Expectant Management of Pneumothorax in Preterm Infants Receiving Assisted Ventilation: Report of 4 Cases and Review of the Literature

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Pneumothorax is a common complication in infants receiving assisted ventilation. The appropriate management of this condition is not always clearly defined, especially when a large air leak and mediastinal shift are present but the infant is hemodynamically stable. Despite the complications associated with chest tube placement, this remains the most common approach in such cases. We report 4 cases of preterm infants who developed large pneumothoraces with mediastinal shift while on assisted ventilation and were managed conservatively, with substantial improvement within 12–96 hours. In this report we also review the literature on pneumothorax in preterm infants. *Key words: pneumothorax; thoracostomy; chest drainage; preterm.* [Respir Care 2012;57(5):789–793. © 2012 Daedalus Enterprises]

Introduction

Over the last years the use of ventilatory strategies such as early nasal CPAP (nCPAP), permissive hypercapnia (pH $<$ 7.20 and P_{aCO_2} $<$ 60 mm Hg),[1] and permissive hypoxemia (arterial oxygen saturation 88–92%) has increased substantially for the management of extreme preterm infants with respiratory distress.[2,3] The goal is to provide adequate ventilation while avoiding lung injury. However, even using this more gentle ventilatory approach we have reported an incidence of pneumothorax (PTx) of 3.8–9% in infants with birth weight $<$ 1,250 g.[4,5] The management of PTx is not clearly defined in the literature, especially in symptomatic infants under assisted ventilation and with chest radiograph (CXR) showing a substantial amount of air leak and mediastinal shift but who are hemodynamically stable. In these cases the most usual treatment is the insertion of a chest tube, a procedure associated with substantial complications.[6,7] In this study we report 4 preterm infants who were successfully managed with expectant treatment of symptomatic PTx diagnosed during nCPAP, pressure controlled synchronized intermittent mandatory ventilation, or high frequency oscillatory ventilation (HFOV) therapy. The clinical and radiological findings improved within 12–96 hours after the diagnosis. Finally, we review the literature on management of symptomatic PTx in infants on assisted ventilation. This study was performed at McMaster Children's Hospital, McMaster University, Hamilton, Ontario, Canada.

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Case Report 1

This male infant was the second twin born to a 37-year-old mother at 29 weeks and 6 days of gestation, delivered by cesarean section due to breech presentation. Birth weight was 1,590 g, and Apgar scores were 8 and 9 at 1 and 5 min, respectively. nCPAP was applied at birth

