Original article

<http://dx.doi.org/10.5385/jksn.2011.18.2.257>
pISSN 1226-1513 • eISSN 2093-7849

Characteristics of Pneumothorax in a Neonatal Intensive Care Unit

Ho Seop Lim, M.D., Ho Kim, M.D., Jang Yong Jin, M.D., Young Lim Shin, M.D., Jae Ock Park, M.D., Chang Hwi Kim, M.D. and Sung Shin Kim, M.D.

Department of Pediatrics, College of Medicine, Soonchunhyang University, Bucheon, Korea

Purpose: The development of postnatal pneumothorax and its common causes and clinical aspects were studied to promote early diagnosis and proper management.

Methods: A retrospective study of neonates who were hospitalized in the neonatal intensive care unit at Soonchunhyang University Bucheon Hospital from 2001 to 2010 was performed. Term neonates were divided into a spontaneous pneumothorax group and a secondary pneumothorax group. The secondary group was divided into term and preterm groups.

Results: Of 4,414 inpatients, 57 (1.3%) were diagnosed with pneumothorax. Of term newborn patients, 28 (80%) had a secondary pneumothorax, and seven (20%) had a spontaneous pneumothorax. No differences were observed for gender, birth weight, resuscitation, or duration of admission between the spontaneous and control groups. The duration of treatment with a thoracostomy (20 patients, 57%) was longer in the spontaneous group (5.4 ± 2.9 days vs. 2.7 ± 2.0 days) than that in the control group. Patients with respiratory distress syndrome (RDS) developed a pneumothorax 22.8 hours after surfactant treatment, whereas patients with transient tachypnea of the newborn (TTN), pneumonia, and meconium aspiration syndrome (MAS) developed pneumothorax after 16.6 hours. Of 50 patients with a secondary pneumothorax, 19 (38%) had RDS, 11 (22%) had MAS, 7 (14%) had TTN, and six (12%) had pneumonia. Among term newborns, 42.9% were treated only with 100% oxygen. Among preterm newborns, 72.6% and 27.3% needed a thoracostomy or ventilator care, respectively.

Conclusion: A pneumothorax is likely to develop when pulmonary disease occurs in neonates. Therefore, it is important to carefully identify pneumothorax and provide appropriate treatment.

Key Words: Pneumothorax, Neonate, Respiratory distress syndrome, Meconium aspiration syndrome

Introduction

Pneumothorax is defined as the presence of air between the visceral and parietal pleura, and it leads to lung collapse. Air leaks through holes in lung tissue into the spaces outside the lung airways. A tension pneumothorax is caused when air enters the pleural space during inspiration but cannot exit during exhalation. The positive pressure results in collapse

of the involved lung and a shift of the mediastinal structure to the contralateral side, leading to a decrease in cardiac output as a result of decreased venous return¹⁾. Pneumothorax occurs during the neonatal period more commonly than in any other time of life. A pneumothorax in term newborns is mostly asymptomatic; however, in ventilated preterm newborns, a pneumothorax can cause a tension pneumothorax and acute respiratory decompensation²⁾. The risk for

Received: 17 September 2011, Revised: 7 October 2011, Accepted: 10 November 2011

Correspondence to: Sung Shin Kim, M.D.

Department of Pediatrics, Soonchunhyang University Hospital, 1174 Jung-dong, Wonmi-gu, Bucheon 420-767, Korea
Tel: +82-32-621-5400, Fax: +82-32-621-5662, E-mail: kimss@schmc.ac.kr

pneumothorax increases in infants with respiratory distress syndrome (RDS), meconium aspiration syndrome (MAS), and pulmonary hypoplasia and in infants who require resuscitation at birth³. Continuous positive airway pressure and high inspiratory pressure ventilation further increase the incidence of pneumothorax⁴. Surfactant, the use of synchronized or volume ventilation, and high-rate low-tidal-volume ventilation decrease the incidence of pneumothorax⁵. In this study, the development of postnatal pneumothorax along with its common causes and the clinical aspects of each cause were studied to promote early diagnosis and improve treatment effectiveness.

