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The Use of Chest Radiograph in Early Assessment of Respiratory Distress Syndrome in Neonates in NICU Patients

Nikhil Chavhan[1], Suhas Ghule[2], Sunil Natha Mhaske[3]

[1]Resident, Dept. of Pediatric [2]Associate Professor, Dept. of Radiology [3]Professor and Dean, Dept. of Pediatric, Padmashree Dr.Vithalrao Vikhe Patil Foundation's College, Vilad Ghat, MIDC, Ahmednagar, Maharashtra 414111, India.

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Abstract

Background: Respiratory distress in the neonatal period can be classified according to cause in abnormalities primarily affecting circulation or development of the thorax and aeration. In neonates the system which is majorly affected is the respiratory and the cardiovascular system, though for differential diagnosis abnormalities of chest wall, tracheobrochial tress, diaphragm and neuromuscular diseases also must be considered. The most effective and commonly used imaging modality in investigation of neonatal respiratory distress syndrome is Chest Radiography. The aim of this study was to assess and evaluate the role of chest X-ray in neonatal respiratory distress.[1] *Materials and methods:* A prospective observational study was conducted in rural tertiary care center. A chest radiograph of 150 neonates were taken in anteroposterior view who came with chief complaint of respiratory distress. In all these patients, the chest radiography findings were noted and correlated with clinical findings. *Results:* Transient tachypnea of newborn is the most commonest cause of respiratory distress in neonates. Transient tachypnea of the newborn (TTNB) was the most common cause of respiratory distress (35.7%). Chest radiography had the highest sensitivity and specificity in pneu-mothorax (PTX), tracheoesophageal fistula, lobar emphysema, and diaphragmatic hernia (100%). Followed by pneumonia, radiography had 81.2% sensitivity and 86.5% specificity; for hyaline membrane disease (HMD), sensitivity and specificity were 80 and 89% respectively; for meconium aspiration syndrome (MAS), sensitivity was 60.5 and specificity was 81.7%; and for TTNB, sensitivity was 36.4% and specificity was 96%. Overall diagnostic accuracy was 59.7%, i.e., the final clinical diagnosis confirmed by CXR. *Conclusion:* A chest radiograph has high sensitivity for congenital diaphragmatic hernia (CDH), PTX, congenital lobar emphysema, tracheoesophageal fistula, pneumonia, and HMD and low sensitivity for TTNB. To sum up, a plain chest radiograph is an indispensable tool in neonates with respiratory distress, but as with any diagnostic modality, it has its own limitations.[2]

Keywords: Chest X-ray; Respiratory distress of newborn.

Introduction

Successful adaptation to breathing at the time of birth is the culmination of an orderly process of pulmonary cell growth and differentiation, leading to alveolar and capillary surfaces capable of providing oxygen and eliminating carbon dioxide. Failure to achieve adequate gas exchange at birth represents respiratory distress which is a major cause of perinatal morbidity and mortality.[1] The causes of respiratory distress in the neonatal period can be classified into abnormalities primarily affecting aeration, circulation or development of the thorax. Conditions of the lungs and cardiovascular system account for the majority but abnormalities of the tracheobronchial tree, chest wall, diaphragm,

Corresponding Author: Nikhil Chavhan, Resident, Dept. of Pediatric, Padmashree Dr.Vithalrao Vikhe Patil Foundation's College, Vilad Ghat, MIDC, Ahmednagar, Maharashtra 414111, India.

E-mail: nikhilroks.45@gmail.com

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and a variety of neuromuscular diseases must also be considered in the differential diagnosis. Chest radiography is the most valuable imaging modality in the investigation of neonatal respiratory disorders.[2]

Respiratory Distress within 48–72 hours is the common disorder occurring in an neonate. The most important indication for chest X-ray is Post-natal respiratory distress.

Respiratory distress is defined by the presence of at least two of the following three features:

- Tachypnea (respiratory rate >60 per minute)
- Retractions (intercostal, subcostal, sternal and suprasternal)
- Noisy respiration (grunt, stridor or wheeze)

Chest radiography is very beneficial in neonates with acute respiratory distress to exclude the surgical and medical causes of respiratory distress. It is the most important indication for neonatal respiratory distress.

