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Pneumothorax in Neonates on Continuous Positive Airway Pressure Support: Prevalence, Risk Factors and Outcome

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Abstract: ***Background: Pneumothorax (PN)is a life threatening condition that occurs more commonly in the neonatal period than any other period of life. Objective: The aim of the study is to evaluate the prevalence of pneumothorax in neonates receiving continuous positive airway pressure (CPAP) support, to asses risk factors and to describe management and outcome. Methods and Materials: This is a retrospective study including 477 neonates with a gestational age between 32-42 weeks, admitted to the neonatal intensive care unit (NICU) at Al-Numan Teaching Hospital from January 2019 to December 2020. Patients were divided into 2 groups, those that needed continuous positive airway pressure support and those that didn't, information was taken from their medical records regarding gender, gestational age, type of delivery, clinical condition, management and outcome. Results: From the 477 patients, 11 patients developed pneumothorax (2.3%). 9 patients with CPAP support (1.8%) and 2 without CPAP support (0.4%). (2.4%) of patients on CPAP support developed pneumothorax, while (1.8%) of patients without CPAP support developed pneumothorax. Regarding patients on CPAP support who developed pneumothorax significant risk factors included prematurity (66.6%), C/S delivery (66.6%), respiratory distress syndrome (RDS) 55.5% and transient tachypnea of newborn (TTN). Drainage by chest tube was needed in 8 patients (88.8%) and one patient died (11.1%). Conclusion: Pneumothorax is a potential risk for neonates admitted to the NICU with a slight increase in prevalence in those needing CPAP support. Good observation, prediction of risk factors (prematurity, C/S delivery, RDS and TTN) and proper management are key factors for good outcome.***

Keywords: Pneumothorax (PN), continuous positive airway pressure (CPAP), neonatal intensive care unit (NICU), respiratory distress syndrome (RDS), transient tachypnea of newborn (TTN), meconium aspiration syndrome (MAS).

1. Introduction

Pneumothorax (PN) is a life threatening condition and occurs more commonly in the neonatal period than any other period of life. (1). It is an air leak that develops between the visceral and parietal pleura following the rupture of an over distended alveolus.

Alveolar distention and rupture can occur in

- Diseased lung such as respiratory distress syndrome (RDS), meconium aspiration syndrome (MAS), and transient tachypnea of newborn (TTN).
- Positive pressure ventilation during neonatal resuscitation.
- As a complication of continuous positive airway pressure (CPAP) and mechanical ventilation (MV).
- Spontaneous rupture of underlying pulmonary malformation (lobar emphysema, congenital lung cyst).(2)

Tension pneumothorax occurs if the accumulation of air with in the pleural space is sufficient to elevate intrapleural pressure above atmospheric pressure. Unilateral tension pneumothorax results in impaired ventilation not only in the ipsilateral lung but also in the contralateral lung because of shift in the mediastinum toward the contralateral side. Compression of the vena cava and torsion of the great vessels may interfere with pulmonary return and cardiac output.(2)

The incidence is 1-2% in full term neonates (majority are asymptomatic) and higher in preterm neonates (about 6%). Signs and symptoms can range from asymptomatic to respiratory distress including tachypnea, dyspnea, grunting, pallor, increase in oxygen requirement, chest asymmetry and decrease breath sounds on the affected side.(3)

Although trans illumination and lung ultrasound are increasingly used, chest radiography is still the gold standard for diagnosis and follow up of pneumothorax.(4)

Treatment of asymptomatic and mildly symptomatic, small pneumothoraces requires only close observation. In neonates with severrespiratory or circulatory embarrassment, emergency decompression by needle thoracentesis is indicated followed by insertion of a chest tube attached to under water seal.(2)

2. Methods and Materials

This is a retrospective study including 477 neonates with a gestational age ranging from 32- 42 weeks admitted to the neonatal intensive care unit at

Al- Numan Teaching Hospital from January 2019 to December 2020 (neonates were either delivered at our hospital or were referred from other hospitals for further management).