Materials and Methods

We reviewed the medical records of all hospitalized infants in the neonatal intensive care unit (NICU) with a radiographically confirmed pneumothorax at the Soonchunhyang University Bucheon Hospital between March 2001 and June 2010 (9 years and 3 months). Spontaneous pneumothorax was defined as an intrapleural air collection in the absence of intubation, positive ventilation, or underlying pulmonary pathology. Secondary pneumothorax was defined as that with underlying lung pathology. Term newborn patients with a pneumothorax were divided into a spontaneous pneumothorax group and a secondary pneumothorax group. The secondary pneumothorax group was further divided into term and preterm neonate groups. Data analysis included gestational age, birth weight, birth place, type of delivery, gender, Apgar score, maternal age, resuscitation type, side of pneumothorax, causes of pneumothorax, accompanying disorders, type of management, time to diagnosis, and mean hospital stay. Time to diagnosis was determined from the nursing and medical notes and the time radiographs were taken. Oxygen treatment was administered to maintain oxygen saturation of 90–95%; a tube thoracostomy was performed in patients with severe respiratory difficulty. Mechanical ventilation was performed in patients with severe respiratory difficulty and low oxygen saturation after supplemental oxygen. Statistical analysis was performed

using Student's t-test, the chi-square test, and a multivariate logistic regression model using SPSS 12.0 (SPSS Inc., Chicago, IL, USA). Results are presented as mean±SD for continuous variables. $P<0.05$ was considered statistically significant. This study was approved by the Institutional Review Board at Soonchunhyang University Bucheon Hospital.

Results

1. Incidence

During the study period, 4,414 infants were admitted to the NICU. A pneumothorax was identified in 57 patients (term, 35 vs. preterm, 22), giving a 1.3% incidence. All seven patients with a spontaneous pneumothorax were term newborns. Of the 35 term newborn patients, seven (20%) had a spontaneous pneumothorax, and 28 (80%) had a secondary pneumothorax (Table 1).

Table 1. Baseline Characteristics of Pneumothorax in Term Infants

	Spontaneous Pneumothorax	Secondary Pneumothorax	<i>P</i>
No.	7 (20%)	28 (80%)	
Sex (M:F)	4:3	16:12	0.668
Birth weight (g) (mean±SD)	3425.7±316.9	3067.9±476.5	0.070
Type of delivery (C/sec:NSVD)	3:4	17:11	0.332
Gestational age (weeks) (mean±SD)	38.9±1.4	38.9±1.1	0.883
Maternal age (years) (mean±SD)	31.1±3.1	31.5±4.5	0.829
Apgar score			
1 min	7.6±1.7	7.2±1.9	0.316
5 min	9.0±1.0	8.5±1.6	0.617
Resuscitation, No (%)			
None	5 (71.4)	16 (57.1)	0.582
O ₂	2 (28.6)	4 (14.3)	
Bag and mask	0 (0.0)	2 (5.7)	
Intubation	0 (0.0)	4 (11.4)	
Cardiac massage	0 (0.0)	2 (5.7)	
Birth place (in:out)	1:6	11:17	0.217
Ventilator, No (%)			
+	0 (0.0)	7 (100.0)	0.176
-	7 (25.0)	21 (75.0)	

Data expressed as number (%).

Abbreviations: C/sec, cesarean section; NSVD, normal spontaneous vaginal delivery.

2. Clinical characteristics

1) Pneumothorax in term infants

No statistically significant differences were observed for gender, gestational age, type of delivery, maternal age, resuscitation, birth place, duration of treatment, duration of admission, or location of pneumothorax between the spontaneous and control groups in term infants (Tables 1 and 2). The mean birth weight of the spontaneous pneumothorax group ($3,425.7 \pm 316.9$ g) tended to be higher than that of the secondary group ($3,067.9 \pm 476.5$ g) ($P=0.070$) (Table 1).

Of term infants with a secondary pneumothorax in, seven (25.0%) were treated with mechanical ventilation (Table 1). No patients in the spontaneous pneumothorax group needed mechanical ventilation. But, this did not reach statistical significance ($P=0.176$).

Pneumothorax tended to occur earlier after birth in term infants of the secondary pneumothorax group compared with the spontaneous pneumothorax group (15.6 ± 17.3 hours vs. 18.9 ± 10.7 hours, respectively), but this did not reach statistical significance (Table 2). The systolic and diastolic blood pressures were significantly lower in the