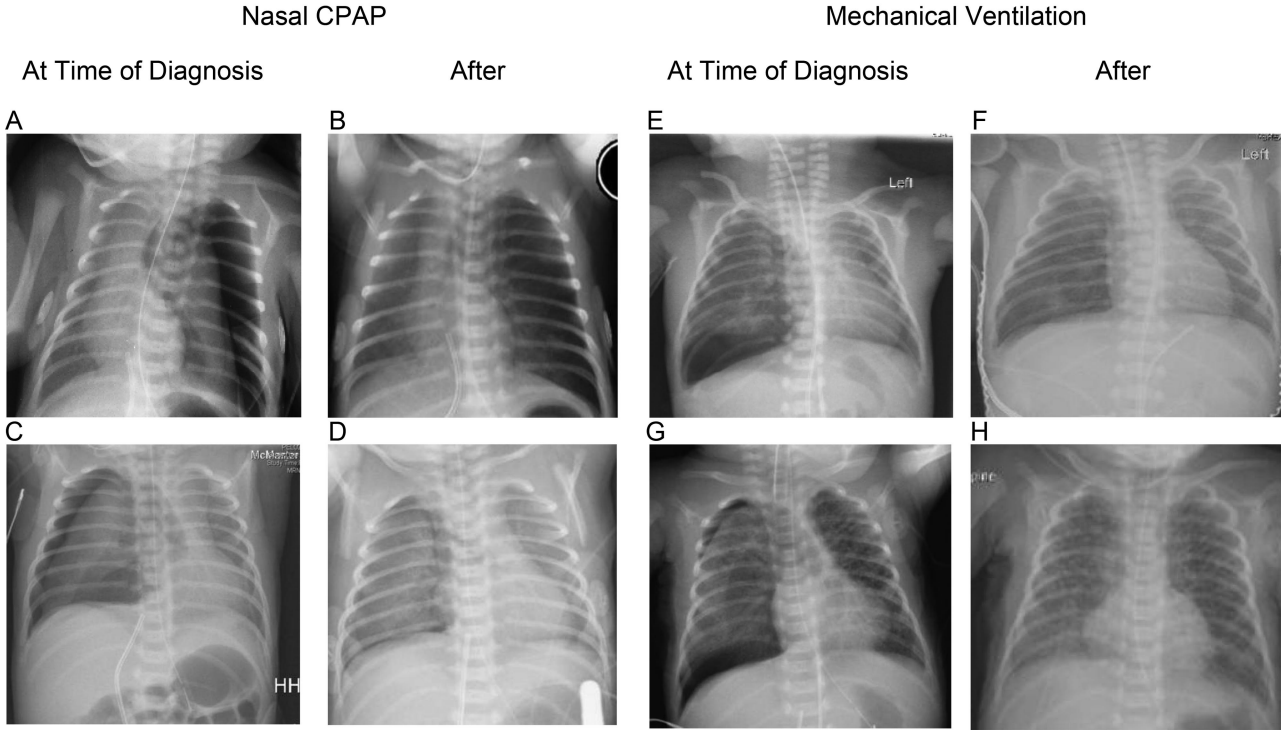

Fig. 1. Chest x-rays (CXRs) of the 4 cases. Case 1: A: Large left pneumothorax (PTx) with substantial mediastinal shift to the right. Complete collapse of the left lung. B: CXR 72 hours later showing improvement in the left PTx, with mild mediastinal deviation to the right. Case 2: C: Large right PTx with mediastinal shift to the left. D: CXR 36 hours later showing persistent but smaller right PTx with mediastinal structures at the midline. Case 3: E: Large right tension PTx with left-shifted mediastinum. F: CXR 12 hours later showing small right PTx with decreased deviation of the mediastinum. Case 4: G: Large right PTx with mild mediastinal deviation to the right. H: Resolution of right side PTx 24 hours later.

due to respiratory distress. At 3 hours of age the infant's respiratory distress worsened, requiring intubation, surfactant administration, and mechanical ventilation. He was extubated later that same day and placed on a ventilator nCPAP system, with a pressure level of 6 cm H_2O. On the following day, the pressure was increased to 7 cm H_2O to maintain oxygen saturation between 88% and 92%. Shortly thereafter the F_{IO_2} was weaned to 0.21.

On postnatal day 3, the infant's respiratory rate increased to 75 breaths/min, with mild retractions. His oxygen needs increased to F_{IO_2} 0.35. Other vital signs, such as heart rate and blood pressure, were within normal range for the gestational age. The anterior-posterior CXR showed a large left PTx with mediastinal shift (Fig. 1A). The capillary blood gas values are presented in Table 1. As the patient was hemodynamically stable, a decision was made not to insert a chest tube and closely monitor vital signs, respiratory status, and CXR.

The infant's oxygen requirement decreased to room air within 12 hours, and the tachypnea resolved within 30 hours. The capillary P_{CO_2} values remained between 49 and 57 mm Hg. Blood pressure, heart rate, and pH levels remained normal at all times. The follow-up CXR revealed no further expansion of the PTx. The degree of mediastinal shift decreased over 24 hours, and by 96 hours the PTx had markedly decreased in size (see Fig. 1B).

Weaning of the CPAP was well tolerated and discontinued 48 hours after the diagnosis of the PTx. The CXR normalized on postnatal day 10, and head ultrasound was normal. At 11 days of age the infant was transferred to the intermediate care unit, on room air and full enteral feeds.

Case Report 2

This female infant was born to a 27-year-old mother at 30 weeks gestation, delivered by cesarean section due to antepartum hemorrhage. Membranes had ruptured at 23 weeks and 5 days, and the mother had received a complete course of betamethasone. Birth weight was 1,560 g, and Apgar scores were 7 and 8 at 1 and 5 min, respectively. The infant developed early respiratory distress with grunting and was placed on nCPAP of 8 cm H_2O.

