CASE REPORT

Successful Ventilation of Acute Respiratory Distress Syndrome Complicated by Pneumothorax Using Airway Pressure Release Ventilation: A Case Report

Sudha Chandelia[1], Sunil Kishore[2], Devki Nandan[3]

Abstract

Pneumothorax can develop in children being mechanically ventilated for 'severe acute respiratory distress syndrome' making the situation worse and challenging for the treating intensivist. There is no evidence on use of 'airway pressure release ventilation' mode in children with acute respiratory distress syndrome complicated by pneumothorax. We present a case of a girl who had severe acute respiratory distress syndrome and developed pneumothorax on pressure control ventilation mode. We had to use 'airway pressure release ventilation' mode in view of severe refractory hypoxemia. Fortunately, the child responded well and weaned off the ventilator over few days. We suggest that 'airway pressure release ventilation' mode may be used successfully in patients with 'acute respiratory distress syndrome' complicated by pneumothorax if intensive and close monitoring is done.

Keywords: Acute respiratory distress syndrome (ARDS), Airway pressure release ventilation (APRV), Pneumothorax, Pressure control ventilation (PCV)

Key messages: APRV may be a useful mode of ventilation in severe ARDS with pneumothorax

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Introduction

The effectiveness of airway pressure release ventilation (APRV) mode in mechanically ventilated children for pediatric ARDS (PARDS) is not clear. The picture gets more complicated when a patient with PARDS on mechanical ventilation develops pneumothorax. There is no evidence if APRV mode can be used in such patients. In this case we were compelled to use APRV mode for deteriorating hypoxemia as rescue therapy. ECMO could not be used. Fortunately with rigorous monitoring, the child responded well and weaned off the ventilator successfully.

Case Description

A six year old girl was admitted to our PICU for respiratory distress due to pneumonia and septic shock. She had hypoxemia refractory to oxygen therapy for which she was intubated and ventilated with pressure control ventilation (PCV) mode. She needed high settings on PCV (Fio_2-100%, PIP-30, PEEP-14, Ti-0.9 sec, RR-28/min) to maintain SpO_2 to 88%. PF ratio and oxygenation index were 70 and 21 respectively. She had to be sedated heavily and paralyzed for asynchrony. PV loop analysis suggested collapsed alveoli. Tidal volumes were low (5 mL/kg). There was no hypercarbia. She maintained blood pressure at epinephrine infusion of 0.3µg/kg/min. After 12 hours her SpO_2 fell to 70% as she developed pneumothorax of right sided lung. Immediate needle aspiration followed by intercostal chest tube drainage (ICD) was done and ventilation continued. But she could not maintain SpO_2 and continuously deteriorated. DOPE was again ruled out. A call for ECMO was sent. After one hour, her peak and plateau pressure were 30 and 26, respectively and saturation ranging from 80 to 82%. The ventilation strategy was changed to APRV mode (FiO_2 to 100%, $P_{high}25$, $P_{low}0$, $T_{high}4$, $T_{low}0.4$) to keep end expiratory flow at around 50–75% of peak expiratory flow rate. We stopped muscle relaxants and decreased sedation so that the child could breathe spontaneously. P_{high} was gradually increased by 2 mbar every 10 minutes to 30 mbar as titrating with chest rise, work of breathing and SpO_2. After half an hour, Saturation was noticed to increase from baseline. After an hour, SpO_2 was 85–87%. Close monitoring was done and after two hours SpO_2 was 88–90%. FiO_2 could be decreased to 80% after 6 hours. Meanwhile the Chest X-ray was collected which showed no pneumothorax and heterogenous opacity in whole right lung consistent with ARDS (Fig. 1). PCO_2 level was 46 with a pH 7.30. There were no further episodes of pneumothorax and child's oxygenation status got better steadily. After two days the FiO_2 could be decreased to 60% and we started weaning from APRV and epinephrine infusion. For this, T_{high} was increased and P_{high} was decreased gradually until we got a continuous pressure at 6 mbar for 15 seconds; over 5 days. The patient was given a T-piece breathing trial for two hours which she tolerated efficiently following which she was extubated as per protocol. The child was transferred to the ward in good general condition.

