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Evaluation of pneumothorax in the neonatal intensive care unit

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Abstract

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Objective: Pneumothorax is one of the most common pulmonary air leak syndromes and appears more often in the newborn period than at any other time of life. In this study, we aimed to determine and compare the demographic characteristics, clinical courses and outcomes of newborns with primary and secondary pneumothorax.
Method: In this single-centre retrospective study, maternal and neonatal data were collected from medical records at Turgut Ozal University Hospital between January 2020 to July 2021.
Results: Twenty-nine newborns diagnosed with pneumothorax, and of these, 16 were male (55.2%), 19 (65.5%) were born by cesarean section, and six (20.7%) were premature. The mean gestational age was 37.5±2.6 weeks, and birth weight was 3063.4±53 grams. The median age at diagnosis was 5 h (1-96), and the mean hospital stay was 9.55±4.38 days. The mean drainage time was 4.1±2.13 days. 13 (44.8%) neonates were classified as primary, while 16 patients (55.2%) had an underlying pulmonary disease or predisposing factor. Our study showed a statistically significant difference between groups regarding Apgar score 5th min and SNAP-II scores ($p < 0.05$). The occurence of pneumothorax was significantly earlier in the primary group ($p<0.05$). Our study revealed significantly longer total oxygen, continuous positive airway pressure and mechanical ventilation durations in the secondary pneumothorax group ($p<0.05$).
Conclusion: Neonatal pneumothorax is still associated with significant morbidity and mortality, and primary pneumothorax had more favorable outcomes than secondary pneumothorax.
Keywords: Newborn, Pneumothorax, Respiratory distress

Öz

Yenidoğan yoğun bakımda izlenen pnömotorakslı olguların değerlendirilmesi

Amaç: Pnömotoraks, en sık görülen pulmoner hava kaçağı sendromlarından biridir ve yenidoğan döneminde yaşamın diğer dönemlerinden daha sık ortaya çıkar. Primer ve sekonder pnömotoraksın karşılaştırmalı klinik seyri hakkında sınırlı veri olduğundan, bu çalışmada primer ve sekonder pnömotorakslı yenidoğanların demografik özelliklerini, klinik seyirlerini ve sonuçlarını belirlemeyi ve karşılaştırmayı amaçladık.
Gereç ve Yöntem: Tek merkezli ve retrospektif tasarlanan çalışmaya, Turgut Özal Üniversitesi Tıp Fakültesi Hastanesi'nde Ocak 2020-Temmuz 2021 tarihleri arasında izlenen pnömotoraks tanılı yenidoğanlar alındı.
Bulgular: Çalışma boyunca yenidoğan yoğun bakım ünitesine yatan 1491 yenidoğanın 29'una pnömotoraks tanısı kondu ve bunların 16'sı (%55.2) erkek, 19'u (%65.5) sezaryen ile doğum ve 6'sı (%20.7) prematüre idi. Ortalama gebelik yaşı 37.5±2.6 hafta ve doğum ağırlığı 3063.4±53 gram idi. Pnömotoraks tanı anındaki medyan yaş 5 saat (1-96) ve ortalama hastanede kalış süresi 9,55±4,38 gündü. 13 (%44.8) yenidoğan primer pnömotoraks olarak gruplandırılırken, 16 hastada (%55.2) altta yatan bir akciğer hastalığı veya predispozan faktör vardı. Toraks tüpü takılan hastalarda ortalama drenaj süresi 4.1±2.13 gündü. 5.dk Apgar skoru ve SNAP-II skorları açısından gruplar arasında istatistiksel olarak anlamlı bir fark olduğunu gösterdi ($p < 0.05$). Ayrıca pnömotoraks tanı zamanı primer pnömotoraks grubunda anlamlı olarak daha erkendi ($p < 0.05$). Çalışmamız sekonder pnömotoraks grubunda anlamlı olarak daha uzun total oksijen gereksinimi, devamlı pozitif havayolu basıncı ve mekanik ventilasyon süreleri ortaya koydu ($p < 0.05$). Toplamda üç yenidoğan kaybedildi ve hepsi sekonder pnömotoraks grubundaydı.
Sonuç: Pnömotoraks yenidoğanlar için hala önemli bir morbidite ve mortalite nedenidir ve primer pnömotoraks olan olgular sekonder olanlara göre daha ılımlı klinik seyire sahiptir.
Anahtar Kelimeler: Yenidoğan, Pnömotoraks, Solunum sıkıntısı

