

## Significance of small anteromedial or subpulmonic pneumothoraces on admission chest radiographs in late preterm/term neonates

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### Abstract

**Purpose:** To determine whether subtle anteromedial or subpulmonic pneumothorax (PTX) on neonatal admission chest radiograph is associated with depressed Apgar scores and significant resuscitation. **Methods:** Retrospective review of 375 neonates admitted to the Neonatal Intensive Care Unit from 2010-2014 with respiratory distress born at 34 - 42 weeks gestation. All patients received anterior-posterior supine chest radiographs within 48 hours of birth. Records were reviewed for details on patient demographics, route of delivery, and Apgar scores at 1 and 5 min. Image interpretations were performed by radiologists and neonatologists blinded to patient clinical details and radiology reports. Significant resuscitative patterns were coded as early or late. Fisher's exact test and odds ratios were used to determine the significance. **Results:** 14/375 (4%) were reported positive for PTX by both radiologist and neonatologist groups. Among these 14, 11 (79%) had early resuscitation with positive pressure ventilation and/or continuous positive airway pressure within 5 min of birth, which was significant compared to the neonates without PTX ( $p = 0.026$ ). The median one minute Apgar for neonates with PTX was lower (5.0) than those without PTX (8.0). No neonate with these chest radiograph findings developed a tension PTX. **Conclusion:** The presence of small anteromedial or subpulmonic PTX is associated with a difficult transition to extra-uterine life which is correlated with low Apgar scores at one minute. Reporting these PTX is important due to its relation to early resuscitation. These radiograph findings may warrant closer monitoring and a higher intensity of care.

**Keywords:** neonatal resuscitation; pneumothorax; chest radiograph; positive pressure ventilation; Apgar score

### Introduction

In the United States, resuscitative measures are required in approximately 10% of the four million annual births, with 1% requiring significant resuscitative measures at delivery [1]. Standard of care for resuscitation in the delivery room follows guidelines by the neonatal resuscitation program (NRP), developed by the American Academy of Pediatrics and the American Heart Association. NRP designates the management approach for neonates based on their appearance at birth and includes body temperature stabilization, tactile stimulation, along with airway and oxygenation management [1].

Intensity of resuscitation in delivery rooms varies. Regarding oxygenation, neonates may receive minimal to no assistance, continuous positive airway pressure (CPAP), positive pressure ventilation (PPV) via bag and mask, PPV via endotracheal intubation, or even cardiopulmonary resuscitation (CPR). Jiang et al, conducted a large multi-center retrospective cohort study of late preterm neonates admitted to the NICU and determined that intubation or higher intensity delivery room resuscitation is associated with increased mortality, morbidity, and resource use in late

preterm neonates [2]. They also found that pneumothorax was more prevalent in neonates requiring higher intensity resuscitation [2].

Pulmonary air leaks more frequently occur in the neonatal period than any other times of life [3, 4]. Interestingly, aggressive resuscitation through positive pressure ventilation (PPV) and continuous positive airway pressure (CPAP) is a known risk factor for pulmonary air leak and

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can result in dissection of air into the pleural space or mediastinum, known respectively as pneumothorax (PTX) or pneumomediastinum (PM), as confirmed through chest radiographs (CXR) [5, 6]. Most cases of air leak occur in neonates with underlying lung disease, especially if mechanical ventilation is required [7]. We noted subtle anteromedial or subpulmonic PTX on routine admission CXRs for patients with respiratory distress and wanted to investigate causation or correlation to this finding.

Our objective was to determine whether subtle anteromedial or subpulmonic pneumothorax (PTX) on neonatal admission chest radiograph is associated with aggressive resuscitation and/or depressed one and five minute Apgar scores, ultimately to guide expectations for hospital course and care.

### Materials and methods

This study is a retrospective chart review consisting of 375 neonates born between 34 0/7 – 42 0/7 weeks of gestation admitted to the NICU of at Loyola University Medical Center in Maywood, Illinois, with respiratory distress from January 1, 2010 to December 31, 2014. Neonates were eligible for evaluation if they met the following inclusion criteria: 1. Received an anterior-posterior supine chest radiograph within 48 hours of birth. 2. Admitted to the NICU.

