ORIGINAL RESEARCH

# Success of Expectant Observation and Needle Aspiration in Reducing the Need for Chest Tube Drainage for Management of Neonatal Pneumothoraces

Nicole T Spillane[1], Laurie Guzman[1], Tara Lozy[1], Zuzanna Michalak[1], Sabrina K Malik[1]

*Received on*: 04 November 2024; *Accepted on*: 30 November 2024; *Published on*: 20 December 2024

## Abstract

**Aim:** Pneumothorax (PTX) is a common morbidity during the newborn period. The aim of this study is to determine the efficacy and safety of expectant observation (EO) and needle aspiration as definitive treatment options for neonatal pneumothoraces.

**Materials and methods:** This is a retrospective single-center study from 2017 to 2019 of 114 PTX. Maternal, neonatal, and PTX characteristics were examined and associations between type of intervention, efficacy of intervention and patient/PTX characteristics were assessed.

**Results:** For primary treatment, 20.2% of PTX were treated with chest tube drainage (CTD), 25.4% with needle aspiration (NA), and 54.4% with EO. The efficacy of primary treatment was 91.3% with CTD, 37.9% with NA, and 96.8% with EO. NA and CTD were utilized more frequently than EO for moderate PTX (59.3 vs 40.9 vs 13.1%, $p < 0.001$), late PTX (75.9 vs 78.3 vs 27.4%, $p < 0.001$), and PTX with tension (41.4 vs 39.1 vs 1.6%, $p < 0.001$). In multivariate analysis, NA was the only factor associated with significantly lower success [adjusted odds ratio (OR) 0.08, 95% confidence interval (CI) 0.02–0.40]. None of the infants experienced any complications.

**Conclusion:** Expectant observation was the most frequent treatment modality and highly successful in management of small PTX. NA was utilized in less mature neonates with more complex PTX; it was safe and avoided more invasive CTD in a significant percentage of neonates.

**Clinical significance:** In our experience, EO and NA were highly safe, efficacious, and definitive management strategies of small pneumothoraces, not just a temporizing procedure to stabilize these infants prior to eventual CTD. CTD, which is much more invasive, was required only in a small fraction of these patients and further study is needed to define its indications.

**Keywords:** Chest tube drainage, Expectant observation, Needle aspiration, Neonates, Pneumothorax, Premature neonates.

*Newborn* (2024): 10.5005/jp-journals-11002-0111

## Introduction

Pneumothorax (PTX; pulmonary air leak) is seen more frequently in neonates than in any other age-group; the incidence can be as high as 4–6% in preterm and 0.2–2% in all neonates.[1,2] These patients are at a higher risk of PTX because of multiple factors, including high transpulmonary pressures generated with the first breaths, rapidly changing pulmonary compliance, frequent need for positive pressure in the delivery room (DR), and high incidence of respiratory disease.[3] Of concern, the recent rise in the use of positive pressure in the DR has been associated with increased neonatal PTX.[4] Timely identification and management of neonatal PTX is critical; it can be associated with respiratory failure and cardiovascular collapse, need for prolonged respiratory support and hospitalization, and death.[3] In addition, preterm infants with PTX show morbidities such as intraventricular hemorrhage and long-term neurodevelopmental disabilities more frequently.[5]

Management of PTX includes expectant observation (EO), needle aspiration (NA), and chest tube drainage (CTD). We still do not have a consensus for the optimal management strategy in neonates.[6] In older children and adults, CTD is widely viewed as definitive treatment of PTX that allows continuous drainage. However, it is invasive, and may be complicated by injury to thoracic and abdominal organs, permanent disfigurement, and phrenic nerve injury.[7,8] Needle aspiration is an attractive alternative as it is less invasive, easier/faster to perform, and does not require prolonged placement of a foreign material. However, it is viewed as a temporizing procedure with a risk of complications related to re-accumulation of free air and the development of tension pneumothorax, respiratory failure, and cardiovascular collapse.[3,9] Expectant observation has been an underreported but a widely used treatment option in neonates. For most clinicians, the comfort with EO is confounded by lack of evidence.