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INTRODUCTION

Pneumothorax (PTX) is one of the most common pulmonary air leak syndromes and appears more often in the newborn period than at any other time of life (1). The incidence of pneumothorax is reported to be 1-2% in term infants, but in preterms, it can be up to 6% depending on gestational week and birth weight (2). By the rupture of an over-inflated alveolus, the air escapes along into the visceral and parietal pleura. Furthermore, it may also occur immediately after birth in association with a maladaptive transmission period without risk factors (3). The most important risk factors for pneumothorax are prematurity, lung pathologies, such as respiratory distress syndrome, meconium aspiration syndrome, transient tachypnea of newborn, pneumonia, pulmonary hypoplasia, male gender, low birth weight and mechanical ventilation (4). Although there are some conflicting results, it has been also found to be related to the use of continuous positive airway pressure (CPAP) and positive pressure ventilation (5,6). Also, ceserian delivery has been suggested as one of the risk factors for pneumothorax, but the evidence is conflicting (7). Pneumothorax is classified into primary or secondary PTX according to the etiology (8). Primary PTX was defined as presenting spontaneously soon after birth and without significant underlying lung disease or presence of predisposing factors such as invasive or non-invasive ventilation. The diagnosis of secondary pneumothorax is made especially in the presence of an underlying lung pathology or in relation to precipitating factors. Small pneumothoraces may be asymptomatic, while larger ones may lead to a rapid increase in intrathoracic pressure with reduced venous return, cardiac output, severe hypotension and even death (9). Treatment options include conservative management (oxygenation and nitrogen washout method), invasive management (needle thoracocentesis or chest tube insertion) and respiratory support (10). Therefore, timely diagnosis of this condition is of paramount importance to set up adequate care and reduce morbidity and mortality.

Currently, there have been limited data on the comparative clinical course of primary and secondary PTX. In this study, we aimed to determine and compare the demographic characteristics, clinical courses and outcomes of newborns with primary and secondary PTX in our institution.

METHOD

This retrospective study included all newborns with pneumothorax hospitalized in the Turgut Ozal University Hospital from January 2020 to July 2021. The data of all neonates were reviewed from the hospital electronic clinical database and clinical medical records. Inclusion criteria were all newborns admitted to the neonatal intensive care unit with respiratory distress and had radiologically confirmed pneumothorax diagnosis. Newborns with major congenital anomalies and who were not diagnosed based on chest x-ray or thorax computed tomography were excluded from this study. Newborns were evaluated for baseline clinical characteristics, such as gestational age, birth weight, delivery mode, APGAR scores at 1st and 5th minutes, delivery room resuscitation, history of prolonged ruptures of membranes >18 h and meconium- stained amniotic fluid, the score for neonatal acute physiology, version II (SNAP-II score), PTX diagnosis time, type and side and if any, concurrent underlying lung pathologies, treatment modalities, respiratory status before and after PTX, duration of hospital stay and outcome (discharge/exitus). The patients were divided into primary and secondary groups according to their medical history, clinical and laboratory findings. Tension pneumothorax was considered if a mediastinal shift and/or flattening of the diaphragm with hemodynamic instability was observed. For delivery room resuscitation procedures, we followed the International Liaison Committee on Resuscitation (ILCOR)-2015 recommendations (11). Nasal CPAP (PEEP 5-8 cm H_2O) was used in spontaneously breathing newborns with respiratory distress or hypoxia in the neonatal intensive care unit. The policy for newborns was to receive non-invasive ventilation to intubate and mechanically ventilate if there was severe apnea, hemodynamic instability, the requirement of FiO_2 >0.4 for 90-94% saturation target and pH<7.20 with $PaCO_2$ >60 mmHg. All x-rays were reviewed by a neonatologist and a radiologist. SNAP-II scores were automatically calculated using six physiological variables (minimum body temperature, mean blood pressure, PaO_2/FiO_2, minimum plasma pH, presence of multiple seizures and urine output). Thoracic drainage indications were lack of spontaneous resolution, increase in respiratory distress, radiological PTX sizes or escalating in respiratory support on follow-up and presence of severe/tension PTX. An 8-10 F chest tube and a closed underwater drainage system were use for thoracic drainage. Tubes were inserted through the fourth -fifth intercostal space and preaxillary line by an experienced neonatologist or pediatric surgeon. When the air leak was completely resolved, the tubes were clamped and then removed after 24 h if the air leak did not recur.

