https://doi.org/10.33472/AFJBS.6.6.2024.8906-8917

African Journal of Biological Sciences

Journal homepage: http://www.afjbs.com

Research Paper Open Access

Clinical Feature and Outcome of Neonatal Pneumothorax in Preterm and Term Newborn in Rural Tertiary Care Hospital.

Dr Shubham Chaudhari[1], Dr Jayashree Jadhav[2]

[1]Senior Resident Dept of Paediatric, Dr BVP RMC LONI
[2]Prof and HOD Dept of Paediatrics Dr BVP RMC LONI

Email: shuchaudhari1111@gmail.com

Article Info

Volume 6, Issue 6, September 2024

Received: 30 July 2024

Accepted: 23 August 2024

Published: 29 September 2024

doi: 10.33472/AFJBS.6.6.2024.8906-8917

ABSTRACT

Neonatal pneumothorax (NP) is a critical condition characterized by the accumulation of air in the pleural space, leading to lung collapse and potential respiratory failure. This study aimed to assess the clinical features and outcomes of NP in neonates at a rural tertiary care hospital. Conducted over two years at Dr. Balasaheb Vikhe Patil Rural Medical College, Loni, this descriptive observational study included 60 neonates diagnosed with NP. Data were collected on demographic characteristics, clinical features, and outcomes.

Results showed that 66.6% of the cases were male, and 51.7% were preterm. Spontaneous pneumothorax occurred in 26.7% of cases, with right-sided pneumothorax being the most common. Mortality rates were high, with 56.25% of preterm and 57.14% of term neonates succumbing to the condition. Significant associations were found between pneumothorax and maternal factors such as PV leak, lack of antenatal steroid coverage, and the use of mechanical ventilation. The study highlights the severe impact of NP, particularly in preterm infants, and emphasizes the need for early detection, intervention, and improved maternal care to reduce its incidence and improve outcomes.

Keywords: Neonatal Pneumothorax, Preterm Neonates, Respiratory Failure, Mortality, Antenatal Care, Mechanical Ventilation.

© 2024 Dr Shubham Chaudhari, This is an open access article under the CC BY license (https://creativecommons.org/licenses/by/4.0/), which permits unrestricted use, distribution, and reproduction in any medium, provided you giveappropriate credit to the original author(s) and the source, provide a link to the Creative Creative Commons license, and indicate if changes were made

1. INTRODUCTION

Pneumothorax implies the presence of air in the pleural space between the visceral and parietal pleura.[1] with the first inspiratory breath, the newborn creates a transpulmonary pressure greater than 100 cm of water column and opens the lungs that were closed in-utero. After a couple of breaths, this pressure normalizes and the lungs take over their function. If the transpulmonary pressure remains elevated for a long time, the alveoli rupture occurs, accumulating air between the visceral and parietal pleura. The air created in the interpleural space leads to a pathological condition called neonatal pneumothorax (NP). Pneumothorax developed in this way is called spontaneous (primary, idiopathic).[2] The reason for the development of secondary pneumothorax in newborns may be respiratory distress syndrome (RDS), mechanical ventilation (MV), pneumonia, sepsis, aspiration of meconium, blood and amniotic fluid, or congenital lung malformations. [3] The consequences of primary and secondary pneumothorax are high pressure within the pleural space followed by lung collapse on the affected side, immediate hypoxia, hypercapnia and subsequent circulation collapse.[4] Based on the size of the pulmonary collapse, pneumothorax can be partial or total, unilateral or bilateral. A small amount of air can be asymptomatic and be resorbed by the body, while the presence of a larger amount of air endangers the life of the newborn. [5, 6] the incidence of pneumothorax in neonates is highly variable depending on several factors. Among many risk factors, prematurity and mechanical ventilation are considered the most important. Risk factors for neonatal PT also include respiratory distress syndrome, meconium aspiration syndrome, congenital malformations, infections, transient tachypnoea of the newborn, immaturity, and specific respiratory procedures such as mechanical ventilation, intubation, endotracheal suctioning, and fraction of inspired oxygen> 0.4. [7] The incidence of pneumothorax in preterm infants who are supported with mechanical ventilation varies from as high as 33% [7] to as low as 6%.[8,9] The risk also increases with the presence of meconium aspiration, hyaline membrane disease, pneumonia, and pulmonary hypoplasia. [7-11] Use of positive pressure ventilation during resuscitation also increases the risk of pneumothorax in the newborn. [12] Nasal continuous positive airway pressure (CPAP) at birth has recently been considered as a treatment modality in preterm infants. Multiple reports have indicated that the use of early CPAP is associated with decreased intubation, fewer oxygen days and lower rates of bronchopulmonary dysplasia (BPD). [13,14] The relationship between the early use of CPAP and pneumothorax has not been settled. A single trial demonstrated that infants receiving CPAP at birth had a higher rate of pneumothorax compared to those randomized to receive mechanical ventilation (9% versus 3%). [15] However, this finding was not replicable in other reports.[13,14] It has been postulated that the increased rate of pneumothorax in CPAP supported babies may be due to a decreased rate of surfactant administration, since surfactant use has been associated with reduced rates of pneumothorax in mechanically ventilated infants.[16,17] However, the relationship of surfactant and pneumothorax in spontaneously breathing infants supported with CPAP has not been explored. [17] Hence, we planned this descriptive observational study with the objective to study the clinical feature and outcome of neonatal pneumothorax in preterm and term neonates in rural tertiary care hospital.