This study was designed to describe our experience with the three different management strategies for this potentially serious and common neonatal condition. More specifically, we wanted to determine the safety and efficacy of EO and NA compared with CTD. Patient and pneumothorax characteristics associated with each

[1]Department of Pediatrics, Hackensack University Medical Center, Hackensack Meridian School of Medicine, Hackensack, New Jersey, United States

**Corresponding Author:** Nicole T Spillane, Department of Pediatrics, Hackensack University Medical Center, Hackensack Meridian School of Medicine, Hackensack, New Jersey, United States, Phone: +917-446-6656, e-mail: nicole.spillane@hmhn.org

**How to cite this article:** Spillane NT, Guzman L, Lozy T, *et al*. Success of Expectant Observation and Needle Aspiration in Reducing the Need for Chest Tube Drainage for Management of Neonatal Pneumothoraces. Newborn 2024;3(4):245–250.

**Source of support:** Nil

**Conflict of interest:** None

of these three treatment modalities were examined. This study is expected to provide further information to assist clinicians in their management of neonatal PTX.

## Materials and Methods

This is a retrospective study of admissions to our level 3 NICU from January 2017 to June 2019 who developed a PTX. Eligible patients were identified from unit-based quality improvement metrics which routinely track all PTX. Maternal and neonatal baseline characteristics and outcomes were abstracted from the electronic medical records. Respiratory support was categorized into three groups: (i) invasive mechanical positive pressure; (ii) noninvasive positive pressure [nasal intermittent ventilation and continuous positive airway pressure (CPAP)]; and (iii) support with a low-flow nasal cannula with minimal oxygen supplementation or observation in room air. Pneumothorax was defined by the accumulation of air in the pleural space on chest radiograph (CXR) as interpreted by a radiologist. The size of the PTX was determined by the degree of lung collapse: (a) collapse $\leq$ 20% was defined as small; (b) 21–39% as moderate; and (c) $\geq$ 40% as large. Safety was defined by the lack of tension (no mediastinal shift) seen on repeat CXR, cardio-respiratory stability (no changes in blood pressures/urine output needing fluid boluses or vasopressors), and no altered respiratory stability. The success of the intervention was evaluated based on the first intervention for PTX; efficacy was defined as improvement/resolution of the PTX without a need for secondary intervention(s) within 24 hours.

In the DR, the decision to provide CPAP and/or positive pressure ventilation (PPV) was made by a team leader (a neonatologist, neonatology fellow, nurse practitioner, or a physician assistant). The American Academy of Pediatrics Neonatal Resuscitation Program guidelines were utilized with initiation of CPAP/PPV for persistent apnea, gasping, or heart rate (HR) < 100 beats per minute (bpm).[10] Newborns with a HR > 100 bpm with labored breathing or cyanosis were provided supplemental oxygen and evaluated for CPAP. Pulse oximetry was used for monitoring all infants. CPAP was initiated with 5 cm of water pressure, provided via a T-piece resuscitator/face mask. Gestational age was assigned by the best obstetrical estimate. This study conformed with the Declaration of Helsinki and was approved by the Institutional Review Board.

### Statistical Analysis

Continuous variables were summarized using mean and standard deviation (SD) for normally distributed data, and median and interquartile range (IQR) for non-normally distributed data. Normality was assessed using the Shapiro–Wilk test and visualized with Q–Q plots. Categorical variables were summarized using counts and percentages. Associations between medical intervention or intervention success and patient/PTX characteristics were assessed using the appropriate statistical tests: Student's two-sided *t*-test or Welch's *t*-test for normally-distributed continuous parametric variables and one-way analysis of variance (ANOVA) for comparisons of >2 such groups. The Homoscedasticity for ANOVA was assessed using Levene's test. Wilcoxon rank-sum test was used for non-parametric variables and a Chi-square test for categorical variables. Categories with expected frequencies <5% were noted and excluded from further analysis. A *p*-value significance threshold of 0.05 was used for all tests.

Significant associations were followed by pairwise group comparisons using the false discovery rate (FDR) method to control for multiple hypothesis testing. When significant differences were found, the Cochran–Mantel–Haenszel test was used to examine the effects of potential confounding variables such as gestational age and pneumothorax size. Logistic regression was used for multivariate modeling to understand the relationship between medical intervention or intervention success and confounding variables. All statistical analyses were performed using JMP®, Version 17.2 (SAS Institute Inc., Cary, NC, 1989–2024).