The present study was approved by the institutional review board (2021/60), and informed consent was obtained from parents.

Statistical Analysis

Data were given as median (min-max), mean (standard deviation), and number (percent). Compliance with the normal distribution was done with the Kolmogorov-Smirnov test. Mann-Whitney U test, independent samples t-test, Pearson chi-square test, Yatesin corrected chi-square test, Fisher exact chi-square test were used in statistical analyses where appropriate. A p-value of <0.05 was considered

statistically significant. IBM SPSS statistics 26.0 program was used in the analysis.

RESULTS

During the study period, 1491 neonates were admitted to the neonatal intensive care unit and 29 newborns were diagnosed with pneumothorax with an incidence of 1.94% among hospitalized newborns. Of the 29 newborns with pneumothorax, 16 were male (55.2%) and 19 (65.5%) were born by cesarean section and six (20.7%) were premature. The mean gestational age was 37.5±2.6 weeks and birth weight was 3063.4±53 grams. Four of the patients (13.8%) had prolonged ruptures of membranes and 10 patients (34.5%) had meconium-stained amniotic fluid. Delivery room resuscitation was required in six (20.7%) neonates with PTX; two of them were intubated in the delivery room, the others only needed positive pressure ventilation, but none of them received chest compression or drug administration.

The median age at diagnosis of PTX was 5 h (1-96). PTX was right sided in 15 (51.7%) neonates, left sided in seven patients (24.1%), and the rest were bilateral. In most patients (58.6%), PTX size was evaluated as non-tension, while in others it was evaluated as tension pneumothorax.

Only two cases of PTX were treated conservatively, inhaling free-flow oxygen to promote spontaneous resolution. Most of the patients required chest drainage. The mean drainage time was 4.1±2.13 days and none of the patients developed any complications related to the thorax drainage tube. The demographic and clinical characteristics of participants are summarized in Table 1.

We also classified the patients as primary and secondary according to their etiology and compared the results. 13 (44.8%) neonates were classified as primary PTX, while 16 patients (55.2%) had an underlying pulmonary disease or predisposing factor.

There were no iatrogenic cases secondary to a clinical procedure during the study period. Our study demonstrated a statistically significant difference between primary and secondary pneumothorax groups in terms of Apgar score 5th min and SNAP-II scores ($p < 0.05$). In addition, the occurence of pneumothorax was significantly earlier in the primary PTX group ($p < 0.05$) (Figure 1). Besides, our study revealed significantly longer total oxygen, CPAP and mechanical ventilation durations in the secondary pneumothorax group ($p < 0.05$).

Table 1. Clinical and demographic characteristics of participants

		Total (n=29)	Primary Pneumothorax Group (n=13)	Secondary Pneumothorax Group(n=16)	p-value
Gestational week, Mean±SD		37.52±2.63	38.38±1.26	36.81±3.23	0.094
Birth weight, gr, Mean±SD		3063.45±536.44	3238.85±361.99	2920.94±619.69	0.135
Male, n		16	6	10	0.614
Cesarean section, n		19	6	13	0.064
Delivery room resuscitation, n		6	1	5	0.183
APGAR 1st min, median (min-max)		8(2-9)	9(4-9)	7.5(2-9)	0.151
APGAR 5th min, median (min-max)		9(7-10)	10(7-10)	9(7-10)	0.047
Nulliparity, n		10	5	5	0.714
PROM, n		4	3	1	0.299
MSAF, n		10	5	5	0.714
SNAP-II score, median (min-max)		10(5-37)	5(5-21)	14(5-37)	0.017
Diagnosis time,h,median(min-max)		5(1-96)	3(1-16)	23.5(1-96)	0.005
Locali-zation	Right-sided	15	6	9	0.748
	Left-sided	7	3	4	
	Bilateral	7	4	3	
Tension pneumothorax, n		12	3	9	0.154
Duration of chest drainage, days, Mean±SD		4.1±2.13	3.15±1.91	4.88±2.03	0.094
Hospitalization, days, Mean±SD		9.55±4.38	7.46±2.54	11.25±4.88	0.158
Death, n		3	0	3	0.232