secondary pneumothorax group than those in the spontaneous pneumothorax group at the onset of pneumothorax ($P=0.044$ and $P=0.005$, respectively). However, the systolic and diastolic blood pressures in the two groups were within the normal range according to gestational age (Table 2). Patients in the secondary pneumothorax group tended to have a longer hospital stay than those in the spontaneous group (12.8 ± 8.8 days vs. 9.7 ± 4.9 days, respectively), but this did not reach statistical significance (Table 2). Bilateral pneumothorax developed in 14.3% of patients in both groups. The major side was right dominant in both groups (Table 2). Only one (14.3%) patient's condition in the spontaneous pneumothorax group resolved with only supplemental oxygen therapy, whereas 12 (42.9%) resolved with only supplemental oxygen therapy in the secondary pneumothorax group (Table 3). Five patients (71.5%) in the spontaneous group underwent a thoracostomy and mechanical ventilation. Fifteen patients in the secondary pneumothorax group (53.6%) required a thoracostomy, and 12 (42.9%) needed mechanical ventilation (Table 3). The duration of treatment with supplemental oxygen only, tube thoracostomy, and ventilator did not differ between the two groups (Table 3). The elapsed time for full treatment with thoracostomy (20 patients, 57%) was significantly longer in the spontaneous

Table 2. Clinical Characteristics of Pneumothorax in Term Infants

	Spontaneous Pneumothorax (n=7)	Secondary Pneumothorax (n=28)	P
Onset (hours) (mean $\pm$ SD)	18.9 $\pm$ 10.7	15.6 $\pm$ 17.3	0.627
Admission duration (days) (mean $\pm$ SD)	9.7 $\pm$ 4.9	12.8 $\pm$ 8.8	0.388
Location			
Right	4 (57.1)	18 (64.3)	0.918
Left	2 (28.6)	6 (21.4)	
Bilateral	1 (14.3)	4 (14.3)	
Pneumomediastinum	0 (0.0)	3 (10.7)	0.501
Hypotension	0 (0.0)	0 (0.0)	
Blood pressure (mmHg) (mean $\pm$ SD)			
Systolic	74.6 $\pm$ 5.9	67.4 $\pm$ 98.5	0.044
Diastolic	49.9 $\pm$ 4.7	41.9 $\pm$ 6.5	0.005

Data expressed as number (%).

Table 3. Treatment of Pneumothorax in Term Infants

	Spontaneous Pneumothorax (n=7)	Secondary Pneumothorax (n=28)	P
Oxygen	1 (14.3)	12 (42.9)	0.163
Tube Thoracostomy	5 (71.5)	15 (53.6)	
+Oxygen	1 (14.3)	4 (14.3)	
+HFOV	2 (28.6)	1 (3.6)	
+SIMV	2 (28.6)	10 (35.7)	0.529
HFOV	0 (0.0)	0 (0.0)	
SIMV	1 (14.3)	1 (3.6)	
Duration of treatment (days)	4.0 $\pm$ 2.5	3.4 $\pm$ 2.0	0.033
Tube Thoracostomy	5.4 $\pm$ 2.9 (n=5)	2.7 $\pm$ 2.0 (n=15)	
Oxygen only	3.0 (n=1)	3.5 $\pm$ 2.1 (n=12)	
Ventilator only	2.0 (n=1)	3.0 (n=1)	0.824

Data expressed as number (%).

Abbreviations: HFOV, high-frequency oscillatory ventilation; SIMV, synchronized intermittent mandatory ventilation.

pneumothorax group than that in the secondary pneumothorax group (5.4 ± 2.9 days vs. 2.7 ± 2.0 days, respectively) ($P=0.033$) (Table 3).

Perinatal risk factors were rare in patients with a spontaneous pneumothorax (Table 4). In terms of perinatal risk factors for a secondary pneumothorax, 10 patients (35.7%) had meconium staining and three (10.7%) had perinatal asphyxia.

Two patients died, but pneumothorax was not the direct cause.

In terms of pulmonary disease preceding secondary pneumothorax, Mean developmental time for a pneumothorax in patients with MAS, pneumonia, and transient tachypnea of the newborn (TTN) was 14.3 ± 18.2 hours. Patients with RDS developed a pneumothorax following treatment with surfactant after 22.8 ± 6.0 hours (Table 5).

2) Secondary pneumothorax

The secondary pneumothorax group was divided into

Table 5. Time of Diagnosis by Radiographs of Secondary Pneumothorax according to Associated Pulmonary Conditions in Term Infants

	Time (hours) (mean $\pm$ SD)
Mean onset time	14.3 ± 18.2
Meconium aspiration syndrome	15.6 ± 23.4
Pneumonia	6.6 ± 5.1
TTN	16.6 ± 11.4
RDS (after surfactant use)	22.8 ± 6.0

Abbreviations: TTN, transient tachypnea of the newborn; RDS, respiratory distress syndrome.