Exclusion criteria included death within 24 hours of admission, major congenital anomalies, and absence of CXR within 48 hours. This study was approved by Loyola University Medical Center Institutional Review Board.

#### Electronic medical record review

We examined short term outcomes during NICU admission, looking at progressive respiratory distress and/or development of a tension pneumothorax. Electronic medical records were also reviewed for details on patient demographics, route of delivery, and Apgar scores at one and five minute.

#### CXR Review

Neonatal chest radiographs that were performed on day 0 or day 1 of birth were included in the study (Figure 1). These chest radiographs were separately interpreted by two groups: 1. Two radiologists (pediatric radiology attending and diagnostic radiology PGY2 resident); 2. Two neonatologists (neonatology attending and PGY5 neonatology fellow). Both groups were blinded to patient clinical details, radiology reports, and the other group's interpretation. The chest radiograph was considered positive for pneumothorax if there was free air in the pleural space, sharp cardiac border or mediastinal stripe or hyperlucent peripheral space with absence of lung markings along with visualization of visceral pleura (Figure 2). We defined tension PTX as one that increased intrathoracic pressure and caused signs of hypotension, bradycardia, and hypoxemia; radiographically, the above signs may be present along with a shift of mediastinum to the contralateral side or depression of the hemidiaphragm. The chest radiograph was considered indeterminate when there was questionable sharp cardiac border and negative when the aforementioned signs were absent. Only the positive cases were included for statistical analysis.



Figure 1 CXR without noted signs of air leak, enhanced online.

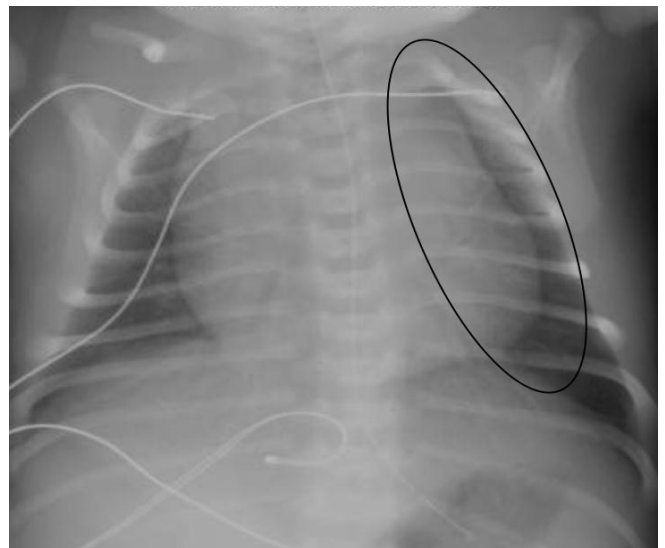


Figure 2 CXR with subpulmonic PTX, enhanced online.

#### Resuscitation review

Resuscitation was classified as minor (from no intervention to suctioning or free-flow oxygen) versus significant (CPAP, PPV via bag and mask, PPV via endotracheal tube, or CPR). Significant resuscitative patterns were coded as early (within the first five minutes of life) or late (after the first five minutes of life).

#### Statistical analysis

Descriptive statistics include baseline demographic information, route of delivery, and Apgar scores. Fisher's exact test and odds ratios were used to determine the significance with a 0.05 significance level. Any associations with  $p < 0.05$  were considered statistically significant. The statistical analysis was conducted using SPSS Version 22.0 (IBM Corp. Released 2013. IBM SPSS Statistics for Windows, Version 22.0. Armonk, NY: IBM Corp).

### Results

#### Descriptive statistics

We reviewed 375 neonatal CXRs for neonates admitted to the NICU for respiratory distress (Table 1). The group

without noted PTX (n = 361) median gestational age was 37.5 weeks, and was 44.3% female, 55.4% male, and 0.3% ambiguous sex. A majority were delivered via cesarean section (62.9%) compared to vaginal birth (37.1%). Median one minute Apgar score was 7.5, and median five minutes Apgar score was 9. No significant association between gestational age, birth weight, and presence of PTX was found in our analysis.

