region of 5 patients with ARDS of more than two weeks' duration similar to the index case; mostly having pneumonia.[9] Though large cysts are supposed to be associated with higher ΔP and tidal volume, their formation in dependent regions of *p*ARDS suggest role of other mechanisms as well, for these poorly aerated regions are not exposed to high ventilatory pressure. In fact, *p*ARDS has been shown to have significantly more consolidation,[3] and these consolidated areas are demonstrated to be the predominant sites of pseudocyst formation in experimental studies.[10] Inflammatory consolidation seems to have contributory role.

Two theories have emerged to explain dependent distribution of pseudocysts in *p*ARDS. First, infection or ischemic necrosis in the dependent consolidated-collapsed lung may have caused damage early in ARDS with subsequent bullae formation when lung gets re-expanded, and exposed to high airway pressure.[9] Recently, in a CT study of late-stage ARDS caused by severe acute respiratory syndrome (SARS), presence of thick-walled air cysts, that too in fibrotic areas, supports the hypothesis of necrosis in the areas of inflammation and infection being the predisposing factor.[11] The index case had *p*ARDS and demonstrated persistent structural abnormality in the form of ground-glass densities, consolidation and pseudocysts mostly in the posterior dependent regions of the lung. It reiterates the postulation of infective necrosis as the cause. High tidal volume which he received for reasonably longer period might have additive contribution. Second postulation is damage due to shear stress at the junction of aerated and collapsed lung.[12]

To conclude, *p*ARDS may get complicated by

pseudocysts in late stages, preferentially in dependent lung regions. Ventilatory strategy of recruitment maneuvers, low ΔP (thus low plateau pressure) and low tidal volume (6-8 ml/Kg) may be more critical in the management of *p*ARDS in order to reduce the incidence of pseudocyst formation and other potential structural lung abnormalities. Surgical drainage may be considered in select cases.

Contributions: AKB; Clinical management of the patient, literature review, draft of the manuscript. SCS; Clinical management, appraisal of the manuscript, will act as gaurantor. MJ; Clinical management, appraisal of the manuscript. AKS; Radiological investigations and expert opinion thereon.

Conflict of Interest: None.

Role of Funding Source: None.

REFERENCES

1. Mercier JC, Dauger S, Durand P, Javouey E. Acute Respiratory Distress Syndrome in children. In Fuhrman BP, Zimmerman J eds. *Pediatric Critical Care*. Philadelphia, Mosby Elsevier, 2006; 731-743.
2. Treggiari MM, Romand JA, Martin JP *et al.* Air cysts and bronchiectasis prevail in nondependent areas in severe acute respiratory distress syndrome: A computed tomographic study of ventilator-associated changes. *Crit Care Med* 2002; 30: 1747-1752.
3. Goodman LR, Fumagalli R, Tagliabue P *et al.* Adult respiratory distress syndrome due to pulmonary and extrapulmonary causes: CT, clinical and functional correlations. *Radiology* 1999; 213: 545-552.
4. Curley MAQ, Hibberd PL, Fineman LD *et al.* Effect of Prone Positioning on Clinical Outcomes in Children with Acute Lung Injury: A Randomized Controlled Trial. *JAMA* 2005; 294: 229-237.
5. Baranwal AK, Singhi SC, Jayashree M. A 5-year PICU experience of Disseminated Staphylococcal Disease, Part 1: Clinical and Microbial profile. *J Trop Pediatr* 2007; 53: 245-251.
6. Imamoðlu M, Cay A, Koºucu P *et al.* Pneumatoceles in postpneumonic empyema: an algorithmic approach. *J Pediatr Surg* 2005; 40: 1111-1117.
7. Fuji AM, Moulton S. VATS management of an enlarging multicystic pneumatocele. *J Perinatol* 2008; 28: 445-447.
8. Gattinoni L, Caironi P, Pelosi P *et al.* What has computed tomography taught us about the acute respiratory distress syndrome. *Am J Respir Crit Care Med* 2001; 164: 1701-1711.
9. Gattinoni L, Bombino M, Pelosi P *et al.* Lung structure and function in different stages of severe acute respiratory distress syndrome. *JAMA* 1994; 271: 1772-1779.
10. Goldstein I, Bughalo MT, Marquette CH *et al.* Mechanical Ventilation-induced air-space enlargement during experimental pneumonia in piglets. *Am J Respir Crit Care Med* 2001; 163: 958-964.
11. Joynt GM, Antonio GE, Lam P *et al.* Late-stage adult respiratory distress syndrome caused by Severe Acute Respiratory Syndrome: Abnormal findings at thin-section CT. *Radiology* 2004; 230: 339-346.
12. Slutsky A S. Barotrauma and alveolar recruitment. *Intensive Care Med* 1993; 19: 369-371.