Table 4. Perinatal Characteristics of Pneumothorax in Term Infants

	Spontaneous Pneumothorax (n=7)	Secondary Pneumothorax (n=28)
Perinatal asphyxia	1 (14.3)	3 (10.7)
PROM	0 (0)	2 (7.1)
Meconium staining	0 (0)	10 (35.7)
Oligohydramnios	1 (14.3)	0 (0)
Pre-eclampsia	0 (0)	1 (3.6)
Fetal distress	0 (0)	2 (7.1)
IUGR	0 (0)	1 (3.6)
None	5 (71.4)	12 (42.9)

Data expressed as number (%).

Abbreviations: PROM, premature rupture of membranes; IUGR, intrauterine growth retardation.

term and preterm neonate groups. Twenty-eight patients (56%) were in the term neonate group, and 22 patients (44%) were in the preterm neonate group. The mean birth weight of the term neonate group (3067.9 ± 476.5 g) was significantly higher than that of the preterm neonate group (2119.1 ± 697.3 g) ($P<0.0001$). The term neonate group had a longer gestational age than did the preterm neonate group (38.9 ± 1.1 weeks vs. 32.5 ± 3.0 weeks) ($P<0.0001$). No statistically significant differences in resuscitation were observed between the term neonate and control groups. More infants in the term neonate group (17/28, 60.7%) were delivered in an area outside the hospital, whereas the majority of preterm neonates were delivered in the hospital (18/22, 81.8%) ($P=0.003$) (Table 6).

Eighteen patients (81.8%, $P<0.0001$) in the preterm neonate group were treated with mechanical ventilation (Table 6). Pneumothorax occurred earlier in the term neonate group

Table 6. Baseline Characteristics of Secondary Pneumothorax

	Term	Preterm	P
No.	28 (56)	22 (44)	
Sex (M:F)	16:12	16:6	0.200
Birth weight (g)(mean $\pm$ SD)	3067.9 ± 476.5	2119.1 ± 697.3	<0.0001
Type of delivery (C/sec:NSVD)	17:11	18:4	0.095
Gestational age (weeks) (mean $\pm$ SD)	38.9 ± 1.1	32.5 ± 3.0	<0.0001
Maternal age (years) (mean $\pm$ SD)	31.5 ± 4.5	31.6 ± 5.3	0.968
Apgar score			
1 min	7.2 ± 1.9	8.5 ± 1.6	0.135
5 min	6.4 ± 1.7	8.1 ± 1.0	0.260
Resuscitation, No (%)			
None	16 (57.1)	5 (22.7)	0.096
O ₂	4 (14.3)	6 (27.3)	
Bag and mask	2 (7.1)	6 (27.3)	
Intubation	4 (14.3)	4 (18.2)	
Cardiac massage	2 (7.1)	1 (4.5)	
Birth place (in:out)	11:17	18:4	0.003
Ventilator, No (%)			
+	7 (25.0)	18 (81.8)	<0.0001
-	21 (75.0)	4 (18.2)	

Data expressed as number (%).

Abbreviations: C/sec, cesarean section; NSVD, normal spontaneous vaginal delivery.

(15.6±17.3 hours vs. 28.2±13.1 hours, respectively; $P=0.007$) than that in the preterm group. Admission duration was longer for the preterm than for the term neonate group (31.2±27.6 days vs. 12.8±8.8 days; $P=0.002$) (Table 7). Blood pressures in two groups were within normal range for gestational age (Table 7). Twelve patients (42.9%) in the term neonate group had their condition resolve with only supplemental oxygen therapy numbered vs. zero in the preterm neonate group (Table 8). Most patients required a thoracostomy and mechanical ventilation in the preterm neonate group ($P=0.003$) (Table 8). The time of development and full treatment of

Table 7. Clinical Characteristics of Secondary Pneumothorax

	Term (n=28)	Preterm (n=22)	P
Onset (hours) (mean±SD)	15.6±17.3	28.2±13.1	0.007
Admission duration (days) (mean±SD)	12.8±8.8	31.2±27.6	0.002
Location			
Right	18 (64.3)	19 (86.4)	0.166
Left	6 (21.4)	1 (4.5)	
Bilateral	4 (14.3)	2 (9.1)	
Pneumomediastinum	3 (10.7)	3 (13.6)	0.543
Hypotension	0 (0.0)	0 (0.0)	
Blood pressure (mmHg) (mean±SD)			
Systolic	67.4±8.5	63.9±11.4	0.210
Diastolic	41.9±6.5	36.4±7.4	0.007

Data expressed as number (%).