At 15 hours of age, the infant had increased work of breathing, tachypnea, and O_2 needs of F_{IO_2} 0.5 to maintain oxygen saturation between 88% and 92%. She was intubated and received 1 dose of surfactant. Thirteen hours later she was extubated to nCPAP at a pressure of 6 cm H_2O. Since F_{IO_2} was consistently around 0.4, the CPAP level

Table 1. Patient Characteristics and Pneumothorax Details

	Patient 1	Patient 2	Patient 3	Patient 4
Birth weight, g	1,590	1,560	740	1,350
Gestational age, wk	29	30	24	28
Sex	Male	Female	Male	Male
5-min Apgar score	9	8	6	9
Pneumothorax				
Age, d	3	3	1	2
Mode of ventilatory support at time of diagnosis	nCPAP	nCPAP	PC-SIMV	HFOV
Pressure level, cm H_2O	7	7	7*	7*
Maximum F_{IO_2}	0.35	0.45	0.70	0.30
Increase in F_{IO_2}, from baseline, %	67	114	No change	24
pH	7.23	7.31	7.24	NA
P_{O_2}, mm Hg	36	33	58	NA
P_{CO_2}, mm Hg	57	54	56	NA
Bicarbonate, mEq/L	23	27	23	NA
Base deficit	−5	−1	−4	NA
Site of the pneumothorax	Left	Right	Right	Right
Length of time to radiological improvement with conservative management, h	96	48	12	24

* Mean airway pressure.
nCPAP = nasal CPAP
PC-SIMV = synchronized intermittent mandatory ventilation
HFOV = high frequency oscillatory ventilation

was increased to 7 cm H_2O and subsequently the oxygen need decreased to room air. At 72 hours of life the infant became acutely tachypneic and the F_{IO_2} increased from 0.21 to 0.45. A CXR showed a large right PTx with mediastinal shift (see Fig. 1C). She was hemodynamically stable and the capillary blood gas values at the time of diagnosis are presented in Table 1. The PTx was treated conservatively.

The infant's oxygen requirement decreased to room air within 16 hours, and nCPAP was discontinued 48 hours later. At that time, CXR showed a decrease in the PTx size, with mediastinal structures at the midline (see Fig. 1D). The head ultrasound on day 5 of life showed right focal subependymal hemorrhage. On day 22 the infant was transferred to the intermediate care unit, on room air and full enteral feeds.

Case Report 3

This male infant was born to a 37-year-old mother at 24 weeks and 6 days, by vaginal delivery. There was premature rupture of membranes at 23 weeks, and the mother received antibiotics for suspected chorioamnionitis, as well as a complete course of betamethasone. Birth weight was 740 g, and Apgar scores were 3, 6, and 9 at 1, 5, and 10 min, respectively. The infant was intubated in the delivery room due to poor respiratory effort and transferred to the neonatal ICU.

Initial arterial blood gas under mechanical ventilation revealed pH 7.09, P_{CO_2} 78 mm Hg, P_{O_2} 56 mm Hg, HCO_3^- 23 mEq/L, and base excess 9 mEq/L. Early surfactant was administered, but oxygen requirements remained high. A CXR was performed and showed a right-sided large PTx with left shifted mediastinum (see Fig. 1E). F_{IO_2} at this point was between 0.60 and 0.70, but the infant was hemodynamically stable with mean blood pressure and heart rate within normal range. Ventilatory settings and arterial blood gas at the time of diagnosis are presented in Table 1. Expectant management was established and the infant was closely monitored. Subsequently the F_{IO_2} was weaned, and within 4 hours the infant was on room air. Follow-up CXR (12 h later) showed substantial improvement of the air leak (see Fig. 1F).

The infant was extubated on the third day of life to noninvasive ventilation, and remained in the neonatal ICU until 36 weeks corrected age (breathing spontaneously and on room air), when he was transferred to the intermediate care unit on full enteral feeds. All head ultrasounds were normal.

Case Report 4

This male infant was the first twin born to a 35-year-old mother at 28 weeks gestation by cesarean section, due to poor growth of the other twin. The mother received a complete course of betamethasone. Birth weight was 1,350 g, and Apgar score was 7 and 9 at 1 and 5 min, respectively. The infant was started on nCPAP in the delivery room, for respiratory distress.

On the first day of life he remained on nCPAP of 6 cm H_2O, with normal oxygen saturation and blood gases, and low oxygen requirements. At 36 hours of age, oxygen requirements increased acutely and immediate intubation was necessary. A CXR showed bilateral PTx, and chest tubes were inserted on both sides. The infant received 1 dose of surfactant. Subsequently, he developed respiratory acidosis (pH 6.92 and P_{CO_2} 115 mm Hg) and was switched to HFOV. He developed mild hypotension that was managed with volume infusions and dopamine. Over the next 3 days the right PTx re-accumulated, necessitating the placement of a second chest tube. At one point the infant had 3 chest tubes: one on the left and 2 on the right side.

