

Role of Chest X-ray in Respiratory Distress of Neonates

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ABSTRACT

Introduction: The initial diagnosis of an infant with respiratory distress is crucial as life-saving measures can be started immediately. Despite all the improved diagnostic modalities out there, a roentgenogram of the chest is still considered the most reliable diagnostic tool to establish respiratory distress. The aim of this study was to assess and evaluate the role of chest X-ray (CXR) in neonatal respiratory distress.

Materials and methods: This study was a prospective correlational hospital-based study done in 300 neonates in Acharya Vinobha Bhave Rural Hospital, Sawangi (Meghe), Wardha. The neonates who were clinically diagnosed having respiratory distress were evaluated using chest radiograph. In all these patients, the chest radiography findings were noted and correlated with clinical findings.

Results: 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 pneumothorax (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.

Keywords: Chest X-ray, Diagnostic role, Respiratory distress of newborn.

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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 initial diagnosis of an infant with respiratory distress is crucial, as life-saving measures can be started immediately. This fortifies the need for an efficient tool to reinforce a clinical suspicion. Despite all the improved diagnostic modalities out there like ultrasonography, computed tomography (CT) scan, and magnetic resonance imaging, a roentgenogram of the chest is still considered the most reliable diagnostic tool to establish respiratory distress² and is indicated if any infant exhibits the signs. A plain CXR is not only affordable but also widely available and easily executable. Therefore, a plain CXR continues to be the primary mode of imaging for diagnosis.

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

In this study, the role of CXR in the diagnosis of medical and surgical causes of respiratory distress was studied. An analysis was also carried out to see in which situations an X-ray would not help in the diagnosis so that we could study the role of a CT scan in such situations.

MATERIALS AND METHODS

This study was a prospective correlational hospital-based study done in 300 neonates in the department of radio diagnosis, in a tertiary hospital between August 2014 and August 2016. 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. Computed tomography thorax was performed wherever recommended and feasible to confirm the diagnosis. Those neonates whose families were not willing for inclusion in the study, neonates presenting with cardiovascular causes of respiratory distress,

neonates presenting with systemic causes of respiratory distress were excluded.

X-ray Equipment

The radiographs for the study were performed on a portable Siemens Multimobil Series 2.5 X-ray machine. The machine has a tube potential of 40 to 125 kVp, exposure time of 20 ms to 5 s, and source to floor distance of 70 to 200 cm. The system uses a single film screen combination.

Technique of Chest Radiograph in Neonates

The emphasis was on high quality and low exposure in keeping with the As Low As Reasonably Achievable principle and collimation included:

- The beam should be centered at the nipple line and collimated to the outer chest.
- Superiorly: At the level of the chin; nothing above this level should be irradiated.
- Inferiorly: Above the level of the umbilicus.
- Laterally: To include the lateral chest walls.

Patient Positioning

Neonatal chest radiographs were taken in the anteroposterior view and a relative held the neonate.

Statistical Analysis

Statistical analysis was done using descriptive and inferential statistics using test statistics: Sensitivity, specificity, positive predictive value (PPV), negative predictive value (NPV), and accuracy. The software tools used in the analysis were Statistical Package for the Social Sciences version 17.0 and GraphPad Prism 6.0 version. Microsoft Word and Excel were used to generate graphs, tables, etc.

RESULTS

A total of 164 males and 136 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 2 shows the treatment given in neonates with respiratory distress admitted in NICU. Continued positive airway pressure was given in 226 (75.3%) cases and antibiotics were given in 107 (35.6%) cases. Vasopressors were given in 29 (9.6%) cases. Ventilated neonates were 88 (29.3%), followed by surfactant therapy to 54 (18%) cases, and blood transfusion was given in 8 (2.66%) neonates. Surfactant was solely used in the neonates with HMD. Rest of the results of our study are shown in Tables 3 to 9

Table 1: Distribution of patients according to sex

Sex	HMD (n = 64)	MAS (n = 48)	TTNB (n = 107)	PNE (n = 35)	PTX (n = 30)	SUR (n = 16)	Total
Male	36 (56.2%)	27 (56.2%)	58 (54.2%)	15 (42.9%)	18 (60%)	10 (62.5%)	164 (54.7%)
Female	28 (43.8%)	21 (43.8%)	49 (45.8%)	20 (57.1%)	12 (40%)	6 (37.5%)	136 (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: Distribution of patients according to type of treatment