Table 8. Treatment of Secondary Pneumothorax

	Term (n=28)	Preterm (n=22)	P
Oxygen	12 (42.9)	0 (0.0)	0.003
Tube Thoracostomy	15 (53.6)	16 (72.6)	
+Oxygen	4 (14.3)	1 (4.5)	
+HFOV	1 (3.6)	1 (4.5)	
+SIMV	10 (35.7)	14 (63.6)	
HFOV	0 (0.0)	2 (9.1)	
SIMV	1 (3.6)	4 (18.2)	
Duration of treatment (days)	3.4±2.0	3.7±2.0	0.662
Tube Thoracostomy	2.7±2.0 (n=15)	4.2±2.8 (n=16)	0.111
Oxygen only	3.5±2.1 (n=12)	0 (n=0)	
Ventilator only	3.0 (n=1)	1.7±1.0 (n=6)	0.286

Data expressed as number (%).

Abbreviations: HFOV, high-frequency oscillatory ventilation; SIMV, synchronized intermittent mandatory ventilation.

pneumothorax after thoracostomy were longer for the preterm than for the term neonate group (4.2±2.8 days vs. 2.7±2.0 days, $P=0.111$, respectively) (Table 8). Independent predictors of gestational age were analyzed using a multivariate logistic regression model. Birth weight (odds ratio [OR], 1.005; 95% confidence interval [CI], 1.000–1.010) and onset time of pneumothorax (OR, 0.830; 95% CI, 0.702–0.980) reached statistical significance, but the others did not (Table 9).

MAS, pneumonia, and TTN were more frequent in the term neonate group than those in the preterm neonate group, and RDS was more frequent in the preterm neonate group than that in the term neonate group (Table 10).

Discussion

Pneumothorax is a common and potentially life-threatening condition for patients in the NICU. The incidence of pneumothorax is 0.5–1% in term newborns⁶⁾, as high as 13% in infants weighing 501–750 g, and 2% in infants weighing 1,251–

Table 9. Independent Predictors of Gestational Age in the Multivariate Logistic Regression Model

	OR	95% CI	P
Birth weight	1.005	1.000–1.010	0.041
Birth place (in:out)	11.314	0.345–370.788	0.173
Ventilator treatment, No	0.221	0.011–4.543	0.328
Onset time of pneumothorax	0.830	0.702–0.980	0.028
Type of management	0.158	0.023–1.086	0.061
Duration of treatment	1.071	0.947–1.211	0.272

Abbreviations: OR, odds ratio; CI, confidence interval.

Table 10. Associated Conditions of Secondary Pneumothorax

	Term (n=28)	Preterm (n=22)	Total
Meconium aspiration syndrome	11 (39.3)	0 (0.0)	11 (22.0)
Pneumonia	4 (14.3)	2 (9.1)	6 (12.0)
TTN	6 (21.4)	1 (4.5)	7 (14.0)
RDS	2 (7.1)	17 (77.3)	19 (38.0)
Positive ventilation	2 (7.1)	0 (0.0)	2 (4.0)
Ventilator	3 (10.7)	2 (9.1)	5 (10.0)

Data expressed as number (%).

Abbreviations: TTN, transient tachypnea of the newborn; RDS, respiratory distress syndrome.

1,500 g⁷). Pneumothorax occurs far more frequently during the neonatal period than at any other time of life and is most often seen in the first 3 days of life.

In this study, pneumothorax was most often seen in the first 2 days. Although several interventions and disease states markedly increase the risk of pulmonary air leaks, pneumothorax also occurs spontaneously in full-term infants during the first few breaths⁸). It often presents soon after birth with varying degrees of respiratory distress⁹). Pneumothorax should be suspected in any infant with respiratory disease whose condition suddenly deteriorates. Tachypnea is a characteristic finding and may be accompanied by grunting and increasing pallor and cyanosis. Early recognition and treatment are beneficial to avoid damage as a result of hypoxemia, hypercapnia, and impaired venous return⁵). The risk of developing pneumothorax during the neonatal period is great due to the greater frequency of respiratory failure at this age. Consequently, the use of ventilatory support and neonatal resuscitation procedures with positive pressure is deemed necessary. In our study, 18 preterm neonates (81.8%, $P=0.000$) in the secondary pneumothorax group required mechanical ventilation. Powers et al.¹⁰) reported that infants <1,500 g who were diagnosed with pneumothorax during the first 24 hours of life were 13 times more likely to die or develop bronchopulmonary dysplasia. Clinicians must improve mechanical ventilator strategies to reduce pulmonary complications and improve long-term outcomes. Studies have recently shown some form of air leak in 4–9% of newborns with RDS^{11–14}). In our study involving 1,496 newborns with RDS who received surfactant treatment, 1.3% developed a pneumothorax, which was a significantly lower incidence than has been reported. In a retrospective study, Madansky et al.¹⁵) found some form of air leak among 41% of newborns diagnosed with MAS, whereas patients with transient tachypnea presented a 10% incidence of air leaks. Jung et al. reported a pneumothorax incidence of 12.1% among newborns diagnosed with RDS¹⁶). In the present study, the incidence of pneumothorax was 1.3% in NICU patients. Among the patients with secondary pneumothorax, 19 (38.0%) had RDS, 11 (22.0%) had MAS, seven (14%) had TTN, and six