Clinically it is very difficult to distinguish between pulmonary and extra-pulmonary causes of respiratory distress. Respiratory distress in neonate can develop in utero, during delivery or in post-natal period. Any sign of postnatal respiratory distress is an indication for chest x-ray. It has a wide range of causes, some of which are life threatening. Chest radiograph is considered the most reliable diagnostic tool to study the respiratory distress in new born.[2,3]

The outcome of respiratory distress has a devastating impact on the families of the infants, as it usually results in either death or a lifelong disability, with a significant 7% of the newborns diagnosed with respiratory distress.[3]

Materials and Methods

This study was a prospective co relational hospital-based study done in 150 neonates in our tertiary hospital between January 2018 and January 2019. The neonates who were clinically diagnosed having respiratory distress were evaluated using chest radiograph. In all these patients, the chest radiography findings will be noted and correlated with clinical findings.

Results

A total of 82 males and 62 females with respiratory distress were admitted in the neonatal intensive care unit (NICU). We found that there was a dominance of males with respiratory distress in our study (Table 1).

Table 1: Distribution of patients according to sex

Sex	HMD (n =32)	MAS (n = 24)	TTNB (n = 54)	PNE (n = 17)	PTX (n = 15)	SUR (n = 8)	Total
Male	18 (56.2%)	14 (56.2%)	29 (54.2%)	7 (42.9%)	9 (60%)	5 (62.5%)	82 (54.7%)
Female	14 (43.8%)	10 (43.8%)	25 (45.8%)	10 (57.1%)	6 (40%)	3 (37.5%)	68 (45.3%)

PNE: Pneumonia; SUR: Surgical causes of respiratory distress include congenital cystic adenoid malformation, congenital diaphragmatic hernia, congenital lobar emphysema, pulmonary sequestration, and tracheoesophageal fistula.

Table 2: Chest X-ray findings of pleura

CXR findings of lungs	HMD (n = 32)	MAS (n = 24)	TTNB (n = 54)	PNE (n = 17)	PTX (n = 15)	SUR (n = 8)
Normal	32 (100%)	20 (81.2%)	41 (76.7%)	9 (54.3%)	0 (0%)	8 (100%)
PTX	0 (0%)	0 (0%)	0 (0%)	0 (0%)	15 (100%)	0 (0%)
Pleural effusion	0 (0%)	4 (18.8%)	5 (9.3%)	6 (37.1%)	0 (0%)	0 (0%)
Hydro PTX	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)
Lamellar effusion	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)
Interlobar fluid	0 (0%)	0 (0%)	8 (14.0%)	2 (8.6%)	0 (0%)	0 (0%)

PNE: Pneumonia; SUR: Surgical causes of respiratory distress include congenital cystic adenoid malformation, congenital diaphragmatic hernia, congenital lobar emphysema, pulmonary sequestration, and tracheoesophageal fistula.

Table 3: Follow-up scan after 72 hours of onset of respiratory distress

CXR findings of lungs	HMD (n =32)	MAS (n =24)	TTNB (n =54	PNE (n =17)	PTX (n =15)	SUR (n =8)
Normal	4 (12.5%)	6 (25%)	39 (71.9%)	2 (11.8%)	2 (13.4%)	2 (25.0%)
Improvement in lung aeration and vascular definition with decreased lung opacities	14 (43.8%)	10 (41.7%)	15 (28.1%)	4 (23.5%)	3 (20%)	0 (0%)
Worsening of the disease or similar appearance	10 (31.3%)	5 (20.8%)	0 (0%)	7 (41.2%)	0 (0%)	3 (37.5%)
PTX	2 (6.2%)	2 (8.3%)	0 (0%)	4 (23.5%)	10 (66.6%)	0 (0%)
Pulmonary hemorrhage	2 (6.2%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)
Pleural effusion	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)
Not performed	0 (0%)	1 (4.2%)	0 (0%)	0 (0%)	0 (0%)	3 (37.5%)

PNE: Pneumonia; SUR: Surgical causes of respiratory distress include congenital cystic adenoid malformation, congenital diaphragmatic hernia, congenital lobar emphysema, pulmonary sequestration, and tracheoesophageal fistula.