On day 5 of life the CXR showed that a large right PTx with mediastinal deviation was still present, despite that the chest tube was appropriately positioned. Therefore a decision was made to remove the chest tube and manage

the PTx conservatively. The patient was monitored clinically and radiologically, and on the following day the right PTx was unchanged in size (see Fig. 1G). Since the infant remained very stable and on minimal HFOV settings, he was extubated to nCPAP (see Table 1). On the following day the PTx resolved (see Fig. 1H). Head ultrasounds were normal. He was transferred to the intermediate care unit at 38 weeks corrected age, on room air and full enteral feeds.

Discussion

PTx is a serious complication that has been reported to occur in 3–9% of very low birth weight infants and is associated with increased mortality and morbidity.[8–10] From the available scientific literature it is not known when a PTx will rapidly progress and compromise cardiorespiratory stability or resolve spontaneously in infants under positive airway pressure.[11] Usually, no specific treatment is necessary for infants with asymptomatic PTx without underlying pulmonary disease, and needle aspiration has been recommended in infants with mild to moderate symptoms.[6,7,12] Up to recently it was well accepted that a chest tube should be inserted in symptomatic ventilated patients, since a more conservative treatment for those neonates has not included infants receiving mechanical ventilation.[13,14] Litmanovitz and Carlo did a retrospective analysis of expectant management in ventilated neonates with symptomatic PTx and documented for the first time the safety of this approach.[15] In their center, as in our unit, the decision for an expectant treatment was made by the medical team, based on clinical assessment of each patient. Overall, 15% of the infants were successfully managed without a chest tube insertion.

In this study the first 2 neonates had the diagnosis of PTx at day 3 of life, while on nCPAP therapy. In a recent case-control study, 91% of the infants started on nCPAP after birth were already intubated when PTx was diagnosed.[10] For the infants on nCPAP therapy at the time of diagnosis, the median age was 31.3 hours (2–3 days). In the Continuous Positive Airway Pressure or Intubation at Birth (COIN) trial, 18% of the PTx of infants started on nCPAP were detected on day 3 of life, but the mode of support at the time of diagnosis was not reported.[9] Interestingly, only 1 out 28 patients (4%) who developed PTx in the CPAP group was not intubated. None of the studies described how the PTx was treated. In our 2 infants on nCPAP at time of diagnosis, the expectant management of the PTx was successful, despite the large PTx size on CXR and substantial increases in baseline oxygen requirements. This was probably related to the fact that our infants were more mature and had higher birth weights than the infants of the 2 above-mentioned studies. The 2 cases of PTx in infants receiving mechanical ventilation were diagnosed at day 1 and day 2 of life. As reported by Litmanovitz and Carlo, expectant management was more common in ventilated infants with the diagnosis of PTx early in life.[15] Also, similar to our 2 cases, expectant management was successful in infants under lower ventilatory settings and with better blood gases at the time PTx was diagnosed (see Table 1). In our experience, expectant management failed in patients receiving high levels of oxygen supplementation or ventilatory support, or who developed progressive increases in oxygen needs, CO_2 retention, and/or respiratory distress. Continuous and careful assessment will detect this clinical deterioration. We experienced this situation in 2 cases (not in this report), where the insertion of a chest tube was necessary.

The length of time for the clinical and radiological resolution of PTx when expectant management is used has never been reported, and to our knowledge our study is the first to provide this information. We observed the resolution of clinical symptoms and CXR findings between 48 hours and 96 hours after the diagnosis, for the infants on nCPAP, and between 12 hours and 24 hours for the infants on mechanical ventilation. The fourth case of this series describes a very particular case of an infant with a substantial right side PTx under HFOV, and highlights the difficulties associated with multiple and recurrent chest tube insertions. Since the air leak was not improving, we decided to remove the chest tube and observe. Twenty-four hours later the infant remained stable and was extubated to nCPAP. No air leak was observed after 24 hours on nCPAP.

We were prompted to describe our small experience because it adds more information to the tiny literature of PTx in preterm infants, mostly on the expectant management of these cases. In addition, this is a critical issue, since the performance of a tube thoracostomy is a procedure with potential complications, especially in premature infants with small hemithoraces and narrow intercostal spaces.[16–20]

In conclusion, in this study we reported 4 preterm infants who developed significant PTx while receiving positive airway pressure (nCPAP or mechanical ventilation) and were successfully and safely treated with expectant management. The length of time required for the resolution of the PTx with this conservative approach was between 12 and 96 hours. Our experience confirms previous findings that an expectant treatment may be beneficial in some particular cases. Well designed prospective studies are necessary to better define the indications for performing a tube thoracostomy on preterm infants, as well as complications and relevant outcomes associated with this management.