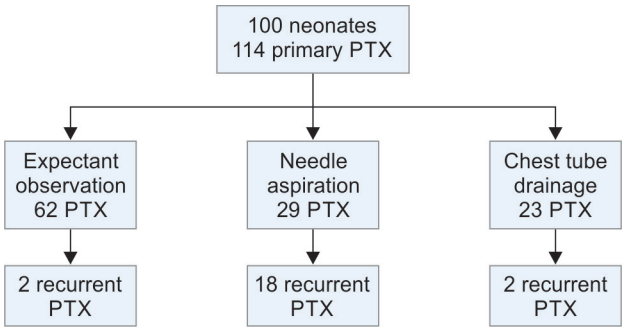


**Fig. 1:** Primary treatment modality and recurrences

## Results

During the study period, there were 17,224 live births of which 2,408 infants were admitted to the neonatal intensive care unit (NICU). There were 114 PTXs in 100 neonates (5% of NICU admissions, 0.7% of all live births) during the study period (Fig. 1). The study population was composed primarily of late preterm and term neonates (median GA 37 weeks, IQR 34–39 weeks). Most were born by Cesarean section (C-section). Among those with PTX, 20.2% were treated with a CTD, 25.4% with NA, and 54.4% with EO. Neonates treated with CTD and NA were less mature and smaller than those treated with EO ($p < 0.001$, Table 1). More males were treated with CTD and EO than NA ($p = 0.04$). There were no additional associations between neonatal/maternal characteristics and treatment modalities. Of note, infants who developed PTX required positive pressures frequently in the DR; 53.7% received CPAP and 13% PPV (Table 1). Most neonates with PTX were admitted to the NICU (83.3%).

In our cohort, there were 57 early and 57 late PTXs. EO was used significantly more frequently for early and small PTX (Table 2 and Fig. 2). Infants with moderate PTX were more likely to be treated with NA and CTD than EO (59.3 vs 40.9 vs 13.1%, $p < 0.001$). A similar pattern was seen with late PTX (75.9 vs 78.3 vs 27.4%, $p < 0.001$), and for tension PTX (41.4 vs 39.1 vs 1.6%, $p < 0.001$; Table 2). Noninvasive PPV was the most common form of respiratory support when the initial PTX occurred. CTD was performed more frequently than EM (43.5 vs 8.1%, $p = 0.001$) for neonates on invasive mechanical ventilation while NA and EM were performed more frequently than CTD (69.0 vs 72.6 vs 43.5%, $p = 0.04$, respectively) (Table 2) for neonates on noninvasive PPV.

The efficacy of CTD was 91.3%, NA was 37.9%, and EO was 96.8%. All failed primary interventions were seen in infants with late PTX. In univariate analyses, NA, tension, size, and timing were significant factors impacting success of the primary intervention (Table 3). In multivariate analysis, only NA remained significant [adjusted odds ratio (aOR) 0.08, 95% confidence ratio 0.02–0.4]. Regarding safety, none of the neonates in our study experienced adverse events such as secondary tension PTX, cardio-respiratory decompensation, or mortality.