Type of treatment	HMD (n = 64)	MAS (n = 48)	TTNB (n = 107)	PNE (n = 35)	PTX (n = 30)	SUR (n = 16)	Total
CPAP	22 (34.4%)	34 (70.8%)	102 (95.3%)	33 (94.3%)	20 (66.7%)	15 (93.7%)	226 (75.3%)
Ventilation	45 (70.3%)	9 (18.8%)	18 (16.8%)	14 (40%)	1 (3.3%)	1 (6.3%)	88 (29.3%)
Inotrops	23 (35.9%)	4 (8.3%)	0 (0%)	0 (0%)	2 (6.6%)	0 (0%)	29 (9.6%)
Antibiotic	11 (17.2%)	21 (43.7%)	35 (32.7%)	32 (91.4%)	8 (26.7%)	0 (0%)	107 (35.6%)
Surfactant	54 (84.4%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	54 (18%)
Transfusion	4 (6.3%)	2 (4.2%)	0 (0%)	1 (2.9%)	1 (3.3%)	0 (0%)	8 (2.66%)

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

Table 3: Chest X-ray findings of pleura

CXR findings of lungs	Pleura					
	HMD (n = 64)	MAS (n = 48)	TTNB (n = 107)	PNE (n = 35)	PTX (n = 30)	SUR (n = 16)
Normal	64 (100%)	39 (81.2%)	82 (76.7%)	19 (54.3%)	0 (0%)	16 (100%)
PTX	0 (0%)	0 (0%)	0 (0%)	0 (0%)	30 (100%)	0 (0%)
Pleural effusion	0 (0%)	9 (18.8%)	10 (9.3%)	13 (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%)	15 (14.0%)	3 (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 4: Pulmonary opacities on chest radiograph for each clinical diagnosis

CXR findings of lungs	Pulmonary opacities					
	HMD (n = 64)	MAS (n = 48)	TTNB (n = 107)	PNE (n = 35)	PTX (n = 30)	SUR (n = 16)
None	12 (18.7%)	17 (35.4%)	68 (63.5%)	7 (20%)	24 (80%)	15 (93.7%)
Reticulogranular pattern	10 (15.6%)	5 (10.4%)	0 (0%)	4 (11.4%)	0 (0%)	0 (0%)
Ground glass opacity	29 (45.3%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)
Linear streaking opacity at hilum	0 (0%)	0 (0%)	39 (36.4%)	0 (0%)	0 (0%)	0 (0%)
Coarse patchy infiltrates	5 (7.8%)	26 (54.1%)	0 (0%)	19 (54.3%)	6 (20%)	1 (6.3%)
Diffuse haziness	8 (12.5)	0 (0%)	0 (0%)	5 (14.3%)	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 5: Follow-up scan after 72 hours of onset of respiratory distress

CXR findings of lungs	HMD (n = 64)	MAS (n = 48)	TTNB (n = 107)	PNE (n = 35)	PTX (n = 30)	SUR (n = 16)
Normal	12 (18.7%)	14 (29.2%)	77 (71.9%)	6 (17.1%)	5 (16.7%)	4 (25.0%)
Improvement in lung aeration and vascular definition with decreased lung opacities	31 (48.4%)	22 (45.8%)	30 (28.1%)	9 (25.7%)	6 (20%)	0 (0%)
Worsening of the disease or similar appearance	20 (31.2%)	12 (25%)	0 (0%)	17 (48.6%)	0 (0%)	7 (43.7%)
PTX	4 (6.2%)	6 (12.5%)	0 (0%)	10 (28.6%)	19 (63.3%)	0 (0%)
Pulmonary hemorrhage	5 (7.8%)	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 (2.1%)	0 (0%)	0 (0%)	0 (0%)	5 (31.3%)

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 6: Distribution of patients based on accuracy of CXR in diagnosis of patients

Disease	Final clinical diagnosis	Clinical diagnosis confirmed by CXR	Accuracy (%)
HMD	64	44	68.8
MAS	48	26	54.2
Transient tachypnea of neonates	107	39	36.4
Pneumonia	35	26	74.3
PTX	30	30	100
CDH	7	7	100
Congenital lobar emphysema	3	3	100
Congenital cystic adenoid malformation	1	0	0
Tracheoesophageal fistula	4	4	100
Pulmonary sequestration	1	0	0
Total	300	179	59.6

Table 7: 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
TTNBs	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
Congenital lobar emphysema	100	100	100	100
Congenital cystic adenoid malformation	0	100	0	99.7
Tracheoesophageal fistula	100	100	100	100
Pulmonary sequestration	0	100	0	99.7

DISCUSSION

In the present study, it was seen that 54.7% of the newborns who developed respiratory distress were males compared with 45.3% females. This was in accordance with a study done by Lureti et al⁴ which showed the frequency of neonatal respiratory distress was higher in males when compared with females. Similarly, Assogba et al⁵ showed that of the 177 patients in the NICU with respiratory distress syndrome (RDS), 99 were males and 78 were females. Miller⁶ similarly showed that the incidence of respiratory distress was almost 3 times higher among males than females.

