Original Article

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Is Pneumothorax Size on Chest X-Ray a Predictor of Neonatal Mortality?

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Abstract

Objective: Pneumothorax in newborns may result in a significant mortality and morbidity. To predict who will survive or die is of great importance in the clinical management. The aim of this study is to address whether assessment of pneumothorax size on chest X-ray may be a predictor of prognosis in newborns presenting with pneumothorax.

Methods: Of 5929 infants admitted to our neonatal intensive care unit (NICU) from January 2007 to April 2011, 60 (1.0%) newborns presenting with pneumothorax were included in the present study. Pneumothorax size was calculated by measuring the widest transverse diameter of pneumothorax area in the posteroanterior view and dividing it by the widest transverse diameter of thoracic cavity above the diaphragm. Clinical data were collected from the patients' records.

Findings: Overall mortality rate was 30% (18 patients). Pneumothorax size was significantly higher in non-survivors (31.1±2.8 vs 16.4±1.4, *P*<0.001). The cut-off point of pneumothorax size for predicting survival was determined as 20%. The sensitivity was 72% whereas the specificity 83%. Preterm birth, low birth weight, resuscitation at birth, need for mechanical ventilation and chest tube insertion were of great significance in predicting mortality. However, of overall significant parameters, only pneumothorax size was the independent prognostic factor by regression analysis (*P*=0.02)

Conclusion: We conclude that the calculation of pneumothorax size in the newborns is a predictor of prognosis with high sensitivity and specificity. Furthermore newborns with pneumothorax size greater than 20% are likely to have worse prognosis.

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Key Words: Chest X-ray; Mortality; Newborn; Pneumothorax; Respiratory Distress

Introduction

Pneumothorax is more frequent in the neonatal period than at any other time in life. Symptomatic pneumothorax occurs in 0.08% of all live births and 5% to 7% of infants with birth weight of below 1500 g[1-4]. Pneumothorax in newborns has a significant mortality and morbidity. The development of a pneumothorax with ensuing hypoxia and hypercapnia is a potentially life-threatening event. To predict who will survive or die for newborns presenting with pneumothorax is of great importance in the clinical management. Traditionally a plain posteroanterior chest radiograph is the most appropriate method in the initial investigation.

The calculation of pneumothorax size on chest X-ray or computed tomography is a significant parameter for decision of treatment in adults[5,6]. However, to our knowledge, the clinical

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significance of this calculation in neonates is still unknown. Therefore we aimed to investigate whether assessment of pneumothorax size on chest X-ray may be a predictor of prognosis in newborns.

Subjects and Methods

Data collection, diagnosis and treatment

This retrospective cohort study was performed on 60 newborns presenting with pneumothorax among 5929 infants admitted to our Neonatal Intensive Care Unit (NICU) from January 2007 to April 2011. Our institution is a tertiary hospital and its NICU has an annual admission of 1500 newborns. The study was approved by the Local Ethics Committee of Tepecik Teaching and Research Hospital. The diagnosis of pneumothorax was based on chest radiography. Clinical data were collected from patients' medical records including gestational age, birth weight, gender, type of delivery, Apgar score, side of pneumothorax, mechanical ventilation, surfactant therapy, underlying lung pathology (transient tachypnea of newborn, pneumonia, meconium aspiration syndrome), duration of hospitalization, time of diagnosis and need for chest tube. The chest tube insertion was performed by the NICU physicians as soon as the clinical indication (presence of acceptable respiratory distress, abnormal blood gas levels and cardiovascular instability) was evident.

A common protocol for mechanical ventilation was performed by a positive pressure ventilator (Babylog 8000 plus, Draeger, Lubeck, Germany). All ventilated infants were initially ventilated using the assist/control mode. FiO_2 was given when it was needed to achieve arterial oxygen saturation between 85% and 95% by pulse oximetry. Inspiratory time was set at 0.35-0.40 sec and positive end-expiratory pressure at 4-6 cmH_2O according to the status of the patient. The peak inspiratory pressure was set by the clinician to keep the blood gasses at the target range. The newborns were switched from the assist/control mode to the SIMV mode for weaning on the basis of each infant's blood gasses and clinical status. Ventilatory rate was then reduced using the SIMV mode of the ventilator. If newborns treated with FiO_2<30% tolerated it at a respiratory rate of 10 bpm, were extubated.

Calculation of pneumothorax size

The calculation was done on the chest X-rays stored electronically in hospital picture archiving and communication system (PACS). Pneumothorax size was calculated as the percentage of the widest transverse diameter of the pneomothorax area in the posteroanterior view to the widest transverse diameter of the thoracic cavity above the diaphragm. The measurement of diameters was performed on the PACS images by using a cursor.

Statistical Analysis

Statistical analysis was performed using a computer program (SPSS 15.0). Fischer's exact test was used to compare categorical variables, Mann-Whitney U test for continuous variables and the Wilcoxon rank sum test for ordinal variables. The regression analysis was performed for evaluating the statistical significance of confounding variables. A receiver-operator characteristic (ROC) curve was used to explore various cut-off values of pneumothorax size. In order to determine whether the cut-off value was significant, sensitivity and specificity values were also calculated.