**Table 1:** Maternal and neonatal characteristics

| *Maternal characteristics* | *Chest tube (n = 20)* | *Needle aspiration (n = 26)* | *Expectant observation (n = 54)* | *Overall (n = 100)* | *p-value* |
|---|---|---|---|---|---|
| Maternal age (years, mean ± standard deviation) | 32 ± 5 | 32 ± 6 | 31 ± 5 | 31 ± 5 | 0.4 |
| Twin gestation (*n*) | 4 (20%) | 0 | 1 (1.9%) | 5 (5%) | * |
| Prolonged rupture (*n*) | 2 (10.5%) | 0 | 7 (13%) | 9 (9.2%) | * |
| Oligohydramnios (%) | 3 (15) | 2 (8) | 7 (13%) | 12 (12.1%) | 0.7 |
| *Neonatal characteristics* | *Chest tube (n = 23)* | *Needle aspiration (n = 29)* | *Expectant observation (n = 62)* | *Overall (n = 114)* | *p-value* |
| Gestational age (weeks, median [IQR] ŦŦ | 34 (28, 37) | 36 (31, 38) | 39 (36, 40) | 37 (34, 39) | <0.001 |
| Birth weight (grams, median [IQR]) ŦŦ | 2205 (1010, 3325) | 2675.0 (1650, 3095) | 3185.0 (2886.3, 3548.8) | 2932.5 (2198.8, 3391) | <0.001 |
| Sex (% male) ŦŦ | 17 (73.9%) | 15 (51.7%) | 48 (77.4%) | 80 (70.2%) | 0.04 |
| Mode of delivery (% cesarean section) | 12 (52.2%) | 21 (72.4%) | 35 (56.4%) | 68 (59.6%) | 0.25 |
| Delivery room resuscitation | | | | | |
| Delivery room CPAP | 9 (42.9%) | 14 (50.0%) | 35 (59.3%) | 58 (53.7%) | 0.39 |
| Delivery room PPV | 4 (19.1%) | 4 (14.3%) | 6 (10.2%) | 14 (13%) | * |
| 1 minute APGAR <7 | 5 (21.7%) | 5 (17.2%) | 14 (22.6%) | 24 (21.1%) | 0.84 |
| 5 minutes APGAR <7 | 4 (17.4%) | 2 (6.9%) | 6 (9.7%) | 12 (10.5%) | * |

**p*-value not reported as assumptions of Chi-square test were not satisfied. ŦSignificance driven by difference in expectant observation compared with needle aspiration and chest tube drainage groups. ŦŦSignificance driven by difference in needle aspiration compared with chest tube drainage and expectant observation groups. CPAP, continuous positive airway pressure; PPV, positive pressure ventilation

**Table 2:** Primary intervention and pneumothorax characteristics

| *Respiratory support/PTX characteristics* | *Chest tube (n = 23)* | *Needle aspiration (n = 29)* | *Expectant observation (n = 62)* | *Overall (n = 114)* | *p-value* |
|---|---|---|---|---|---|
| Invasive positive pressure ventilation Ŧ | 10 (43.5%) | 7 (24.1%) | 5 (8.1%) | 22 (19.3%) | 0.001 |
| Noninvasive positive pressure ŦŦ | 10 (43.5%) | 20 (69%) | 45 (72.6%) | 75 (65.8%) | 0.04 |
| Nasal cannula/room air | 3 (13%) | 2 (6.9%) | 12 (19.4%) | 17 (14.9%) | * |
| Tension ŦŦŦ | 9 (39.1%) | 12 (41.4%) | 1 (1.6%) | 22 (19.3%) | <0.001 |
| Early PTX ŦŦŦŦ | 5 (21.7%) | 7 (24.1%) | 45 (72.6%) | 57 (50%) | <0.001 |
| Late PTX ŦŦŦŦ | 18 (78.3%) | 22 (75.9%) | 17 (27.4%) | 57 (50%) | <0.001 |
| Size – Small ŦŦŦ | 4 (18.2%) | 4 (14.8%) | 52 (85.3%) | 60 (54.6%) | <0.001 |
| Size – Moderate ŦŦŦ | 9 (40.9%) | 16 (59.3%) | 8 (13.1%) | 33 (30%) | <0.001 |
| Size – Large | 9 (40.9%) | 7 (25.9%) | 1 (1.6%) | 17 (15.5%) | * |

**p*-value not reported as assumptions of Chi-square test were not satisfied. ŦSignificance driven by difference in expectant observation and chest tube drainage groups. ŦŦSignificance driven by difference in chest tube drainage compared to needle aspiration and expectant observation groups. ŦŦŦSignificance driven by difference in expectant observation compared with needle aspiration and chest tube drainage groups. ŦŦŦŦSignificance driven by difference in expectant observation compared with needle aspiration and chest tube drainage groups