REFERENCES

1. Thome UH, Carlo WA. Permissive hypercapnia. Semin Neonatol 2002;7(5):409-419.

2. Ambalavanan N, Carlo WA. Ventilatory strategies in the prevention and management of bronchopulmonary dysplasia. Semin Perinatol 2006;30(4):192-199.
3. SUPPORT Study Group of the Eunice Kennedy Shriver NICHD Neonatal Research Network; Finer NN, Carlo WA, Walsh MC, Rich W, Gantz MG, Laptook AR, et al. Early CPAP versus surfactant in extremely preterm infants. The N Engl J Med 2010;362(21): 1970-1979.
4. Hermeto F, Bottino MN, Vaillancourt K, Sant'Anna GM. Implementation of a respiratory therapist-driven protocol for neonatal ventilation: impact on the premature population. Pediatrics 2009;123(5): e907-e916.
5. Ratchada K, Rahman A, Pullenayegum EM, Sant'Anna GM. Positive airway pressure levels and pneumothorax: a case-control study in very low birth weight infants. J Matern Fetal Neonatal Med 2011; 24(7):912-916.
6. Arda IS, Gürakan B, Alíefendíoğlu D, Tüzün M. Treatment of pneumothorax in newborns: use of venous catheter versus chest tube. Pediatr Int 2002;44(1):78-82.
7. Troug WE, Golombek SG. Principles of management of respiratory problems. In: Avery GB FM, MacDonald MG, editors. Avery's neonatology: pathophysiology and management Philadelphia: Lippincott, Williams & Wilkins; 2005:618-619.
8. Walker MW, Shoemaker M, Riddle K, Crane MM, Clark R. Clinical process improvement: reduction of pneumothorax and mortality in high-risk preterm infants. J Perinatol 2002;22(8):641-645.
9. Morley CJ, Davis PG, Doyle LW, Brion LP, Hascoet JM, Carlin JB. Nasal CPAP or intubation at birth for very preterm infants. N Engl J Med 2008;358(7):700-708.
10. Bhatia R, Davis PG, Doyle LW, Wong C, Morley CJ. Identification of pneumothorax in very preterm infants. J Pediatr 2011;159(1):115-120.e1.
11. McIntosh N, Becher JC, Cunningham S, Stenson B, Laing IA, Lyon AJ, et al. Clinical diagnosis of pneumothorax is late: use of trend data and decision support might allow preclinical detection. Pediatr Res 2000;48(3):408-415.
12. Carlo WA, Martin RJ, Fanaroff AA. Assisted ventilation and complications of respiratory distress. In: Martin RJ, Fanaroff AA, Walsh MC, editors. Fanaroff and Martin's neonatal-perinatal medicine: diseases of the fetus and infant. St Louis: Mosby Elsevier; 2006:1122-1145.
13. Katar S, Devecioğlu C, Kervancıoğlu M, Ülkü R. Symptomatic spontaneous pneumothorax in term newborns. Pediatr Surg Int 2006; 22(9):755-758.
14. Trevisanuto D, Doglioni N, Ferrarese P, Vedovato S, Cosmi E, Zanardo V. Neonatal pneumothorax: comparison between neonatal transfers and inborn infants. J Perinatal Med 2005;33(5):449-454.
15. Litmanovitz I, Carlo WA. Expectant management of pneumothorax in ventilated neonates. Pediatrics 2008;122(5):e975-e979.
16. Quak JM, Szatmari A, van den Anker JN. Cardiac tamponade in a preterm neonate secondary to a chest tube. Acta Paediatr 1993;82(5): 490-491.
17. Odita JC, Khan AS, Dincsoy M, Kayyali M, Masoud A, Ammari A. Neonatal phrenic nerve paralysis resulting from intercostal drainage of pneumothorax. Pediatr Radiol 1992;22(5):379-381.
18. Brooker RW, Booth GR, DeMello DE, Keenan WJ. Unsuspected transection of lung by pigtail catheter in a premature infant. J Perinatol 2007;27(3):190-192.
19. Landay M, Oliver Q, Estrera A, Friese R, Boonswang N, DiMaio JM. Lung penetration by thoracostomy tubes: imaging findings on CT. J Thorac Imaging 2006;21(3):197-204.
20. Arya H, Williams J, Ponsford SN, Bissenden JG. Neonatal diaphragmatic paralysis caused by chest drains. Arch Dis Child 1991; 66(4 Spec No):441-442.