Table 4: Sensitivity and specificity of chest radiograph to Diagnose cause of respiratory distress

Disease	Sensitivity	Specificity	PPV	NPV
HMD	80	89	62	95.2
MAS	60.5	81.7	35.6	92.5
TTNB	36.4	96	100	73.9
Pneumonia	81.2	86.5	41.9	97.4
PTX	100	100	100	100
CDH	100	100	100	100
Cong. Lobar emphysema	100	100	100	100
Cong cystic adenoid malformation	0	100	0	99.7
Tracheosophageal fistula	100	100	100	100
Pulmonary sequestration	0	100	0	99.7

Table 5: Distribution of patients based on accuracy of CXR in diagnosis of patients

Disease	Final clinical diagnosis	Clinical diagnosis confirm by CXR	Accuracy
HMD	32	22	68.8
MAS	24	13	54.2
Transient tachypnea of neonates	54	18	36.4
Pneumonia	17	13	74.3
PTX	15	15	100
CDH	3	3	100
Cong.lobar emphysema	1	1	100
Cong. Cystic adenoid malformation	1	0	0
Tracheosophageal fistula	2	2	100
Pulmonary sequestration	1	0	0
Total	150	87	58

Discussion

In the present study, it was seen that 54.7% of the new-borns who developed respiratory distress were males compared to 45.3% of females. This was in accordance with a study done by Lureti *et al.* which showed the frequency of neonatal respiratory distress was higher in males when compared with females.[4] Similarly, Assogba *et al.* showed that out of the 177 patients in the NICU with respiratory distress syndrome (RDS), 99 were males and 78 were females.[5]

Miller similarly showed that the incidence of respiratory distress was almost 3 times higher among males than females.[6]

Out of 150 cases identified with respiratory distress, the commonest cause for respiratory distress was TTNB seen in 54 cases (35.7%) followed by HMD in 32 cases (21.3%), MAS in 24 cases (16%), pneumonia in 17 cases (11.7%), PTX in 15 cases (10%), and surgical causes of respiratory distress in 8 cases (5.3%). Similar results were seen in the study done by Gouyon *et al.* where the commonest cause for respiratory distress in newborns was TTNB (72%), followed by MAS (61%) and RDS (38%).[7] Hermansen and Lorah similarly found that TTNB is the most common cause of neonatal respiratory distress, constituting more than 40% of cases and suggested that a detailed history is critical for proper evaluation.[8] However, in a study done by Nagendra *et al*, the commonest cause for respiratory distress in neonates was RDS (18.8%) followed by TTNB (14%) and MAS (12.5%).[9] This variability in the present study was due to increased number of cesarean deliveries during the study period, giving rise to more number of TTNB cases. Another study done by Sarvaiya *et al.* stated that the commonest cause

Table 6: Distribution of patients according to type of outcome

Type of outcome	HMD (n=32)	MAS (n = 24)	TTNB (n = 54)	PNE (n = 17)	PTX (n = 15)	SUR (n = 8)	Total
Normal and discharged	16 (50%)	13 (54.2%)	54 (100%)	9 (52.9%)	10 (63.3%)	2 (18.7%)	104 (68%)
Worsening of disease	6 (18.7%)	5 (20.8%)	0 (0%)	3 (17.6%)	0 (0%)	0 (0%)	14 (9.7%)
Death	10 (31.3%)	6 (25%)	0 (0%)	4 (28.5%)	5 (36.7%)	0 (0%)	25 (17.7%)
Referred to higher center	0 (0%)	0 (0%)	0 (0%)	1 (6%)	0 (0%)	6 (81.3%)	7 (4.6%)

PNE: Pneumonia; SUR: Surgical causes of respiratory distress include congenital cystic adenoid malformation, congenital diaphragmatic hernia, congenital lobar emphysema, pulmonary sequestration, and tracheoesophageal fistula.

of respiratory distress in neonates was TTNB (32.20%), which was followed by HMD (20.33%), neonatal pneumonia (16.94%), MAS (11.86%), cardiac causes (5.08%), tracheoesophageal fistula (4.23), and diaphragmatic hernia (2.54%).[10] In the present study, abnormal CXR findings were seen in 66% cases and were more in HMD (17.3%), TTNB (13%), MAS (11.33%), pneumonia (9.7%), and CDH (2.3%). This was significant in early diagnosis for a newborn in respiratory distress. Studies done by MacDonald and Seshia identified the usefulness of X-ray in neonatal respiratory distress in 89 cases. They observed that an abnormal chest radiogram was seen more in MAS (30.2%), followed by HMD (29.2%), PTX (2.2%), and CDH (1.12%). This variability in the present study was due to a larger sample size and more number of TTNB (54) cases.