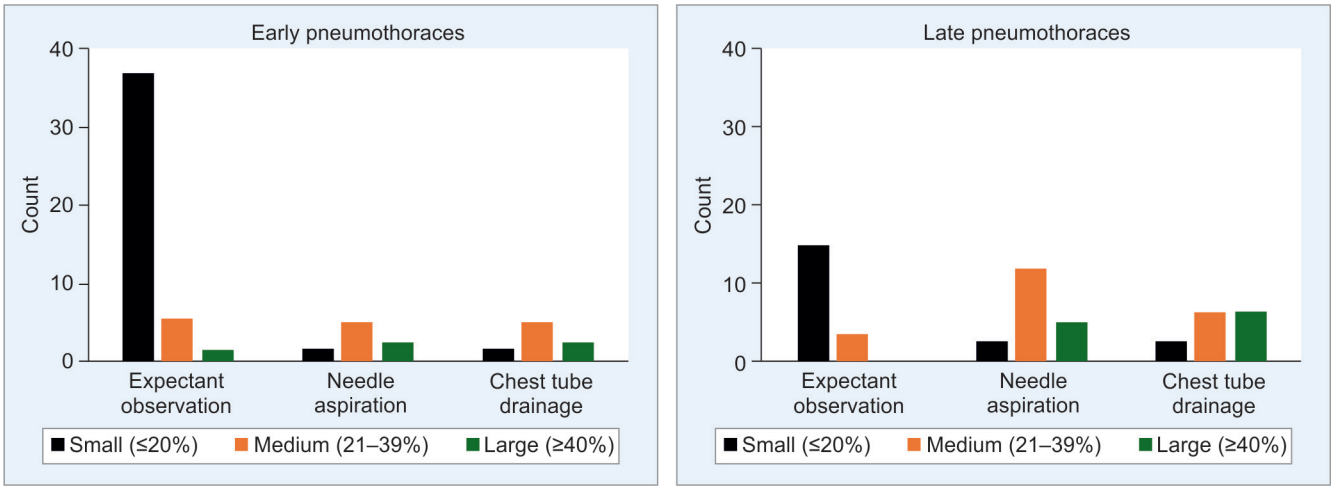


**Fig. 2:** Primary treatment modality, pneumothorax size, and timing. Early pneumothoraces occurred before 6 hours, late pneumothoraces at ≥6 hours of life

**Table 3:** Univariate and multivariate regression for factors predicting treatment success

| | *Crude* | | | *Adjusted* | | |
|---|---|---|---|---|---|---|
| *Factors examined for treatment success* | *OR* | *95% CI* | | *OR* | *95% CI* | |
| Chest tube drainage (ref: Expectant observation) | 0.51 | 0.13 | 2.17 | 0.78 | 0.12 | 4.92 |
| Needle aspiration (ref: Expectant observation) | 0.05* | 0.01 | 0.14 | 0.08** | 0.02 | 0.40 |
| Tension component (ref: No) | 0.20* | 0.07 | 0.54 | 0.36 | 0.09 | 1.46 |
| PTX size (ref: Small) | 0.23* | 0.09 | 0.57 | 0.94 | 0.21 | 4.24 |
| Respiratory support (ref: Room air/nasal cannula) | 0.84 | 0.22 | 2.63 | 1.25 | 0.26 | 6.02 |
| Pneumothorax (ref: Early) | 0.37* | 0.15 | 0.88 | 0.75 | 0.21 | 2.64 |
| Gestational Age (ref: ≥ 37 weeks) | 0.65 | 0.28 | 1.5 | 1.39 | 0.38 | 2.64 |

*N* = 110, CI, confidence interval; OR, odds ratio. Tension component: 0 = No 1 = Yes, Size: 0 = Small 1 = Moderate/Large, Respiratory support: 0 = Room air/nasal cannula 1 = Noninvasive and invasive positive pressure, Pneumothorax: 0 = Early 1 = Late, Gestational Age 0 ≥ 37 weeks, 1 < 37 weeks.
*Statistically significant in univariate analyses. **Statistically significant in multivariate analysis

## Discussion

Despite PTX occurring most frequently in the neonatal population, there is a lack of consensus among neonatologists on the most appropriate management for this condition. In this single-center retrospective chart review, we describe the three primary interventions for management of PTX, and the characteristics of patients and PTXs associated with each intervention and predictors of success. Expectant observation was most frequently practiced for small PTX diagnosed early in more mature neonates; it was safe and highly successful as a definitive intervention, not just as a temporizing procedure. The demographics and PTX characteristics of patients treated with NA and CTD were similar; they were less mature and more likely to have moderate/late PTX or PTX with tension. Needle aspiration was the definitive treatment and possibly obliviated the need for a CTD in about 40% of neonates with a PTX. Failed primary interventions occurred exclusively after 6 hours.