Aim

To study clinical feature and outcome of neonatal pneumothorax in preterm and term newborn

Objective

1) To study etiology for the development of neonatal pneumothorax.
2) To study the clinical feature for the development of neonatal pneumothorax.

2. MATERIALS AND METHOD

Our study is a descriptive longitudinal observational study with all the neonates who developed pneumothorax in inborn and outborn NICU. It was conducted from 2 years from december 2020- december 2022 at Dr Balasaheb Vikhe Patil Rular Medical College, LONI after obtaining approval from the ethical committee. Due written and informed consent was taken from the parents of neonates before including them in the study.

Inclusion Criteria

1. All neonates with pneumothorax
2. Babies whose parents are giving informed written consent for inclusion in study

Exclusion Criteria

1. Babies having major congenital malformations.

Data Collection

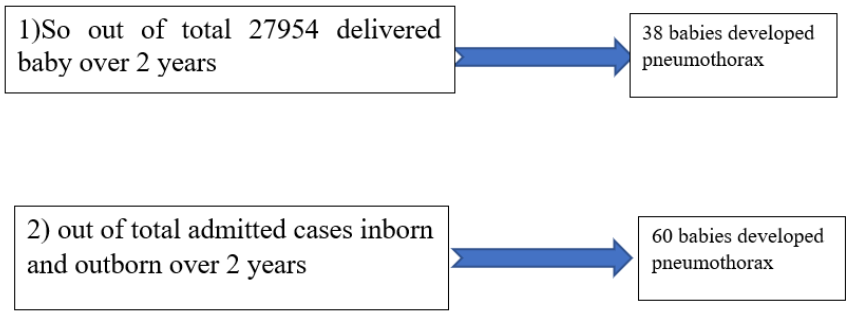
All neonates with pneumothorax in inborn and outborn NICU meeting the inclusion criteria had included in the study.

3. METHODS

Method of collection of data

The data was obtained from neonates that were delivered in our hospital which were admitted in inborn NICU and referred from another hospital which were admitted in outborn NICU and met the inclusion and exclusion criteria. As soon as we noticed any neonate who had sudden increased in distress, fluctuation in saturation or unexplained event of cyanosis, we had screen that neonate for pneumothorax. Initially we had done bedside screening tans-illumination test and if transillumination test is positive we did chest x-ray to diagnosed pneumothorax. As soon as we diagnosed the case of pneumothorax, we retrospectively had taken details history like maternal history of PV leak, significant ANC scan, antenatal received steroids dose, any major illness, details about delivery like type of delivery, gestational age, mode of resuscitation of, APGAR score, use of AMBU bag required for resuscitation and need for use of oxygen in labour room itself and all the similar history we record from the baby that had referred to us.