Out of 300 cases identified with respiratory distress, the commonest cause for respiratory distress was TTNB

Table 8: Distribution of patients based on accuracy of CXR and CT scan

Disease	Diagnosis confirmed by CT	Diagnosis confirmed by CXR	Accuracy of X-ray (%)	Accuracy of CT (%)
Congenital lobar emphysema	3	2	66.6	100
Congenital cystic adenoid malformation	1	0	0	100
Tracheoesophageal fistula	4	4	100	100
Pulmonary sequestration	1	0	0	100
Total	9	6	66.7	100

Table 9: Distribution of patients according to type of outcome

Type of outcome	HMD (n = 64)	MAS (n = 48)	TTNB (n = 107)	PNE (n = 35)	PTX (n = 30)	SUR (n = 16)	Total
Normal and discharged	31 (48.4%)	26 (54.2%)	107 (100%)	18 (51.4%)	19 (63.3%)	3 (18.7%)	204 (68%)
Worsening of disease	12 (17%)	10 (20.8%)	0 (0%)	7 (20%)	0 (0%)	0 (0%)	29 (9.7%)
Death	21 (32.8%)	12 (25%)	0 (0%)	9 (25.7%)	11 (36.7%)	0 (0%)	53 (17.7%)
Referred to higher center	0 (0%)	0 (0%)	0 (0%)	1 (2.9%)	0 (0%)	13 (81.3%)	14 (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

seen in 107 cases (35.7%) followed by HMD in 64 cases (21.3%), MAS in 48 cases (16%), pneumonia in 35 cases (11.7%), PTX in 30 cases (10%), and surgical causes of respiratory distress in 16 cases (5.3%). Similar results were seen in the study done by Gouyon et al⁷ where the commonest cause for respiratory distress in newborns was TTNB (72%), followed by MAS (61%) and RDS (38%). Hermansen and Lorah⁸ 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. However, in a study done by Nagendra et al,⁹ the commonest cause for respiratory distress in neonates was RDS (18.8%) followed by TTNB (14%) and MAS (12.5%). 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 al¹⁰ stated that the commonest cause 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%).

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 Seshia¹ 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 (107) 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 al¹¹ study in which clinical and radiographic diagnosis in HMD matched in 95% of cases. Shahri et al¹² observed that in 39 patients of HMD, the sensitivity and specificity were 35 and 82% respectively. 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 radiographic tests were 36.4 and 96% respectively. This is similar to the study of Kurl et al¹¹ in which 48% of clinical and radiographic diagnosis matched properly. Similarly, Agrawal et al¹³ 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. Also the study of Ponhold¹⁴ revealed that the diagnosis of TTNB is mainly based on clinical signs and symptoms.

The sensitivity and specificity of the CXR in pneumonia were 81.2 and 86.5% respectively, in the present study. Similarly, Shahri et al¹² found that for pneumonia, radiography had 73% sensitivity and 87% specificity.

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 al² in which all patients with PTX were diagnosed on CXR.

In this study, congenital lobar emphysema was seen in three cases of which two cases had left upper lobe involvement and one case had right upper lobe involvement and all cases were diagnosed on chest radiograph. However, CT scan thorax was recommended in a doubtful case of right upper lobe congenital lobar emphysema. Similarly, in a study by Salih and Al-Saad,¹⁵ 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 al¹⁶ and Ozelic et al¹⁷ which concluded that all cases of congenital lobar emphysema can be seen on chest radiographs.

In this study, 4 (1.3%) cases of tracheoesophageal fistula was diagnosed on chest radiogram. The use of CT thorax was only limited to confirming the type of tracheoesophageal fistula, and all the cases were of type C. Similarly, in a study done by Sarvaiya et al,¹⁰ 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,² 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. These were confirmed by a multidetector computed tomography (MDCT) scan thorax. Similarly, Elhamd et al¹⁸ stated that MDCT was problem solving in complicated cases in whom the simpler tests were inconclusive. It was found that MDCT was useful in confirming the presence of the lesion, determining the extent of the lesion, and defining the associated abnormalities in all our cases which include congenital lobar emphysema and congenital pulmonary airway malformation. Similarly, Donnelly et al¹⁹ stated that in cases with unclear diagnosis, CT often provides diagnostic information about the exact anatomic location of the lesion that is difficult to determine on chest radiography.

In our study, 54 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 al²⁰ who reported the radiologic findings in 110 neonates treated with exogenous surfactant for established RDS. Uniform improvement was demonstrated on posttreatment 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 al²¹ 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 extrapulmonary causes of respiratory distress.

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