(12.0%) had pneumonia.

Choi et al.¹⁷) reported perinatal characteristics of meconium aspiration in 21% of patients, premature rupture of membranes (PROM) in 21%, oligohydramnios in 17%, pre-eclampsia in 13%, and perinatal asphyxia in 56%. In the present study, meconium staining (28.6%), perinatal asphyxia (11.4%), PROM (5.7%) and fetal distress (5.7%) occurred in the term neonate pneumothorax group. Pneumothorax during respiratory distress is associated with an increased risk for intraventricular hemorrhage, chronic lung disease, and death¹⁸). Our results showed that 7.1% of 56 infants with pneumothorax developed a germinal matrix hemorrhage (data not shown).

Abnormalities in epithelial-mesenchymal interactions, such as impaired development of type IV collagen, may contribute to pulmonary hypoplasia and urinary tract anomalies. Bashour and Balfe¹⁹) found that 19% of neonates with a spontaneous pneumothorax had congenital major urinary tract anomalies (CMUTA) and died of pulmonary hypoplasia within the first 24 hours of life. Al Tawil et al.²⁰) reported that 1.7% of patients with pneumothorax had CMUTA, as revealed by renal ultrasound. This finding was comparable to the 1.4% CMUTA reported in healthy newborn infants²¹). In our study, only one of 36 (2.7%) infants who underwent abdominal ultrasonography showed left hydronephrosis and ureteral dilatation (Vesicoureteral reflux, grade IV). According to our data and those of other researchers, a screening ultrasound of the urinary tract may not be indicated in newborn patients with a pneumothorax. Pneumothorax in an infant can be virtually asymptomatic or may be associated with severe circulatory disturbances including hypotension and hypoperfusion. Systemic hypotension results (air block syndrome when there is sufficient intrathoracic pressure to severely compress the intrathoracic vessels)²²). Our results showed that 57 infants with pneumothorax did not develop systemic hypotension. There is a general agreement that specific treatment is not necessary for infants with asymptomatic pneumothorax and without underlying pulmonary disease. However, needle aspiration may be useful for infants with mild symptoms. As a general rule, a pneumothorax can resolve spontaneously if it affects <15% of a patient's hemithorax, otherwise, the air

must be removed. It is well accepted that inserting an intrapleural catheter (chest tube) is required for ventilated infants; however, a tube thoracostomy may result in serious morbidities²³⁾. Lung injury, phrenic nerve paralysis, chylothorax, and hemorrhagic pericardial effusion have been reported as complications of chest tube placement in neonates⁵⁾. Our study showed that 57% of 35 term infants with pneumothorax underwent a thoracostomy, and 62% of 50 infants with a secondary pneumothorax underwent a thoracostomy. The high rate of tube thoracostomy was related to the geographic characteristics of our NICU. There are few normal full-term deliveries in our hospital, as our patients are usually referred from other hospitals for respiratory difficulty or are high-risk pregnancy patients. Among patients with a spontaneous pneumothorax, six of seven were transferred from other hospitals for respiratory distress and had already received supplemental oxygen but had not improved. Administering 100% high-flow oxygen decreases the amount of nitrogen in the blood and creates a nitrogen gradient between the air in the pleural cavity and the pleural capillaries, resulting in gas absorption. However, 100% oxygen is harmful to developing retinas and lung tissue in newborns, particularly preterms. Therefore, we used supplemental oxygen with a target oxygen saturation of 90–95%. However, we did not experience any complications secondary to tube thoracostomy. Smith et al.⁹⁾ reported that progressively worsening respiratory distress with in patients with a spontaneous pneumothorax treated with tube thoracostomy may indicate the presence of persistent pulmonary hypertension (PPHN) that requires inhaled nitric oxide and extracorporeal membrane oxygenation. We did not experience any cases of PPHN. However, worsening respiratory distress in patients treated for pneumothorax warrants further investigation for PPHN. Esme et al.²⁴⁾ reported that 25% of newborns with pneumothorax died, and Navael et al.²⁵⁾ reported that mortality in newborns with pneumothorax was 65%. Among our 57 patients, two died, but the pneumothorax was not the direct cause.