Findings

Of 60 newborns (1.0%) presenting with pneumothorax among 5929 patients, 46 (76%) were preterm and 14 (24%) term. Pneumothorax was on the right side in 30 (50%) newborns, on the left side in 21 (35%) and bilateral in 9 (15%) patients. Of 46 preterm infants, 41 were on mechanical ventilation and 28 needed chest tube as overall 6 term infants on mechanical ventilation (Fig. 1).

Patients' characteristics are summarized in Table 1. The mean gestational age of patients was 33.6±4.4 weeks and mean birth weight 2282±909g. Of overall 60 newborns, 45 (75%) were male and 15 (25%) female. Forty-three deliveries (71.6%) were by cesarean section, and the remaining by vaginal delivery. The underlying

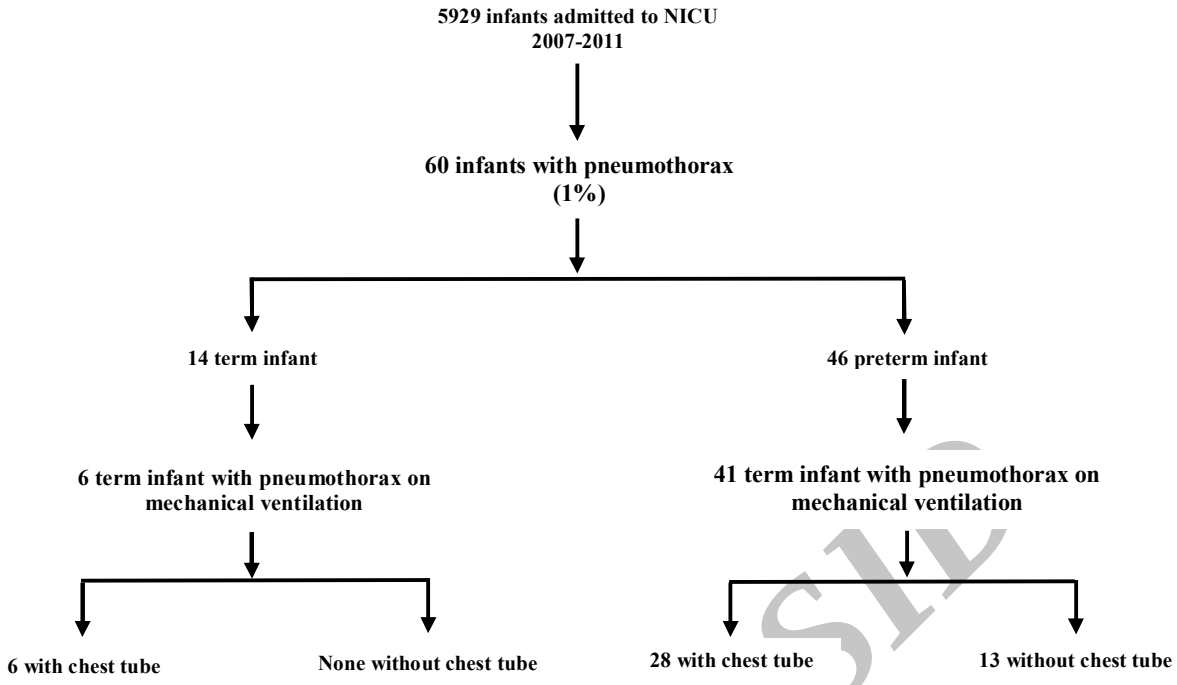

Fig. 1: The flowchart of the study group

cause of pneumothorax was identified in 45 (75%) infants. Seven patients (11%) had transient tachypnea of the neonate, 10 (17%) pneumonia and 27 (45%) respiratory distress syndrome. Overall mortality rate was 30% (18 patients). The cause of deaths included sepsis in immaturity and respiratory failure in 8 (44.4 %) patients, sepsis in 5 (27.7%), severe intraventricular hemorrhage in 3 (16.6%) and hypoxia in 2 (11.1%). Five patients (13.3%) received prophylactic surfactant whereas 21 (35%) received rescue therapy.

Results of statistical analysis for prognostic significance of pneumothorax size calculated on chest X-ray and clinical parameters are summarized in Table 2. Pneumothorax size was significantly higher in non-survivors (31.1±2.8 vs. 16.4±1.4, $P<0.001$) and also in patients treated with a chest tube (25.8±1.9 vs. 14.2±2.0, $P<0.001$). In addition, mortality discrimination was quantified by calculation of the area under the ROC curve. Area under the curve (AUC) was 0.85 (good discrimination by an area is ≥ 0.80). The cut-off point of pneumothorax size for predicting survival was determined as 20%. The sensitivity of the calculation of pneumothorax according to the cut-off value was 72% whereas specificity was 83%.