We recorded all the details if the neonate had RDS and required surfactant, if they had congenital pneumonia, MAS, history of birth asphyxia. Then we had recorded the vitals- Heart rate, respiratory rate, oxygen saturation level, capillary refill time and cyanosis. If baby presented with small pneumothorax like pockets and with no distress then we had done observation to check spontaneous resolution of pneumothorax. If it had not resolved or increased in size causing respiratory distress then we had taken baby on CPAP followed by needle aspiration or icd insertion of that pneumothorax. After collecting the data we had analysed and result are as follows.



4. RESULTS

Demographic Distribution

Table 1. Demographic characteristic of neonatal pneumothorax

Demographic characteristics		Pre term (n=32)	Term (n=28)	Total (n=60)	P value
Gender	Male	20 (62.5%)	20 (71.42%)	40(66.66%)	0.5
	Female	12 (37.5%)	8 (28.57%)	20(33.33%)	
Birth weight	<1 kg	8 (25%)	0	8 (13.33%)	**<0.001**
	1.1-1.5 kg	19 (59.37%)	1 (3.57%)	20(33.33%)	
	1.6-2 kg	4 (12.5%)	5 (17.85%)	9(150%)	
	>2 kgs	1 (3.12%)	22 (78.57%)	23(38.33%)	
GA	<30 Weeks	14 (43.75%)	0	14(23.33%)	**<0.001**
	31-34 weeks	15 (46.85%)	0	15 (25%)	
	35-36 weeks	3 (9.37%)	0	3 (5%)	
	>37 weeks	0	28 (100%)	28 (46.66%)	
Inborn/Outborn	Inborn	20 (62.5%)	18 (64.28%)	38 (63.33%)	1.0
	Outborn	12 (37.5%)	10 (35.71%)	22 (36.66%	
PV leak	Yes	23 (71.85%)	7 (25%)	30 (50%)	**0.001**
	No	9 (28.12%)	21 (75%)	30 (50%)	
Antenatal steroid coverage	Yes	11 (34.37%)	3 (10.71%)	14 (23.33%)	**0.03**
	No	21 (65.62%)	2 (7.14%)	46 (76.66%)	
Type of delivery	Forceps	0	1 (3.57%)	1 (1.66%)	0.51
	LSCS	16 (50%)	12 (42.85%)	28 (46.66)	
	VXVG	16 (50%)	15 (53.57%)	31 (51.66%)	

Out of total patients of neonatal pneumothorax 40 are male (66.6%) and 20 (33.33%) were female. Out of 60 patients 23(33.33%) has more than 2 kgs birth weight followed by 20 (33.33%) in 1-1.5 kg category which is statistically significant.

Out of total pneumothorax cases most of the babies were more than 37 weeks of gestation (46.66%) which is statistically significant. Inborn babies were 38(63.33%) and outborn were 32(33.66%). Most of the mothers had history of pv leak in 50% of cases which is statistically significant. Most of the mothers had no antenatal steroid coverage which is 46(76.66%) which is statistically significant.

Etiology

Table 2- Etiology of neonatal pneumothorax

Etiology		Pre term (n=32)	Term (n=28)	Total (n=60)	P value
Birth asphyxia	Yes	3 (9.37%)	12 (42.85%)	15 (25%)	**0.006**
	No	29 (90.62%)	16 (57.14%)	45 (75%)	
Surfactant given	Yes	24 (75%)	11 (39.28%)	35(58.33%)	**0.008**
	No	8 (25%)	17 ((60.71%)	25(41.66%)	
MAS	Yes	2 (6.25%)	21 (75%)	23(38.33%)	**<0.001**
	No	30 (93.75%)	7 (25%)	37(61.66%)	
Congenital Pnuemonia	Yes	19 (59.37%)	11 (39.28%)	30 (50%)	0.2
	No	13 (40.62%)	17 (60.71%)	30(50%)	

Out of total cases of pneumothorax 15 babies (25%) had history of birth asphyxia which is more see in term babies and is statistically significant. Out of 60 pneumothorx babies 35(58.33%) babies received surfactant which is mostly seen in preterm babies and it is statistically significant. Meconium aspiration syndrome is one of the cause of neonatal pneumothorax which is more commonly seen in term babies 21(75%) which is statistically significant. The percentage of babies having congenital pneumonia were equal in term and preterm babies.