The patients were divided into 2 groups, those who required continuous positive airway pressure (CPAP) and those who didn't (only needed oxygen via face mask or nasal cannula). Neonates were put on CPAP support according to the following criteria:

- Significant respiratory distress (tachypnea > 60 breaths/ minute, grunting, intercostal and subcostal recession, and cyanosis).
- Unable to maintain target oxygen saturation at FiO2 40-60% (target level for full term neonate >92% oxygen saturation and for preterm > 90% oxygen saturation).(2)

Neonates were monitored carefully for vital signs, oxygen saturation (SpO2), work of breathing and CPAP parameters (pressure, flow and FiO2).Pneumothorax was suspected if there was a sudden deterioration in the clinical condition or increase in oxygen requirement and was confirmed by chest radiography.Chest tube under water seal was done for most of the patients.

Data was taken from patients medical records regarding gestational age, gender, type of delivery, body weight, clinical presentation, method of treatment and outcome.

3. Results

Our study included 477 neonates, 303males (63.5%) and 174 females (36.4%). 369 neonates needed CPAP support (77.3%) and 108 did not need CPAP support (22.6%).From the total number of patients 11 neonates developed pneumothorax (2.3%), 9 with CPAP supportive therapy (1.88%) and 2 without CPAP support (0.41%).The incidence of pneumothorax in patients with CPAP was (2.4%) and in patients without CPAP was (1.8%).

Table 1: Data regarding gender, gestational age, type of delivery, birth weight and pneumothorax cases

Data	Total number of patients	Patients with CPAP support	Patients without CPAP support
Total number	477 (100%)	369 (77.3%)	108 (22.6%)
Male	303 (63.5%)	235 (49.2%)	68 (14.2%)
Female	174 (36.4%)	134 (28%)	40 (8.3%)
Gestational age			
32 – 36 weeks	147 (30.8%)	127 (26.6%)	20 (4.19%)
37 – 42 weeks	330 (69.1%)	234 (49%)	96 (20.1%)
Type of delivery			
NVD	191 (40%)	132 (27.6%)	59 (12.3%)
C/S	286 (59.9)	237 (49.6%)	49 (10.2%)
Birth weight			
< 2.5 kg	177 (37.1%)	152 (31.8%)	25 (5.2%)
>2.5 kg	300 (62.8%)	217 (45.4%)	83 (17.4%)
PN cases	11 (2.3%)	9 (1.88%)	2 (0.41%)
Male	7 (1.46%)	6 (1.25%)	1 (0.2%)
Female	4 (0.8%)	3 (0.62%)	1 (0.2%)

NVD (normal vaginal delivery), C/S (cesarean section), PN (pneumothorax).

Respiratory distress syndrome (RDS) was the most common cause for admission in the neonatal intensive care unit (NICU), 316 patients (66.2%). Followed by transient tachypnea of newborn (TTN), 70 patients (14.6%). From those diagnosed with RDS, 260 (82.2%) needed CPAP support and 56 (17.7%) did not need CPAP support. 6 patients with RDS developed pneumothorax (1.89%), 5 patients were on CPAP support (1.58%) and one patient without CPAP support (0.3%).

Table 2: Clinical conditions of neonates admitted to NICU and prevalence of CPAP use and development of pneumothorax

Clinical condition	Total Number of patients	Number on CPAP	Number without CPAP	Total number of PN cases	Number of PN with CPAP	Number of PN withoutCPAP
RDS	316 (66.2%)	260 (82.2%)	56 (17.7%)	6 (1.89%)	5 (1.58%)	1 (0.3%)
TTN	70 (14.6%)	47 (67.1%)	23 (32.8%)	3 (4.2%)	2 (2.8%)	1 (1.4%)
Congenital pneumonia	19 (3.9%)	14 (73.6%)	5 (26.3%)	1 (5.2%)	1 (5.2%)	0
MAS	13 (2.7%)	9 (69.2%)	4 (30.7%)	1 (7.6%)	1 (7.6%)	0
Birth asphyxia	21 (4.4%)	14 (66.6%)	7 (33.3%)	0	0	0
CHD	13 (2.7%)	2 (15.3%)	11 (84.6%)	0	0	1*
Others	25 (5.2%)	0	25	0	0	0

*one patient had RDS plus CHD.RDS (respiratory distress syndrome), TTN (transient tachypnea of newborn), MAS (meconium aspiration syndrome), CHD (congenital heart disease).