In conclusion, a neonatal pneumothorax is likely to develop when underlying diseases that can accompany dyspnea exist. In particular, when treating patients with respiratory disease

such as RDS, pneumonia, MAS, and/or TTN, it is important to carefully identify a pneumothorax and provide appropriate treatment for symptoms.

한글요약

목적: 신생아기에 기흉 발생과 관련된 호발 요인 및 각 원인에 따른 임상 양상을 조사하여 조기 진단 및 치료 효과 향상을 도모하기 위해 본 연구를 시행하였다.

방법: 2001년부터 2010년까지 순천향대학교 부천병원 신생아 집중치료실에서 기흉으로 진단받은 환아를 대상으로 후향적으로 조사하였다. 만삭아에서 발생한 원발성 기흉군과 이차성 기흉군으로 분류하였고, 이차성 기흉군에서 만삭아군과 미숙아군으로 분류하여 비교 분석하였다.

결과: 총 입원 환자 4,414명 중 57명(1.3%)이 기흉으로 진단받았고 만삭아 이차성 기흉 28명(80%), 만삭아 원발성 기흉 7명(20%)이었다. 두 군간의 성별, 출생 체중, 심폐소생술의 종류, 입원기간에 의미있는 통계학적 차이는 없었다. 흉강 삽관술 시행한 환자(20명, 57%)에서 호전까지의 기간은 원발성 기흉군에서 의미있게 길었다(5.4 ± 2.9 일 vs. 2.7 ± 2.0 일). 만삭아 이차성 기흉군에서 신생아 호흡곤란 증후군 선행 환자에서 폐표면활성제 투여 후 22.8시간에 기흉이 발생하였고, 태변 흡입 증후군, 폐렴, 신생아 일과성 빈호흡 환자에서는 16.6시간 후에 기흉이 발생하였다. 이차성 기흉군에서 신생아 호흡곤란 증후군(19명, 38%), 태변 흡입 증후군(11명, 22%), 신생아 일과성 빈호흡(7명, 14%), 폐렴(6명, 12%)이 선행되었다. 이차성 기흉군의 만삭아군에서 환자의 42.9%가 100% 산소 치료만으로 호전되었다. 미숙아군에서는 환자의 72.6%에서 흉강삽관술 및 27.3%에서 인공 기계환기 치료를 필요로 했다.

결론: 신생아 시기에 폐질환이 존재시 기흉이 호발하였다. 따라서 기흉 속발 여부를 주의 깊게 관찰하고 증상에 맞는 적절한 치료가 필요할 것으로 사료된다.

References

- 1) Posner K, Needleman JP. Pneumothorax. *Pediatr Rev* 2008;29:69-70.
- 2) Klinger G, Ish-Hurwitz S, Osovsky M, Sirota L, Linder N. Risk factors for pneumothorax in very low birth weight infants. *Pediatr Crit Care Med* 2008;9:398-402.
- 3) Zenciroğlu A, Aydemir C, Baş AY, Demirel N. Evaluation of pre-