Clinical Features

Table 3- Clinical features of neonatal pneumothorax

Clinical features		Preterm (n=32)	Term (n=28)	Total (n=60)	P value
Spontaneous Pneumothorax	Yes	5 (15.62%)	11 (39.28%)	16	**0.04**
	No	27(84.37%)	17 (60.71%)	44	
Pneumothorax 1st detected at age	<48 hours	22 (68.75%)	18(64.28%)	40	0.78
	>48 hours	10(31.25%)	10 (35.71%)	20	
Side involved	Bilateral	4 (12.5%)	10 (35.71%)	14	0.09
	Left sided	11 (34.37%)	6 (21.42%)	17	
	Right sided	17 (53.12%)	12 (42.85%)	29	
outcome	Death	18 (56.25%)	16 (57.14%)	34	1.0
	Discharge	14 (43.75%)	12 (42.85%)	26	

Out of total 60 cases of neonatal pneumothorax, spontaneous pneumothorax is seen in 16 babies which is statistically significant. Pneumothorax was detected in less than 48 hours in most of the babies.Out of 60 cases most common side involved were right sided pneumothorax followed by left sided which is not statistically significant.34 babies with neonatal pneumothorax were expired while 26 got discharged which is not statistically significant.

5. DISCUSSION

This is descriptive longitudinal study involving all neonates inborn and outborn who developed pneumothorax during hospital stay during period of December 2020 to December 2022.

1) Pneumothorax cases according to gender

Study	**Gender wise distribution**	
	Males (%)	**Females (%)**
Present study	66%	33%
Silva IS et al[23]	60.4%	39.6%
APILIOGULLARI et al[20]	77%	23%
Al-Anbari AJ et al[26]	65.9%	34.1%
Andersson j et al[28]	69%	31%

- In present study, Out of 60 cases of pneumothorax, 40 (66.6%) were males and 20 (33.33%) were females. Our study is comparable with the Silva IS et al[23], APILIOGULLARI et al[20], Al-Anbari AJ et al[26] and Andersson j et al[28].

2) Pneumothorax cases according to birth weight

- In this study, maximum cases of pneumothorax was seen in birth weight >2 kg group (38.3%) followed by in 1.1-1.5 kg group (33.3%) which is comparable to study done by Al-Anbari AJ et al[26], shows neonates with 48.8% cases in birth weight of 2.1-3 kg group.

3) Pneumothorax cases according to term and preterm

Study	Distribution according to term vs preterm	
	Preterm	**Term**
Present study	51.7%	48.3%
APILIOGULLARI et al[20]	83%	17%
Andersson j et al[28]	13%	75%
Jovandaric M Z et al[27]	71.6%	28.4%

In this study, distribution of term and preterm babies with pneumothorax is 48.3% and 51.7% respectively. Jovandaric M Z et al[27] had higher percentage of preterm babies. Their study reported that most of the babies was delivered by caesarean section (69.8%).
Pneumothorax is known complications in preterm babies as well as in caesarean section. As there is wet lungs in LSCS born babies and forced breathing that can lead to pneumothorax. In our study, preterm were 51.7% and LSCS born among them were 50% (16 out of 32 babies).Andersson j et al[28] has higher percentage in term babies as compared to preterm babies as they did not included <25 weeks gestation babies.

4) Neonatal pneumothorax according to gestational age

Present study shows, out of all cases, 16 (26.7%) each were born at 30-34 weeks and >37 weeks of gestation. 15 (25%) were born at 34-37.0 weeks and remaining 13 (21.7%) born at <30 weeks gestation. Mean gestational age was 34.2 weeks.In Al-Anbari AJ et al[26], divided cases into 2 groups, 31-40 weeks (85.4%) cases and 21-30 weeks (12.2%) cases. This is comparable to our study as 31-40 weeks (>84%) cases and < 30 weeks 21.7% cases.Jovandaric M Z et al[27] showed average gestational age of 34.62+/- weeks and >71.6 % were preterm babies
Other study does not shows any distribution according to the gestational age.It is known fact that, in preterm incidence of pneumothorax is more. This indicate hyaline membrane disease (HMD) was the most common underlying pulmonary disorder for pneumothorax.