Abbreviations: PROM; premature rupture of membranes, MSAF; Meconium stained amniotic fluid

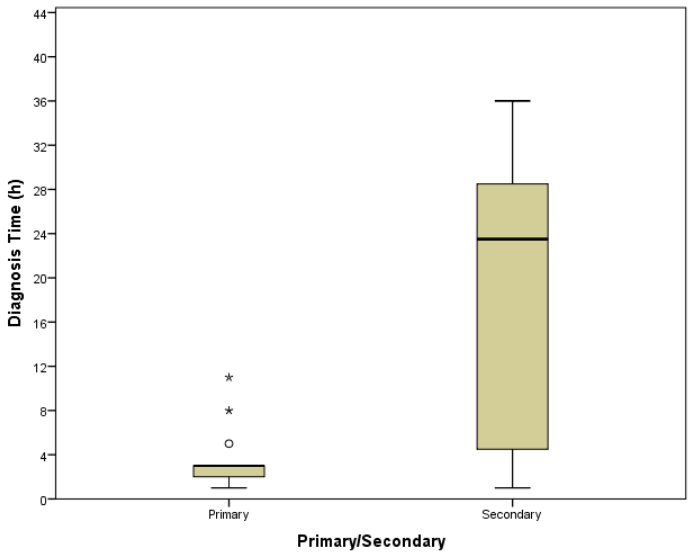

Figure 1. Postnatal age (h) at which primary or secondary pneumothorax was diagnosed.

In addition, the respiratory support status of the patients in both groups before and after the pneumothorax diagnosis is given in Table 2 in detail. The results also indicated that there was no significant difference between the groups regarding gender, birth weight, gestational week, delivery mode, resuscitation requirement at delivery, presence of prolonged ruptures of membranes and meconium-stained amniotic fluid, localization of pneumothorax, removal time of the chest tube, duration of hospitalization and survival.

The mean length of hospital stay was 9.55±4.38 days. Three neonates died, and all of them were in the secondary PTX group. One of the patients who died was a premature baby with respiratory distress syndrome, the other was a term neonate with pulmonary hypoplasia and the last one was term meconium aspiration syndrome with hypoxic-ischemic encephalopathy.

DISCUSSION

In this single-center retrospective study, we evaluated the demographic and clinical characteristics of newborns with pneumothorax. Consistent with previous studies, our findings showed that neonatal pneumothorax is still associated with significant morbidity and mortality. According to our data, the incidence of pneumothorax in hospitalized neonates was 1.94% which was lower than a study from Saudi Arabia that reported a 3.9% incidence (12). In a descriptive regional Danish study, the incidence among hospitalized neonates was reported as 0.9% (13). Else, in another study from Turkey evaluating PTX in NICU over a 10-year period, it was 1.9% (14). These different results may be due to a variety of population sizes and characteristics of patients.

The results of this study showed that there was a predominance of male gender and born with cesarean section among total newborns diagnosed with PTX. Consistent with our findings in this study, in a study that analyzes risk factors for developing pneumothorax in term neonates, PTX was more common in males and in the absence of labor (15). Again, in a study in which newborns with PTX were compared according to chest tube requirements, male gender and cesarean delivery were more common in total participants (16).

Table 2. Detailed respiratory data of patients with pneumothorax

		Total (n=29)	Primary Pneumothorax Group (n=13)	Secondary Pneumothorax Group (n=16)	p-value
Respiratory status before PTX,n	Room air	5	5	0	0.009
	Only oxygen	11	8	5	
	CPAP	10	0	8	
	MV	3	0	3	
Respiratory status after PTX ,n	Room air	1	1	0	0.001
	Only oxygen	9	8	1	
	CPAP	3	2	1	
	MV	16	2	14	
Total oxygen days, mean±SD		0.79±1.29	0.46±0.88	1.06±1.53	0.041
Total CPAP days, mean±SD		3.48±5.51	1.08±2.9	5.44±6.4	0.001
Total mechanical ventilation days, mean±SD		5.24±5.12	2.62±1.33	7.38±6.05	0,006

Abbreviations: PTX; pneumothorax, CPAP: continuous positive airway pressure, MV: mechanical ventilation

In general, respiratory problems in the neonatal period are more common in males. Besides, cesarean birth is known to predispose term and near-term newborns to develop transient tachypnea (17).