**Table 1** Descriptive statistics.

	Without PTX (n = 361)	With PTX (n = 14)
Median gestational age	37.5 weeks	38.0 weeks
Sex	44.3% female, 55.4% male, 0.3% ambiguous	28.6% female, 71.4% male, 0.0% ambiguous
Route of delivery	Caesarean section (62.9%), vaginal birth (37.1%)	Caesarean section (71.4%), vaginal birth (28.6%)
Median 1-Min Apgar	7.5	5.5
Median 5-Min Apgar	9.0	8.0

*CXR coding*

89/375 (24%) neonatal chest radiographs on admission were reported for presence of PTX by either the radiologist or neonatologist group or both. However, only 14/89 (16%) were reported positive in agreement by both groups. Among these 14 neonates, 11 (79%) had early resuscitation with PPV and/or CPAP within 5 min of birth, which was significant compared to the neonates without PTX (p = 0.026). The median 1 min Apgar for neonates with PTX was lower (5.0) than those without PTX (8.0). No neonate with these chest radiograph findings developed a tension PTX. There were no known cases of pneumothorax that were missed by either radiologists or neonatologists in our study group. In addition, no chest tube drainage or other intervention to relieve PTX was required in our study group.

**Discussion**

Radiographic appearance of pneumothorax depends on multiple factors including gravity, recoil capacity of lung and the anatomy of pleural recesses. Also, anterior pneumothorax in neonates have atypical appearance which may be easily overlooked or misinterpreted as pneumomediastinum if not vigilant, especially when it is small in a supine neonate. It is essential to identify small pneumothorax to prevent its progression to tension pneumothorax [8-10].

Depending on the anatomy of the pleural recesses, the pneumothorax can be anteromedial, subpulmonic, apicolateral and posteromedial in location, with the first two being the most common [8, 10, 11]. The anteromedial space is the non-dependent pleural recess while supine; hence a small amount of air commonly accumulates in this space (as an anteromedial pneumothorax), which can later extend into the subpulmonic space and then the apicolateral space as more air is trapped [8-10, 12].

There are a few useful signs that have been used to describe neonatal pneumothoraces. 1. The ‘large hyperlucent

hemithorax sign’ when the free air collects anterior to the lung and the free lateral lung margin is not visualized. It is commonly mistaken as artifact of positioning, especially when there is no mediastinal shift and the diaphragm is only mildly depressed. When suspected, cross table lateral, regular lateral or decubitus view with involved side up should be obtained for confirmation [9]. 2. The ‘medial stripe sign’ where free air collects medial to the lung and pushes the lung and bronchovascular markings posteriorly, delineating the mediastinal edge sharply. This sign should be interpreted with caution especially when present bilaterally as pneumomediastinum can present with sharp margins as well [9]. The large hyperlucent hemithorax and medial stripe sign are useful in identifying small collections of free gas in the anteromedial chest. 3. The ‘medial herniation of parietal pleura sign’ appears as a crescent-shaped lucency medial to the upper thoracic spine, which is sharply delineated on its lateral aspect by the mediastinal pleural stripes and contralateral lung [12]. However, this sign is evident with larger collections of free air anteriorly. These signs help in guiding the placement of chest tubes anteriorly rather than the usual posterior placement. When the free air collects in the subpulmonic location, the useful clues include basilar hyperlucency, double diaphragm, depressed diaphragm, distinct cardiac apex, and apical pericardial fat tags [11].

Differentiating anteromedial pneumothorax from pneumomediastinum is important. Pneumomediastinum on frontal radiograph presents typically as bilateral central air collections in the superior mediastinum outlining the thymus, caudally extending to the inferior cardiac silhouette and as free air confined to the upper retrosternal space on lateral radiographs. No shift of air to the non-dependent chest wall is seen on the lateral decubitus image [9]. During CXR analysis for our study, most patients with positive or equivocal findings for PTX showed subtle and often multiple radiologic signs.