From the 369 patients on CPAP, 9 patients developed pneumothorax (2.4%), 6 males (66.6%) and 3 females (33.3%). 5cases had RDS (55.5%), 2 cases had TTN (22.2%), one case had MAS (11.1%) and one case had congenital pneumonia (11.1%). The diagnosis was confirmed by chest radiography and 2 cases needed CT scan of chest for final confirmation. Treatment was conservative for one patient (11.1%) and 8 patients needed insertion of

chest tube under water seal (88.8%). 8 patients had complete recovery of their condition (88.8%) and one patient died (11.1%).

Table 3: Criteria of patients that developed pneumothorax while on CPAP support

Number of patients	
Total	9
Male	6 (66.6%)
Female	3 (33.3%)
Gestational age	
32- 36 weeks	6 (66.6%)
37- 42 weeks	3 (33.3%)
Birth weight	
< 2.5 kg	4 (44.4%)
>2.5 kg	5 (55.5%)
Type of delivery	
NVD	3 (33.3%)
C/S	6 (66.6%)
Clinical condition	
RDS	5 (55.5%)
TTN	2 (22.2%)
MAS	1 (11.1%)
Congenital pneumonia	1 (11.1%)
CPAP parameters FiO2	
40- 60%	6 (66.6%)
>60%	3 (33.3%)
Duration on CPAP until development of PN	
First 24 hrs	1 (22.2%)
24- 48 hrs	6 (66.6%)
48- 72hrs	1 (11.1%)
CPAP parameters flow in liter	
4- 6 liters	7 (77.7%)
6- 8 liters	2 (22.2%)
Site of PN	
Unilateral right side	4 (44.4%)
Unilateral left side	2 (22.2%)
Bilateral	3 (33.3%)
Method of treatment	
Conservative	1 (11.1%)
Chest tube	8 (88.8%)
Outcome	
Improved	8 (88.8%)
Died	1 (11.1%)

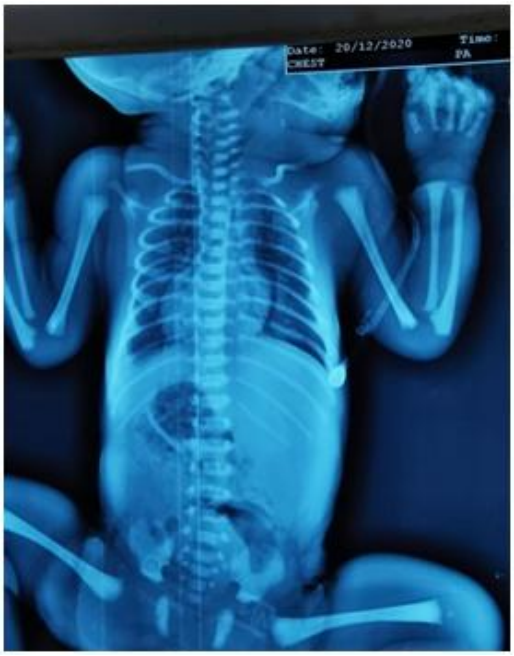

Figure 1: Radiography of chest with suspected left side pneumothorax

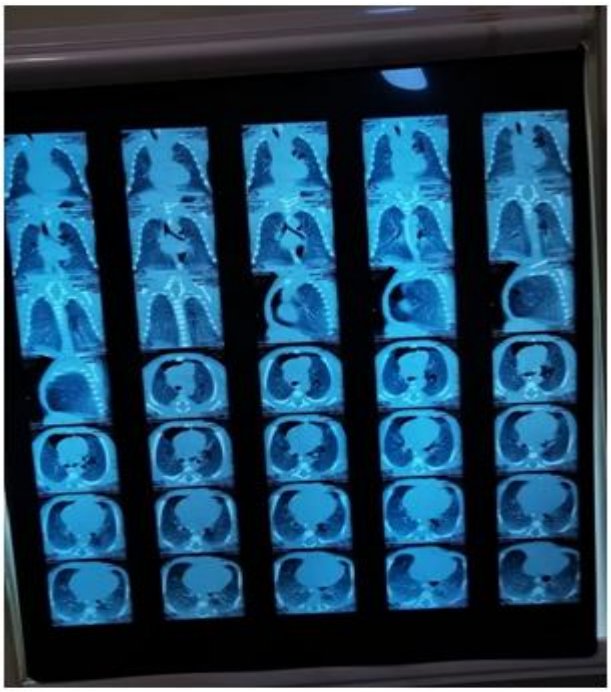

Figure 2: CT scan of chest to confirm left sided pneumothorax

From 108 patients who did not need CPAP support 2 patients developed pneumothorax (1.8%). First patient was a male neonate, 36 weeks gestational age, delivered by c/s and developed RDS. He only needed oxygen via face mask but after 12 hrs he developed a sudden deterioration in his condition, chest radiography showed right side pneumothorax, chest tube was put for him and removed after 3days with complete recovery of his condition.