[1–3]Division of Pediatric Critical Care, Department of Pediatrics, ABVIMS and Dr Ram Manohar Lohia Hospital, New Delhi, India

Corresponding Author: Sudha Chandelia, Division of Pediatric Critical Care, Department of Pediatrics, ABVIMS and Dr Ram Manohar Lohia Hospital, New Delhi, India, e-mail: sudhach83@rediffmail.com

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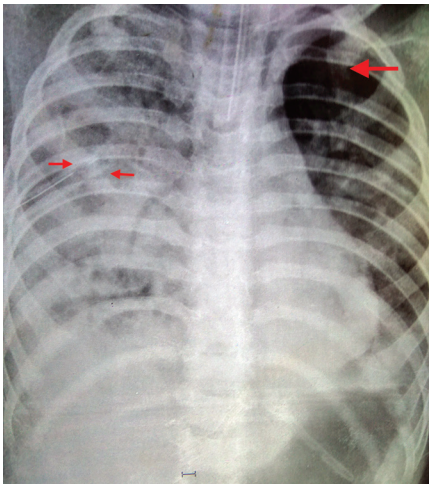

Fig. 1: Chest X-ray of the patient after intercostal chest tube drainage. Red arrow showing intercostal drainage tube on right side. The whole lung shows heterogeneous opacity. Air also seen in left pleura (red arrow)

Discussion

Pneumothorax is a critical complication in patients with ARDS on mechanical ventilation with an overall incidence of pneumothorax ranging between 12.3% and 77%[1–3] Pneumothorax increases mortality in ARDS patients (66% mortality in ARDS with pneumothorax compared to 46% in ARDS without pneumothorax (*p* value 0.01).[3] Possible mechanisms and factors have been discussed in literature.[2] Patients with ARDS have poor compliance and usually have to be treated with high pressures. This increase in alveolar pressure at some of the sensitive alveoli may result in tear in the alveolar wall and air leak. Despite of many precipitating factors, ARDS has been shown to be independently associated with occurrence of pneumothorax.[2,4] It is more common in late than early ARDS.[3] With time the lung becomes more heterogeneous with some areas of restrictive lung and some areas of emphysematous lung.[2,3,5] Therefore, bullae can form and can rupture with high pressures used to ventilate these children. The literature on guiding treatment of pneumothorax in mechanically ventilated patient is scant. It ranges from simple ICD to sclerotherapy.[6] Our patient responded to ICD drainage. The utility of APRV mode of ventilation is unclear in severe PARDS. Further, there are no recommendations on how a patient with ARDS and pneumothorax should be ventilated. APRV is a type of time triggered, pressure-controlled mode yet very different in application. Two pressure levels are applied one at a higher (P_{high}) and another at a lower level (P_{low}). P_{high} is the continuously applied pressure for a duration of 4–5 sec (i.e T_{high} for inspiration) with brief release of pressure to zero level (i.e P_{low}) for 0.4–0.5 sec (i.e T_{low}) for CO_2 removal. Its unique feature is that patient is allowed to breathe spontaneously at both pressure levels without any asynchrony/breath stacking.

As it gives a high pressure for a longer time (30 mbar for 4–5 sec in this case) and also keeps the alveoli distended at release phase (done by keeping end expiratory flow at 50-75% of peak expiratory flow rate by adjusting using T_{low}); theoretically it can cause air leak more frequently and severely as compared to other modes.

However, the evidence shows lower incidence of barotraumas in APRV mode. In a randomized controlled trial of APRV in PARDS in children, the incidence of pneumothorax was more in control group 15.4% as compared to 11.5% in APRV group.[7] Similarly in studies in adults with ARDS, the incidence of pneumothorax was lower in APRV mode.[8,9] Peak pressures are lower with APRV than with low tidal volume ventilation which may be the reason;[2] because maximum PEEP levels do not seem to increase pneumothorax incidence in ARDS patients.[10] APRV is like CPAP giving a high PEEP (P_{high}) with brief release of pressure.

We used APRV as rescue therapy when conventional ventilation failed to maintain saturation in this child. After instituting APRV there was no further episodes of air leak. There was also no worsening in hypotension. Improvement in oxygenation was prompt and sustained. We suggest that children with severe PARDS and pneumothorax that have been stabilized by intercostal drainage and have not developed bronchopleural fistula can be ventilated with APRV safely and successfully.

Conclusion

APRV may be a safe and effective mode for ventilation of ARDS complicated with pneumothorax in patients stabilized by intercostal drainage.

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