We determined that the CXR findings in our study were neither a predictor nor sequela of tension PTX. Although no tension PTX developed in our study group, the presence of these radiographic findings was significantly correlated with a difficult transition to extra-uterine life, which is associated with low Apgar scores at one minute. Discussion with our pediatric radiologists indicated that radiologists may be under-calling these subtle lucencies due to concern that clinical decisions may be altered and excess intervention undertaken. We would recommend radiologists describe this CXR finding as benign miniscule anterior pneumothorax with no tension. Clinically it is important to recognize these lucencies as a means of more information about both the neonates’ earlier resuscitation and developing hospital course.

Reporting these PTX is important due to its relation to early resuscitation. Of note, our study suggests that if early resuscitation is performed, perhaps there should be a low threshold to check for PTX in the setting of worsening respiratory distress. Additionally, our study supports the American College of Obstetricians and Gynecologists (ACOG) recommendations for delaying delivery until 39 weeks of gestation is completed, as our

study demonstrated that early term infants (37-38 weeks) were at risk for respiratory complications [13]. Our study also illustrates the importance of proper assessment and appropriate Apgar scoring, which could reduce excessive early resuscitative measures resulting in iatrogenic pneumothoraces.

Apgar scores have been used for over 60 years to quickly assess a neonate's clinical condition at birth [14]. However, the Apgar score has been shown to carry significant inter-observer variability [15, 16]. It is still unclear whether or not low Apgar scores are associated to the need for resuscitation. Although one and five minute Apgar scores have minimal neurological predictive value, it is still critical to know the degree of depression and extent of resuscitation given in the first five minutes of life [17].

The Apgar score is a way to communicate with other health care providers how the neonate did at a point of critical transition. Lower Apgar scores might predict a difficult transitional period requiring a higher level of care. It also might trigger closer inspection of cord blood gases. The Apgar score in patients with PTX may be lower due to elevated respiratory effort and heart rate that may be associated with PTX. Despite our best intentions, an Apgar score can be inflated when unexpected resuscitation is needed and immediate documentation is not possible. In our experience, neonates requiring significant resuscitation in the first five minutes of life rarely have a one minute Apgar of > 7. Per Jiang et al, (2015), close monitoring of respiratory status is indicated for neonates who received ventilation support at birth. Intensive care is required for neonates who received delivery room intubation with or without CPR, especially during the first week of life [5].

Although Apgar scores are subjective, we found a significant association between these radiographic findings and low one minute Apgar score secondary to significant resuscitation. The incidence of respiratory distress in late preterm and early term neonates exceeds 5%. Approximately 3% of low risk deliveries will have an Apgar of three or less at one minute of life. One minute Apgar scores traditionally have minimal predictive value in long term neurodevelopmental outcomes. Most current NRP guidelines recommend no supplemental oxygen in a vigorous cyanotic neonate as they normally transition from saturations in the 60s to the 90's in the first 10 min of life. We would recommend future long term neurodevelopmental studies to assess the effects of significant resuscitation and low one minute Apgar scores in this unique population.

#### *Strengths/limitations*

One strength of this study is a relatively large number of CXRs reviewed. Additionally, interpretations were performed by multiple clinicians including senior attending physicians. Some limitations include that radiographs with ambiguity can be interpreted with subtle differences. Additionally, the study is retrospective, which inherently may contain more sources of bias and confounders than a prospective study.

#### **Conclusions**

Although clinically benign, the presence of small

anteromedial or subpulmonic PTX is associated with a difficult transition to extra-uterine life which is correlated with low Apgar scores at one minute. Reporting these PTX is important due to its relation to early resuscitation. Although one minute Apgar scores have no correlation with neurodevelopmental outcomes, these radiograph findings may warrant closer monitoring and a higher intensity of care.

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#### **Conflicts of interest**

The authors declare no conflicts of interest.

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