The second case was a full term female, product of NVD, referred to our hospital as a case of CHD with bilateral pneumothorax. Bilateral drainage with chest tubes was done for her, but patient died because of her CHD

Figure 3: Chest radiography of a patient with bilateral pneumothorax and CHD

4. Discussion

CPAP is used to maintain positive pressure during both inspiratory and expiratory phases when the neonate is breathing spontaneously. It increases oxygen saturation by increasing residual capacity of lung, increasing pulmonary compliance and preventing alveolar collapse. Therefore it has become widely used in NICUs and has reduced the need for invasive therapy (intubation and mechanical ventilation).(5)

One of the complications of CPAP is the development of air leaks especially pneumothorax. Our study is to find the prevalence of pneumothorax in patients with CPAP support and to identify risk factors for development of pneumothorax while on CPAP.

From the 477 neonates included in our study 11 developed pneumothorax (2.3%), 9 of them were on CPAP support (1.88%) and 2 were without CPAP (0.41%) from the total number. Regarding those on CPAP (2.4%) developed pneumothorax in comparison of (1.8%) of those not on CPAP and developed pneumothorax. This shows a slight increase in prevalence in pneumothorax in patients on CPAP support and goes with other studies that show a higher number of patients were on CPAPsupport when they developed pneumothorax.(6), (7), (8).

Regarding the risk factors the following was taken into consideration

1) Underlying lung disease

All the 9 patients on CPAP had an underlying lung disease, the most common was RDS (55.5%) followed by TTN (22.2%), MAS (11.1%) and congenital pneumonia (11.1%). This is consistent with other studies that also found there was a higher risk of pneumothorax with RDS and TTN.(1)

2) Gender

In our study pneumothorax was more common in males (66.6%), this may be explained by the higher admission rate. Some studies showed male gender as a risk factor (8), while others showed no difference.(1)

3) Gestational age

In our study it was more common in the preterm group(66.6%)especially late preterm (35- 36 weeks) this is consistent with several studies that showed prematurity as a risk factor.(1), (2), (8).

4) Type of delivery

66.6% of our patients with pneumothorax were delivered by C/S, this may be explained by the higher incidence of RDS and TTN in patients delivered by C/S. This is in consistent with several Studies that showed C/S to be a risk factor for the development of pneumothorax.(1), (8), (9).

Regarding pneumothorax the following was noted :

1) Timing of development of pneumothorax while on CPAP
   In our study 66.6% developed pneumothorax between 24- 48 hours, this goes with several studies that showed an average of 36 hours for development of pneumothorax.(8), (10)
2) Site of pneumothorax
   In our study right side pneumothorax was the most common (44.4%) followed by bilateral pneumothorax (33.3%) and then left sided pneumothorax (22.2%).This goes with many studies that show unilateral (especially right side) pneumothorax is more common than bilateral pneumothorax.(9)
3) Treatment and outcome
   In our study only one patient was treated conservatively (11.1%), while 8 patients required drainage with chest tube (88.8%). The mean time of chest tube drainage was 3-4 days and there were no complications related to chest tube insertion. Other studies have showed a higher rate of conservative treatment around 30%. (1). Only one patient died (11.1%) so pneumothorax was not identified as a predictor of mortality and that may be due to proper management in NICU. (1), (11).

5. Conclusion

Pneumothorax is a potential risk for neonates admitted to the NICU, with a slight increase in prevalence in patients needing CPAP support.

It is anundesired emergency state that requires immediate and adequate action for recognition and treatment, therefore good observation, prediction of risk factors (prematurity, S/C delivery and underlying lung disease especially RDS and TTN) and proper management are the key factors for better outcome.

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