In the present study, the diagnosis of pneumothorax was made no later than 48h of life (except in one patient whose PTX occurred at 96h) and it is mostly right-sided. Consistent with our results, in a previous study evaluating neonatal PTX, they made a diagnosis in the first 48 h of life in 80% of all cases, and the most frequently affected side was the right side (19). In another study investigating the early clinical findings of PTX, it was reported that 97% of PTX cases occurred in the first 72 hours of life and it was often right-sided (56%) which is in keeping with our data[6]. The data in the presented study also identified that 55.2% of the cases had secondary PTX. While Al Matary et al found the secondary PTX rate to be 76.7% in their study, in another study, including a large cohort, it was reported as 75% (12,19). In another study, in which three years of data were compiled, the secondary PTX rate was reported as only 36.4% (9). This inconsistency between results may be due to the varying underlying conditions of the patients, possible diversity in mechanical ventilation strategies, and the frequency of serial x-ray monitoring of lung status, particularly in cases of increasing respiratory distress. In addition, the actual rate of spontaneous PTX may be higher than that given in the current literature because some asymptomatic or spontaneously resolved cases may be unnoticed.

In previous studies, PTX emergence was found earlier in term babies and in cases with a birth weight >2500 compared to the premature babies or low birth weight groups (4,9,13). In our study, we found that the median age at diagnosis of PTX was 5 h (1-96) and the diagnosis time was significantly earlier in the primary PTX group ($p < 0.05$). This result can be attributed to the different pathogenesis of primary and secondary pneumothoraces, affecting the timing of occurrance. Our study also demonstrated a statistically significant difference between groups in terms of Apgar score 5th min and SNAP-II scores. This difference can be clearly understood as patients with underlying lung pathologies or risk factors are expected to have lower Apgar scores and higher SNAP-II scores. Further, for the same reason, our study revealed that total supplemental oxygen usage, CPAP and mechanical ventilation durations were significantly longer in the secondary PTX group. In line with our results, Hadzic et al. found that total mechanical ventilation days were significantly longer in the secondary PTX group (20). Moreover, similar to our results, they reported that all patients who died in their study population were in the secondary PTX group (20). Shaireen et al. also reported that none of the patients died in their population-based cohort study that included 92 cases with spontaneous PTX[3]. These common results regarding varying mortality rates by primary or secondary PTX may depend on the lower morbidity rates of spontaneous PTX.

A previous study that evaluated the pneumothorax cases in neonatal intensive care unit, reported the mean drainage time to be 4.16±4.76 days (21). In this study, we found that the mean drainage time was 4.1±2.13 days and there was no statistically significant difference between groups. Additionally, Basheer et al. noted the mean duration of hospital stay as 10.5±5.85 days and chest tube duration as 4.82±1.88 days in their series, which required chest tube placement in approximately 90% of participants (22). Similarly, Silva et al. noted that the median hospitalization was 9.5 (1-167) days in their pneumothorax cases group (23). The mean hospitalization time was 9.55±4.38 days, with no statistically significant difference between groups in this study.

Our study has several limitations, such as the retrospective design, and contains only small population. In addition, since limited data exist to date on the detailed clinical course with comparison in newborns with primary and secondary pneumothorax, we think that our study contributes to the literature in this context.

CONCLUSION

Based on the results of the present study, neonatal pneumothorax is still associated with significant morbidity and mortality, and primary pneumothorax had more favorable outcomes than secondary PTX. Given the clinical variety of the neonatal PTX, further studies are needed to more clearly define and compare the neonatal outcomes and the risk factors between primary and secondary pneumothoraces.

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Peer-Review

Both externally and internally peer reviewed

Conflict of Interest

The authors declared that they have no conflict of interests regarding content of this article.

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Ethical Declaration

Ethical approval was obtained from Turgut Ozal University Clinical Research Ethical Committee with date 08.20.2021 and with number 2021/60, and Helsinki Declaration rules were followed to conduct this study.

Authorship Contributions

Concept: N.A.M., S.S., E.B., Design: N.A.M., E.B., Data Collection or Processing: N.A.M., S.S., E.B., T.Ç., Analysis or Interpretation: N.A.M., S.S., E.B., T.Ç., Literature Search: N.A.M., S.S., E.B., Writing: N.A.M., S.S.

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