Like previous investigators, we found a high rate of positive pressure use in the DR and PTX. In our study, 53.7% received DR CPAP, a proportion that resembled those of Smithhart et al.[4] These investigators also detected a significant association between the need for DR CPAP in late preterm/term infants and PTX (OR 4.6, 95% CI: 3.6–6.0). The well-baby population who are at or close to term gestation frequently show asymptomatic and mildly symptomatic PTX. In contrast, the preterm/critically ill patients experience significant respiratory distress with PTX requiring respiratory support.[1,11,12] Similar to other investigators, >80% of the infants in our study were receiving noninvasive or invasive positive pressure at the time of diagnosis.[12,13]

In our cohort, most patients with PTX were term or late preterm, were male, and were born via C-section. PTX occurred in a larger proportion of preterm infants, but the total number of PTXs was larger in late preterm and term infants likely because these patients comprised a larger fraction of all infants.[3,14,15] Also, late preterm and term infants have more developed musculature, are able to generate higher negative intrapleural pressures, and have more compliant lungs. These physiologic factors predispose this population to early PTX, particularly when exposed to positive pressure. Like others, we also noted a higher incidence of PTX in male infants.[3,12,16] This finding is likely due to the increased risk for respiratory distress in male neonates; human and animal studies show less lung maturity in male fetuses.[17–21] The risk following C-section is likely secondary to retained fetal lung fluid and delayed surfactant secretion. This higher risk has been described in both elective vs emergency C-sections and in preterm and term neonates.[20,22]

Several studies have described the rate of PTX in NICU populations and among all live births. A retrospective analysis

of >71,000 NICU admissions in the Canadian Neonatal network identified a high rate of PTX with a bimodal distribution in gestational age (GA) (4% for GA < 32 weeks, 2.6% for 32–36 weeks, and 6.7% for GA ≥ 37 weeks).[2] A US study of about 13,800 live births noted PTX in 0.27% in infants born with a birth weight ≥2,500 gm and 2.5% in <2,500 gm.[12] A Swedish study of 24,000 live births reported PTX in 0.31% with 87% of PTX occurring in term and post-term newborns.[15] In our study, the overall rate of PTX was 5% which closely aligns with the rate of 4.45% in the Canadian neonatal network with a majority of PTX identified in infants with GA > 32 weeks (83%).

Historically and contemporarily, PTX has been associated with significant morbidity and mortality.[2,12] To minimize the risk for catastrophic deterioration associated with symptomatic PTX, CTD is a common invasive intervention used by clinicians.[3,23,24] This intervention offers the advantage of definitively and continuously evacuating air. However, CTD is more invasive with higher risk of injury to surrounding structures, future breast deformity, and infectious complications.[7,8] Currently, there are limited data to guide clinicians when less invasive options such as NA and EO are suitable options.[6]

Interestingly, EO was the most frequently utilized and successful intervention in our study. Previous studies examining EO have been limited to select populations or do not examine the success of EO as the primary management strategy.[14,24–26] Based on our experience, EO is highly successful in the management of early and small PTXs even for symptomatic infants and should be considered in this population. For NA, there have been two small randomized controlled trials (RCTs) comparing NA and CTD.[13,27] Arda et al.[27] randomized newborns to drainage with a CTD vs drainage with an 18 gm venous catheter. The complication rate was significantly lower (5.5 vs 30.5%, $p < 0.05$) for the venous catheter group and no infant required chest tube insertion. In a RCT enrolling neonates with symptomatic PTX, NA successfully precluded the need of a CTD in 30% of subjects. Even in preterm infants ≤32 weeks, NA was efficacious and reduced the need of CTD in 18%. In the NA group, fewer infants required assisted ventilation, and no adverse events were seen with this procedure.[13] We also found that NA could successfully avoid CTD, possibly in a larger subset (40%). Of those who failed NA, no neonates experienced hemodynamic instability due to delayed CTD.