5) Neonatal pneumothorax and maternal history of p/v leak

Study	Distribution according to pv leak (%)
Present study	50%
Jovandaric M Z et al[27]	8%

- Out of the all cases, 50 % (30) cases had maternal history of significant pv leak, being a rural area there is lack of awareness among women and patients were coming from low socioeconomic group and patients were also coming from distant places for delivery, so due to poor hygiene , there was increased in numbers of pv leak cases.
- Significant pv leak leading to sepsis, congenital pneumonia so eventually there was preterm delivery who required surfactant and oxygen support by various ways which leads to pneumothorax as complication. Jovandaric M Z et al[27] study shows that, 8 % cases had maternal history of significant pv leak.

6) Neonatal pneumothorax and antenatal steroid coverage

Study	Distribution according to steroid coverage (%)
Present study	23.3%
Al-Anbari AJ et al[26]	29.3%

- Present study shows out of all preterm pneumothorax (51.7%) cases, 23.3 % cases had maternal steroid cover which is similar to Al-Anbari AJ et al[26] 29.3%.As present study was done in rural area and most of the patients report to hospital very late, so steroid coverage to mother was less in our setup leading to RDS who required surfactant and CPAP and might progress to pneumothorax as complication.

7) Neonatal pneumothorax and type of delivery

Study	Distribution according to type of delivery (%)		
	Vaginal	**LSCS**	**Instrumental**
Present study	51.7%	46.7%	1.7%
APILIOGULLARI et a[62]	33%	67%	-
Al-Anbari AJ et al[26]	43.9%	56.1%	-
Andersson j et al[28]	37%	35%	27%

- In our study, 51.7% delivered by vaginally, 46.7% by LSCS and 1.7% by instrumentally who developed pneumothorax which is comparable with Al-Anbari AJ et al26[26] ·APILIOGULLARI et al[20] reported 67% of LSCS delivered cases who developed pneumothorax as they had studied very small sample size. Andersson j et al[28] has higher percentage of instrumental delivery 27% as compared to our study. Though LSCS is said to be cause for pneumothorax. TTN due to LSCS and wet lungs is underlying cause for pneumothorax.In our study both vaginally and LSCS delivery is almost equal.

8) Neonatal pneumothorax and birth asphyxia cases

Study	Distribution according to birth asphyxia case
Present study	25%
Andersson j et al[28]	25%
Lim HS et al[21]	14.3%

- Present study shows 25 % babies had history of birth asphyxia which is comparable with Andersson j et al[28].Lim HS et al[21] had lower percentage of history of birth asphyxia which is not comparable to present study. Mannan MA et al[24] also showed significant association of pneumothorax and low APGAR score at birth and resuscitation at birth. In present study, most of the birth asphyxia babies were outborn 31.8% out of 22 babies. Bag and mask or IPPV was given outside or came ventilated leading to pneumothorax. This bag and mask or bag and tube ventilation was many time performed by nontrained person in case of outborn referred neonate

9) Neonatal pneumothorax and surfactant given

Study	Distribution according to surfactant given (%)
Present study	58.3% (35)
Al-Anbari AJ et al[26]	41.5%
Lim HS et al[21]	38%
Jovandaric M Z et al[27]	39%
kim E et al[29]	38.9%

- In comparison with present study, Al-Anbari AJ et al[26] , Lim HS et al[21], Jovandaric M Z et al[27] and kim E et al[29] used surfactant 41.5%, 38%, 39% 38.9% cases respectively which is relatively lesser as compared to present study. All of them have less number of patients.Present study shows, 58.3 % (35) cases received surfactant in which 24 (out of 31) were preterm baby and 10 were MAS baby and one neonate who presented with respiratory distress.