In the present study, the sensitivity and specificity of the radiography in HMD were 80 and 89% respectively, and in MAS, the sensitivity and specificity were 60.5 and 81.7%. This correlates to the findings of Kurl *et al*. study in which clinical and radiographic diagnosis in HMD matched in 95% of cases.[11] Shahri *et al*. observed that in 39 patients of HMD, the sensitivity and specificity were 35 and 82% respectively.[12] This variability in the present study was due to a bigger sample size and also due to interobserver variation in interpretations.

In TTNB cases, the sensitivity and specificity of radio-graphic tests were 36.4 and 96% respectively. This is similar to the study of Kurl *et al*. in which 48% of clinical and radio-graphic diagnosis matched properly.[11] Similarly, Agrawal *et al.* found that many newborn with transient tachypnea had clear chest films and that the concept of TTNB should be expanded to include cases with normal chest films.[13] Also the study of Ponhold revealed that the diagnosis of TTNB is mainly based on clinical signs and symptoms.[14]

The sensitivity and specificity of the CXR in pneumonia were 81.2 and 86.5% respectively, in the present study. Similarly, Shahri *et al.* found that for pneumonia, radiography had 73% sensitivity and 87% specificity.[12]

The specificity and sensitivity of the radiography in diagnosing PTX were 100%. The findings were in accordance with a similar study done by Marini *et al.* in which all patients with PTX were diagnosed on CXR.

In this study, congenital lobar emphysema was seen in one case of which had left upper lobe involvement and right upper lobe involvement and all cases were diagnosed on chest radiograph.[14,15]. Similarly, in a study by Salih and Al-Saad, congenital lobar emphysema was seen in two patients, both affecting the left upper lobe and the appearance was characteristic. Similar findings were observed in studies done by Mhiri *et al.* and Ozcelic *et al.* which concluded that all cases of congenital lobar emphysema can be seen on chest radiographs.

In this study, 2 (1.3%) cases of tracheoesophageal fistula were diagnosed on chest radiogram.[16] Similarly, in a study done by Sarvaiya *et al.*, 5 (4.23%)

neonates were diagnosed with tracheoesophageal fistula, 4 (80%) were diagnosed with esophageal atresia with tracheoesophageal fistula between distal end of esophagus and trachea (type C) and 1 (20%) with (type B) only esophageal atresia with no stomach air shadow seen.

For CDH and congenital lobar emphysema, the sensitivity and specificity of radiographic tests were 100%. Similarly, in a study by Marini *et al.*, all cases of hernia were confirmed by radiographs.

In the present study, in cases of congenital cystic adenoid malformation and pulmonary sequestration, a chest roentgenogram was inconclusive. Similarly, in our study, 26 neonates with HMD were treated with surfactant and improvement was seen on chest radiograph in 31 patients (57.4%), which is comparable to studies done by Dinger *et al.*, who reported the radiologic findings in 110 neonates treated with exogenous surfactant for established RDS. Uniform improvement was demonstrated on post-treatment chest radiographs in 38% of the infants, asymmetric improvement in 35%, no improvement in 10%, and interstitial gas in 17%.

There was a 17.7% mortality rate in our study and the most common cause was HMD (7%), MAS (4%), PTX (3.7%), and pneumonia (3%). Shrivastava *et al*.[17] studied 1,000 babies and found that the most common respiratory cause of neonatal death was birth asphyxia (44%) followed by RDS (4.4%) and MAS (1.9%). This variation in the present study was due to the exclusion of extra-pulmonary causes of respiratory distress.[17]

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