Our study is limited by several factors. For one, it is a single-center, retrospective study. Our local practice for interventions for PTX may not be generalizable to other NICUs. Furthermore, there is variability in our practice with some clinicians preferring to immediately place a chest tube after NA. This variability may have negatively biased the success of NA as a definitive treatment option. It was also limited by the sample size, particularly regarding the number of patients who failed the primary intervention. Additionally, CXRs were interpreted by multiple radiologists and there was variation in the views obtained (anterior-posterior and/or lateral decubitus). Standardized definitions of the PTX size were utilized to minimize bias, but bias could not be eliminated.

## Conclusion

In this single-center study, EO was the most frequently utilized treatment modality and was highly successful in management of small early PTXs. NA was utilized in less mature neonates with more complex PTXs; it is a safe and reasonably efficacious option that avoided more invasive CTD in some neonates.

## Acknowledgment

The authors would like to thankful to Jeanette Haugh and the Pediatric Research Team at Joseph M. Sanzari Children's Hospital at Hackensack University Medical Center for their assistance in IRB preparation and submission. The authors also thankful to Lisa Eiland, MD for her thoughtful review of the manuscript.

### Ethical Approval

This study conforms with the Declaration of Helsinki and was approved by the Institutional Review Board of Hackensack University Medical Center, Protocol #2023-0123. A waiver of consent was granted by the IRB.

### Author Statements

Nicole Spillane, Zuzanna Michalak, Laurie Guzman, and Sabrina Malik designed the study, collected data, performed data analysis, and wrote and edited the manuscript. Tara Lozy assisted is study design, data analysis, and biostatistical support.

### Data Availability

A deidentified dataset will be made available to editors, reviewers, and readers on request.

## Orcid

*Nicole T Spillane* https://orcid.org/0000-0002-9689-0743
*Sabrina K Malik* https://orcid.org/0000-0002-0338-0219

## References

1. Steele RW, Metz JR, Bass JW, et al. Pneumothorax and pneumomediastinum in the newborn. Radiology 1971;98(3):629–632. DOI: 10.1148/98.3.629.
2. Duong HH, Mirea L, Shah PS, et al. Pneumothorax in neonates: Trends, predictors and outcomes. J Neonatal-Perinat Med 2014;7(1):29–38. DOI: 10.3233/NPM-1473813.
3. Jovandaric MZ, Milenkovic SJ, Dotlic J, et al. Neonatal pneumothorax outcome in preterm and term newborns. Medicina (Mex) 2022;58(7):965. DOI: 10.3390/medicina58070965.
4. Smithhart W, Wyckoff MH, Kapadia V, et al. Delivery room continuous positive airway pressure and pneumothorax. Pediatrics 2019;144(3):e20190756. DOI: 10.1542/peds.2019-0756.
5. Özek E, Kersin SG. Intraventricular hemorrhage in preterm babies. Turk Arch Pediatr Pediatri Arş 2020;55(3):215–221. DOI: 10.14744/TurkPediatriArs.2020.66742.
6. Bruschettini M, Romantsik O, Zappettini S, et al. Needle aspiration versus intercostal tube drainage for pneumothorax in the newborn. Cochrane Libr [Internet] 2019;2019(2):CD011724. DOI: 10.1002/14651858.CD011724.pub3.
7. Rainer C, Gardetto A, Frühwirth M, et al. Breast deformity in adolescence as a result of pneumothorax drainage during neonatal intensive care. Pediatrics 2003;111(1):80–86. DOI: 10.1542/peds.111.1.80.
8. Reed RC, Waters BL, Siebert JR. Complications of percutaneous thoracostomy in neonates and infants. J Perinatol 2016;36(4):296–299. DOI: 10.1038/jp.2015.190.
9. Esme H, Dogru Ö, Eren S, et al. The factors affecting persistent pneumothorax and mortality in neonatal pneumothorax. Turk J Pediatr 2008;50(3):242–246. PMID: 18773669.
10. Weiner GM, Zaichkin J, (Eds). Textbook of Neonatal Resuscitation. 8th edition. American Academy of PediatricsItasca, IL; 2021 [online].