10) Surfactant received and preterm/term

- Present study shows, 35 (58.33%) neonates with pneumothorax received surfactant, out of which 24 (68.5%) were preterm and 11(31.4%) were term. Jovandric Mz et al[27] shows out of 74 cases, 28 (52.8%) preterm neonates with pneumothorax received surfactant which is comparable to present study and 2 (9.5%) were term neonates with pneumothorax which is not comparable to present study. As Jovandric Mz et al studied on more preterm as compared to term baby.Development of pneumothorax post surfactant is common so prematurity along with RDS and post surfactant is risk factor for development of pneumothorax.

11) Neonatal pneumothorax and MAS baby

Study	Distribution of pneumothorax cases in MAS babies (%)
Present study	38% (n= 23)
Al-Anbari AJ et al[26]	19.5%
Andersson j et al[28]	22%
Lim HS et al[21]	14%

- In present study, out of 60 cases of pneumothorax, 23 had MAS who developed pneumothorax. In comparison with Al-Anbari AJ et al[26], Andersson j et al[28] and Lim HS et al[21] we had large number of MAS with pneumothorax, as out of 23 cases 9 were outborn babies which reported very late to hospital. Out of 23 (38%) cases of MAS, 10 (43.47%) received surfactant. So MAS along with post-surfactant is predictor of pneumothorax.

12) Neonatal pneumothorax and congenital pneumonia

Study	Distribution of pneumothorax cases in congenital pneumonia babies (%)
Present study	51.7% (n=31)
Al-Anbari AJ et al[26]	7.3%
Andersson j et al[28]	5%
Jovandaric M Z et al[27]	75%

- Present study shows congenital pneumonia with pneumothorax was in 51.7% of cases which is compatible to Jovandaric M Z et al[27].Andersson j et al[28] and Al-Anbari AJ et al[26] had lower percentage of congenital pneumonia cases with pneumothorax.Present study shows higher number of cases of congenital pneumonia which is attributed to large number of cases with maternal history of PV leak and outborn cases. While other study had not included the outborn cases of pneumothorax.Underlying lung pathology like congenital pneumonia is risk factor for pneumothorax.

13) Neonatal pneumothorax and spontaneous pneumothorax cases

Study	Spontaneous pneumothorax cases (%)
Present study	26.7% (n=16)
Al-Anbari AJ et al[26]	26.8%

- In our study, spontaneous pneumothorax cases was seen in 26.7% of cases which is comparable to study done by Al-Anbari AJ et al[26] who reported spontaneous pneumothorax in 26.58% cases.

14) Neonatal pneumothorax and pneumothorax first detected at age

Study	Age of detection of pneumothorax cases (%)	
	<48 hours	**>48 hours**
Present study	43.3%	56.7%
APILIOGULLARI et al[20]	80%	20%

In our study we detected 43.3% pneumothorax cases within 48 hours of life and 56.7% after 48 hours of life.While APILIOGULLARI et al[20] reported 80% of cases within 48 hours of life, this is not comparable with our study as APILIOGULLARI et al[20] had preterm 83% and LSCS rate was higher 76% which may be the cause for higher number of pneumothorax cases within 48 hours of life.

15) Neonatal pneumothorax and pneumothorax side involved

Study	Distribution of side involved in pneumothorax		
	Right side	**Left side**	**Bilateral**
Present study	48.3%	28.3%	23.3%
Silva IS et al[23]	46.3%	43.3%	10%
APILIOGULLARI et al[20]	40%	30%	30%
Al-Anbari AJ et al[26]	65.9%	19.5%	14.6%
Jovandaric M Z et al[27]	47%	36%	16%
kim E et al[29]	63.9%	25%	4%

In present study, we found 48.3% of right sided pneumothorax, 28.3% left sided pneumothorax and 23.3% bilateral pneumothorax. Our study was comparable with Silva IS et al[23], APILIOGULLARI et al[20], Jovandaric M Z et al[27].Al-Anbari AJ et al[26] and kim E et al[29] found right sided pneumothorax cases slightly more higher (65.9% and 63.9% respectively) than left side. It is known fact that right sided pneumothorax is more than left sided as right bronchus is straight causing more infection and meconium aspiration on right side.