The confounding factors including early gestational age, low birth weight, resuscitation at birth, mechanical ventilation and need for chest tube were of great significance in predicting mortality. However regression analysis revealed

Table 1: Demographics and patients' characteristics (n=60)

Characteristics	Mean (±SD)	Frequency (%)
Gestational age (week)	33.6 (4.4)	-
Birth weight (g)	2282 (909)	-
Gender (male/ female)	-	45 / 15
Type of delivery (vaginal/cesarean section)	-	17 / 43
Resuscitation at birth	-	44 (73.3%)
Underlying primary lung pathology	-	45 (75%)
Duration of hospitalization (days)	15.6 (14.4)	-
Mortality	-	18 (30%)

SD: Standard Deviation

Table 2: Statistical analysis of significance in predicting mortality

Variables	Survivors (n=42)	Non-survivors (n=18)	*P.* value
Gestational age (week)*	34.5 (0.7)	31.3 (0.8)	0.006
Birth weight (g)*	2575 (134)	1716 (177)	0.001
Gender (male/ female)	33/9	12/6	0.3
Type of delivery (vaginal vs C/S)	12/30	5/13	0.9
Resuscitation at birth	28	16	0.07
Surfactant therapy	16	10	0.2
Time of diagnosis (hour)*	31.6 (6.9)	49.7 (16.6)	0.2
Mechanical ventilation	19	18	0.006
Chest tube insertion	19	16	0.01
Pneumothorax size (%)	16.4 (1.4)	31.1 (2.8)	< 0.001

* Data are presented as mean (±standard deviation)

that only pneumothorax size was the independent prognostic factor (*P*=0.02). In contrast, other parameters such as gender, type of delivery, time of diagnosis did not show any statistical significance between survivors and non-survivors.

Discussion

In the present study we aimed to evaluate significance of pneumothorax size in predicting the mortality of newborns. The development of a pneumothorax with ensuing hypoxia and hypercapnia is a potentially life-threatening condition and 30% of the infants in the present study died in NICU. This mortality rate is comparible with data in the literature of the last 20 years[7,8]. Even if not fatal, morbidity is a significant risk in these patients. The risk for developing pneumothorax is increased in infants with respiratory distress syndrome, meconium aspiration syndrome, and pulmonary hypoplasia and in infants who need resuscitation at birth[9]. Pulmonary disease is the underlying condition in 59-61% of neonates with pneumothorax[10-12]. In our study pulmonary pathology was evident in 72% of the cases. Twenty four cases (44.4%) had severe respiratory distress syndrome. This finding can be explained by the fact that the majority of our cases were preterm. Based on our findings we think that low birth weight and preterm birth are the significant risk factors for developing pneumothorax.

Development of pneumothorax is increased in infants resuscitated with positive pressure ventilation and/or chest compression in the delivery room[10,11,13,14]. The pathogenesis is either the rupture of over distended alveoli during resuscitation or lung injury due to rib fracture fallowing chest compression. This hypothesis is in consistent with higher percentage of resuscitated cases in our study. Three fourth of our cases had a history of mechanical ventilation which was more common in non-survivors like those who needed chest tube.

Although the risk factors related to mortality in the neonates presenting with pneumothorax are well-known, any practical method to predict who will survive or die is still of great importance in the clinical setting. The diagnosis of pneumothorax is usually confirmed by imaging techniques which may also yield information about its size as well. The size of pneumothorax on chest X-ray or computed tomography is a significant parameter in adults for treatment of the disease[5,6]. To the best of our knowledge, there is no study in the English medical literature investigating the prognostic value of pneumothorax size in newborns. The retrospective nature of our study may carry known limitations. However the present study was carried out in a single large unit, therefore decreasing variation in the respiratory therapy was applied. No changes in ventilation guidelines were implemented during the study period.

Three dimensional lung volumes or lung pathologies like pneumothorax can be calculated by magnetic resonance imaging or computed tomography[15]. Although these techniques are more reliable than routine chest X-ray, they are less practical especially in clinically unstable patients like those in the NICU. In addition chest X-

ray is also a less expensive method. Because anteroposterior chest X-ray is a routine method, it is practical for the calculation of pneumothorax size in the NICU like assessment of cardiothoracic index and also reasonable for a retrospective study.

In the present study, calculation of pneumothorax size revealed statistical significance as a prognosticator in the neonatal period. The pneumothorax size was significantly higher in non-survivors and appeared as an independent prognostic factor among the confounding variables. The present study also showed that the neonates who had a pneumothorax size greater than 20% calculated by our method were likely to have worse prognosis. The risk of mortality was 13 times higher in these newborns than in those with smaller pneumothorax size. Categorization of the patients according to the cut-off value appeared to show higher sensitivity and specificity. Although pneumothorax is not a cause of death, patients with pneumothorax usually carry higher risk of death and related complications due to more severe clinical status. Therefore we think that larger size of pneumothorax contributes to mortality in newborns.

Conclusion

In conclusion development of pneumothorax in the neonatal period carries high risk of mortality especially in low birth weight and premature infants. Therefore identifying the risk groups by calculation of pneumothorax size can be a practical and reliable method. However further studies are in need to emphasize whether this method has a rationale to be used in clinical protocols.

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Conflict of Interest: None

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