Available from: https://publications.aap.org/aapbooks/book/694/Textbook-of-Neonatal-Resuscitation.
11. Gato JM, Sacristán PA, Vázquez NL, et al. Incidence of ultrasonographic signs of pneumothorax in asymptomatic neonates. Pediatr Pulmonol 2023;58(6):1691–1696. DOI: 10.1002/ppul.26378.
12. Aly H, Massaro A, Acun C, et al. Pneumothorax in the newborn: Clinical presentation, risk factors and outcomes. J Matern Fetal Neonatal Med 2013;27(4):402–406. DOI: 10.3109/14767058.2013.818114.
13. Murphy MC, Heiring C, Doglioni N, et al. Effect of needle aspiration of pneumothorax on subsequent chest drain insertion in newborns. JAMA Pediatr 2018;172(7):664. DOI: 10.1001/jamapediatrics.2018.0623.
14. Vibede L, Vibede E, Bendtsen M, et al. Neonatal pneumothorax: A descriptive regional Danish study. Neonatology 2017;111(4):303–308. DOI: 10.1159/000453029.
15. Andersson J, Magnuson A, Ohlin A. Neonatal pneumothorax: Symptoms, signs and timing of onset in the post-surfactant era. J Matern Fetal Neonatal Med 2022;35(25):5438–5442. DOI: 10.1080/14767058.2021.1882981.
16. Girard I, Sommer C, Dahan S, et al. Détresse respiratoire du nouveau-né à terme: quels facteurs de risque de développer un pneumothorax? Arch Pdiatrie 2012;19(4):368–373. DOI: 10.1016/j.arcped.2012.01.019.
17. Anadkat J, Kuzniewicz M, Chaudhari B, et al. Increased risk for respiratory distress among white, male, late preterm and term infants. J Perinatol 2012;32(10):780–785. DOI: 10.1038/jp.2011.191.
18. Altman M, Vanpée M, Cnattingius S, et al. Risk factors for acute respiratory morbidity in moderately preterm infants. Paediatr Perinat Epidemiol 2013;27(2):172–181. DOI: 10.1111/ppe.12035.
19. Elsmén E, Pupp Ih, Hellström-Westas L. Preterm male infants need more initial respiratory and circulatory support than female infants. Acta Paediatr 2004;93(4):529–533. DOI: 10.1080/08035250410024998.
20. De Matteo R, Ishak N, Hanita T, et al. Respiratory adaptation and surfactant composition of unanesthetized male and female lambs differ for up to 8 h after preterm birth. Pediatr Res 2015;79(1):13–21. DOI: 10.1038/pr.2015.175.
21. Ishak N, Hanita T, Sozo F, et al. Sex differences in cardiorespiratory transition and surfactant composition following preterm birth in sheep. Am J Physiol Regul Integr Comp Physiol 2012;303(7):R778–R789. DOI: 10.1152/ajpregu.00264.2012.
22. Benterud T, Sandvik L, Lindemann R. Cesarean section is associated with more frequent pneumothorax and respiratory problems in the neonate. Acta Obstet Gynecol Scand 2009;88(3):359–361. DOI: 10.1080/00016340802668899.
23. Tan YI, Zhan Y, Geng J, et al. Predictors of chest drainage of pneumothorax in neonates. Braz J Med Biol Res 2020;53(8):e9469. DOI: 10.1590/1414-431x20209469.
24. Smith J, Schumacher R, Donn S, et al. Clinical course of symptomatic spontaneous pneumothorax in term and late preterm newborns: Report from a Large Cohort. Am J Perinatol 2010;28(02):163–168. DOI: 10.1055/s-0030-1263300.
25. Kitsommart R, Martins B, Bottino M, et al. Expectant management of pneumothorax in preterm infants receiving assisted ventilation: Report of 4 cases and review of the literature. Respir Care 2012;57(5):789–793. DOI: 10.4187/respcare.01446.
26. Litmanovitz I, Carlo WA A. Expectant management of pneumothorax in ventilated neonates. Pediatrics 2008;122(5):e975– e979. DOI: 10.1542/peds.2008-1269.
27. Arda IS, Gürakan B, Al·lefendioğlu D, et al. Treatment of pneumothorax in newborns: Use of venous catheter versus chest tube. Pediatr Int 2002;44(1):78–82. DOI: 10.1046/j.1442-200X.2002.01502.x.