14) Neonatal pneumothorax and mortality

Study	Mortality (%)
Present study	56% (n=34)
Silva IS et al[23]	30%
Al-Anbari AJ et al[26]	29.3%

Out of 60 cases of pneumothorax, 34 (56.66%) pneumothorax cases died.

6. CONCLUSION

Pneumothorax per se was not a direct cause of mortality. It may be due to adequate and prompt management of pneumothorax in NICU. Death was due to other cause like HIE, DIC, Cardiogenic shock, Septicemia, Pulmonary hemorrahge, NEC and EOS. Outborn babies referred with more complication and they report late in tertiary care centre, may be ventilated outside leading to pneumothorax.

Pneumothorax is relatively frequent in NICU. Its risk factor should be identified promptly and predictor of mortality should be known in order to prevent and treat this critical situation. Risk factors included prematurity, PV leak, birth asphyxia, MAS, congenital pneumonia, use of surfactant should be identified. Underlying pulmonary disease like hyaline membrane disease (HMD) congenital pneumonia, pneumonia due to meconium aspiration syndrome (MAS) should be identified and treated promptly. Chest tube insertion remains main stage of treatment modality, still causing mortality among neonates with pneumothorax so before insertion of chest tube insertion, trial of needle aspiration should be done.

Invasive mechanical ventilation is a risk factor for mortality. Ventilator mode should be selected properly. Sepsis, mechanical ventilation, DIC, birth asphyxia and underlying lung disorder are predictor of mortality in neonates. HFOV is the main modality to be used in the treatment of neonatal pneumothorax. As this study had been done in prehfov era so clinical feature and outcome of neonatal pneumothorax need to study further by use of HFOV. Further research with larger sample sizes and longer study periods is recommended to better understand the risk factors and outcomes associated with neonatal pneumothorax.

Conflict of Interest- none

7. REFERENCE

1. Noppen M, De Keukeleire T. Pneumothorax. Respiration 2008;76:121-127
2. Smith J, Schumacher RE, Donn SM, Sarkar S. Clinical course of symptomatic spontaneous pneumothorax in term and late preterm newborns: report from a large cohort. Am J Perinatol. 2011;28:163–168
3. Aly H, Massaro A, Acun C, Ozen M. Pneumothorax in the newborn: clinical presentation, risk factors and outcomes. J Matern Fetal Neonatal Med. 2014; 27:402-406.
4. Arshad H, Young M, Adurty R, Singh AC. Acute pneumothorax. Crit Care Nurs Q. 2016; 39:176–189.
5. Park SW, Yun BH, Kim KA, SyKo, Lee YK, Shin SM. A Clinical Study abaut Symptomatic Spontaneous pneumothorax. Korean J Perinatol. 2006; 17:304–309.
6. Vibede L, Vibede E, Bendtsen M. · Pedersen L. Ebbesen F. Neonatal Pneumothorax: A Descriptive Regional Danish Study. Neonatology 2017;111:303-308
7. Ogata ES, Gregory GA, Kitterman JA, et al. Pneumothorax in the respiratory distress syndrome: incidence and effect on vital signs, blood gases, and pH. Pediatrics 1976; 58:177–83. 3.