- disposing and prognostic factors in neonatal pneumothorax cases. *Tuberk Toraks* 2006;54:152-6.
- 4) Primhak RA. Factors associated with pulmonary air leak in premature infants receiving mechanical ventilation. *J Pediatr* 1983;102:764-8.
 - 5) Litmanovitz I, Carlo WA. Expectant management of pneumothorax in ventilated neonates. *Pediatrics* 2008;122:e975-9.
 - 6) Katar S, Devecioğlu C, Kervancioğlu M, Ulkü R. Symptomatic spontaneous pneumothorax in term newborns. *Pediatr Surg Int* 2006;22:755-8.
 - 7) Fanaroff AA, Stoll BJ, Wright LL, Carlo WA, Ehrenkranz RA, Stark AR, et al. Trends in neonatal morbidity and mortality for very low birthweight infants. *Am J Obstet Gynecol* 2007;196:147.e1-8.
 - 8) Joo JW, Yang EM, Sohn YJ, Kim MJ, Song ES, Choi YY, et al. Symptomatic spontaneous pneumothorax in the newborn : comorbidities and outcomes. *J Korean Soc Neonatol* 2008;15:166-71.
 - 9) Smith J, Schumacher RE, Donn SM, Sarkar S. Clinical course of symptomatic spontaneous pneumothorax in term and late preterm newborns: report from a large cohort. *Am J Perinatol* 2011;28:163-8.
 - 10) Verma RP, Chandra S, Niwas R, Komaroff E. Risk factors and clinical outcomes of pulmonary interstitial emphysema in extremely low birth weight infants. *J Perinatol* 2006;26:197-200.
 - 11) Verder H, Robertson B, Greisen G, Ebbesen F, Albertsen P, Lundström K, et al. Surfactant therapy and nasal continuous positive airway pressure for newborns with respiratory distress syndrome. Danish-Swedish Multicenter Study Group. *N Engl J Med* 1994;331:1051-5.
 - 12) Dani C, Bertini G, Pezzati M, Cecchi A, Caviglioli C, Rubaltelli FF. Early extubation and nasal continuous positive airway pressure after surfactant treatment for respiratory distress syndrome among preterm infants <30 weeks' gestation. *Pediatrics* 2004;113:e560-3.
 - 13) Escobedo MB, Gunkel JH, Kennedy KA, Shattuck KE, Sanchez PJ, Seidner S, et al. Early surfactant for neonates with mild to moderate respiratory distress syndrome: a multicenter, randomized trial. *J Pediatr* 2004;144:804-8.
 - 14) Reininger A, Khalak R, Kendig JW, Ryan RM, Stevens TP, Reubens L, et al. Surfactant administration by transient intubation in infants 29 to 35 weeks' gestation with respiratory distress syndrome decreases the likelihood of later mechanical ventilation: a randomized controlled trial. *J Perinatol* 2005;25:703-8.
 - 15) Madansky DL, Lawson EE, Chernick V, Taeusch HW Jr. Pneumothorax and other forms of pulmonary air leak in newborns. *Am Rev Respir Dis* 1979;120:729-37.
 - 16) Jung JS, Park SW, Kim CS, Lee SL, Kwon TC. Clinical feature of neonatal pneumothorax induced by respiratory distress syndrome and pneumonia. *Korean J Pediatr* 2009;52:310-4.
 - 17) Choi BJ, Jung JW, Bae SC, Park MS, Yang JI. Clinical study of outcome and predisposing factors for spontaneous pneumothorax in the neonates. *Korean J Perinatol* 2000;11:438-44.
 - 18) Powers WF, Clemens JD. Prognostic implications of age at detection of air leak in very low birth weight infants requiring ventilatory support. *J Pediatr* 1993;123:611-7.
 - 19) Bashour BN, Balfe JW. Urinary tract anomalies in neonates with spontaneous pneumothorax and/or pneumomediastinum. *Pediatrics* 1977;59 Suppl:1048-9.
 - 20) Al Tawil K, Abu-Ekteish FM, Tamimi O, Al Hathal MM, Al Hathlol K, Abu Laimun B. Symptomatic spontaneous pneumothorax in term newborn infants. *Pediatr Pulmonol* 2004;37:443-6.
 - 21) Steinhart JM, Kuhn JP, Eisenberg B, Vaughan RL, Maggioli AJ, Cozza TF. Ultrasound screening of healthy infants for urinary tract abnormalities. *Pediatrics* 1988;82:609-14.
 - 22) Mehrabani D, Gowen CW Jr, Kopelman AE. Association of pneumothorax and hypotension with intraventricular haemorrhage. *Arch Dis Child* 1991;66:48-51.
 - 23) Shin SH, Kim JW, Lee YA, Yoon HS, Lee HJ, Lee KJ. Comparison of therapeutic effects and complications between pigtail catheter and conventional tube thoracotomy for pneumothorax in neonates. *J Korean Soc Neonatol* 1999;6:24-9.
 - 24) Esme H, Doğru O, Eren S, Korkmaz M, Solak O. The factors affecting persistent pneumothorax and mortality in neonatal pneumothorax. *Turk J Pediatr* 2008;50:242-6.
 - 25) Navaei F, Aliabadi B, Moghtaderi M, Kelishadi R. Predisposing factors, incidence and mortality of pneumothorax in a neonatal intensive care unit in Isfahan, Iran. *Zhongguo Dang Dai Er Ke Za Zhi* 2010;12:417-20.