8. Goldberg RN, Abdenour GE. Air leak syndrome. In: Spitzer AR, ed. Intensive care of the fetus and neonate. St. Louis, MO: Mosby- Yearbook; 1996:629–40.
9. Horbar JD, Badger GJ, Carpenter JH, et al. Trends in mortality and morbidity for very low birth weight infants, 1991–1999. Pediatrics 2002; 110:143–51.
10. Yu VYH, Liew SW, Roberton NRC. Pneumothorax in the newborn. Arch Dis Child 1975; 50:449–53.
11. Watkinson M, Tiron I. Events before the diagnosis of a pneumothorax in ventilated neonates. Arch Dis Fetal Neonatal Ed 2001; 85: F201–3.
12. Geary C, Caskey M, Fonseca R, Malloy M. Decreased incidence of bronchopulmonary dysplasia after early management changes, including surfactant and nasal continuous positive airway pressure treatment at delivery, lowered oxygen saturation goals, and early amino acid administration: a historical cohort study. Pediatrics 2008; 121:89–96.
13. Jacobsen T, Gronvall J, Petersen S, Andersen GE. ''Minitouch'' treatment of very low-birth-weight infants. Acta Paediatr 1993; 82: 934–8.
14. Morley CJ, Davis PG, Doyle LW, et al. COIN trial investigators. N Engl J Med 2008; 358:700–8.
15. Stevens TP, Harrington EW, Blennow M, Soll RF. Early surfactant administration with brief ventilation vs. selective surfactant and continued mechanical ventilation for preterm infants or at risk for respiratory distress syndrome. Cochrane Database Syst Rev 2007; 17:CD003063.
16. Meberg A, Greve-Isdahl M, Heier CA. Pulmonary air-leakage in newborn infants. Tidsskr nor Laegeforen 2007; 20:2371–3.
17. Wiswell TE, Tuggle JM, Turner BS. Meconium aspiration syndrome: have we made a difference? Pediatrics 1990; 85:715–21.
18. Ringer SA. Part 3: pneumothorax and air leak. In: Hansen AR, Puder M, editors. 2002 Manual of neonatal surgical intensive care. 2nd ed. Shelton: People's Medical Publishing House; 2009. p. 188–190.
19. Ali R, Ahmed S, Qadir M, et al. Pneumothoraces in a neonatal tertiary care unit: case series. Oman Med J. 2013; 28(1):67–69.
20. B APILIOGULLARI, GS SUNAM, S CERAN1 AND H KOC. Evaluation of Neonatal Pneumothorax. The Journal of International Medical Research 2011; 39: 2436 – 2440
21. Lim HS, Kim H, Jin JY, Shin YL, Park JO, Kim CH, Kim SS. Characteristics of pneumothorax in a neonatal intensive care unit. J Korean Soc Neonatol. 2011 Nov 25; 18(2):257-64.
22. Hany Aly, An Massaro, Ceyda Acun & Maide Ozen (2014) Pneumothorax in the newborn: clinical presentation, risk factors and outcomes, The Journal of Maternal-Fetal & Neonatal Medicine, 27:4, 402-406
23. Silva IS, Flôr-de-Lima F, Rocha G, Alves I, Guimarães H. Pneumothorax in neonates: a level III Neonatal Intensive Care Unit experience. Journal of Pediatric and Neonatal Individualized Medicine (JPNIM). 2016 Sep 14; 5(2):e050220-.
24. Mannan MA, Dey SK, Jahan N, Iqbal S, Karim SR, Ferdous N. Spectrum of Neonatal Pneumothorax at a Tertiary Care Hospital of Bangladesh: A Retrospective Observational Study. Bangladesh Critical Care Journal. 2019 Mar 27; 7(1):12-9.
25. Avadhesh Joshi, Manish Kumar, Grace Rebekah & Sridhar Santhanam (2022) Etiology, clinical profile and outcome of neonatal pneumothorax in tertiary care center in South India: 13 years' experience, The Journal of Maternal-Fetal & Neonatal Medicine, 35:3, 520-524
26. Al-Anbari AJ, Abid JK. Evaluation of Pneumothorax in Neonates in Al Immamian Alkadhomain Medical City. European Journal of Molecular & Clinical Medicine. 2020; 7(2):214-9.

27. Jovandaric, M.Z.; Milenkovic, S.J.; Dotlic, J.; Babovic, I.R.; Jestrovic, Z.; Milosevic, B.; Culjic, M.; Babic, S. Neonatal Pneumothorax Outcome in Preterm and Term Newborns. Medicina 2022, 58, 965.
28. J. Andersson, A. Magnuson & A. Ohlin (2021): Neonatal pneumothorax: symptoms, signs and timing of onset in the post-surfactant era, The Journal of Maternal-Fetal & Neonatal Medicine, DOI: 10.1080/14767058.2021.1882981
29. Eun-Ah Kim, MD1,2, Jae-Hun Jung, MD1,2, Sang-Yoon Lee, MD1,2, Sook-Hyun Park, MD, PhD1,2, and Ji Sook Kim, MD, PhD1,2 Neonatal Pneumothorax in Late Preterm and Full-Term Newborns with respiratory Distress: A Single-Center Experience