East African Medical Journal Vol. 97 No. 11 November 2020
PREVALENCE OF CHEST RADIOGRAPH FINDINGS IN NEONATES WITH RESPIRATORY DISTRESS AT KENYATTA NATIONAL HOSPITAL
Thomas Thiga Gachuiri, MBChB, MMed (Diagnostic Radiology) Consultant Radiologist, Thika Level 5 County Hospital, P.O Box 227, Thika 01000, Gladys Nthambi Mwango, MBChB, MMed (Diagnostic Radiology), Senior Lecturer, Department of Diagnostic Imaging and Radiation Medicine, University of Nairobi, P.O. Box 19676-00202. Ian Mathenge Muriithi, Senior Lecturer, Department of Diagnostic Imaging and Radiation Medicine, University of Nairobi, P.O. Box 19676-00202, Beatrice Mukhabi Mulama, MBChB, MMed (Diagnostic Radiology), Senior Medical Specialist, Department of Radiology, Kenyatta National Hospital P.O. Box 20723-00202, Nairobi, Kenya

Corresponding author. Dr. Gladys Nthambi Mwango, Department of Diagnostic Imaging and Radiation Medicine, University of Nairobi, P.O. Box 19676-00202, Nairobi, Kenya.

PREVALENCE OF CHEST RADIOGRAPH FINDINGS IN NEONATES WITH RESPIRATORY DISTRESS AT KENYATTA NATIONAL HOSPITAL

T. T. Gachuiri, G. N. Mwango, I. M. Muriithi and B. M. Mulama

ABSTRACT

Background: **Most of the global neonatal deaths from pulmonary infections occur in the developing nations. The main imaging used in the diagnosis and follow-up of these patients is the chest radiograph.**
Objective: **To describe the prevalence of chest radiographic findings in neonates with signs and symptoms of respiratory distress admitted at the newborn unit of Kenyatta National Hospital.**
Design: **Descriptive cross-sectional study.**
Subjects: **Neonates aged 1-30 days with clinical signs of respiratory distress and available chest radiograph during the study period.**
Results: **Using consecutive sampling, a total of 100 neonates with clinical signs of respiratory distress and available chest radiographs were recruited following ethical approval and parental informed consent. The male to female ratio was 1.04:1. The median age of neonates studied was 5.3 days (range 1 to 30 days). The mean birthweight was 2.1 kilograms (SD=0.9). Twenty-three percent (23%) of the study population were premature. The chest radiograph patterns were normal in 39% and abnormal in 61%. The abnormal chest findings were "other infiltrate" in 47% and alveolar consolidation in 14%. The most common causes of respiratory distress using radiographic features were respiratory distress syndrome (41.1%), transient tachypnoea of the newborn (16.8%) and neonatal pneumonia (15.8%). Non-pulmonary causes of respiratory distress were diagnosed in six neonates who presented with congenital heart disease (3), metabolic disorders (2) and choanal atresia (1).**
Conclusion: **From the neonatal chest radiograph findings; most neonates present with medical causes of respiratory distress of which the most common radiographic presentation was "other infiltrate".**

INTRODUCTION

The Kenyatta National Hospital Newborn Unit (NBU) has a 60-bed capacity which includes a Neonatal Intensive Care Unit of 6 beds and a high dependence unit of 7 beds. In 2010 there were 2150 NBU admissions of which 1214 were discharged home (KNH Newborn Unit Medical records, 2010). The number of deaths was 913 giving an NBU mortality rate of 42.5%. The 2010-2014 Kenya Demographic and Health Survey showed significant improvement in infant and child mortality rates which declined from 52/1000 and 74/1000 in 1999-2003 to 39/1000 and 52/1000 live births. The least change however was noted in the neonatal mortality rate which declined marginally from 24/1000 live births to 22/1000 in the same period(1).

Pediatric respiratory illness is a major cause of morbidity and mortality, with marked global variation in the epidemiology of such diseases. The highest burden of disease occurs in children in developing countries, where relatively poor resources limit the ability to effectively prevent and treat pediatric respiratory illness (2). These differences highlight the global inequities in healthcare and the urgent need for further research and global measures to prevent and treat the substantial burden of pediatric respiratory disease. Pulmonary disease is the most important cause of morbidity in preterm neonates as the lungs are often physiologically and morphologically immature (3). The neonate presents with apnoea, cyanosis, grunting, inspiratory stridor, nasal flaring, poor feeding, tachypnoea and chest wall retraction.

Radiographs of the chest and the abdomen are the most commonly requested diagnostic X-ray examinations in neonatal intensive care units (4). Satisfactory films can be obtained in incubators using modern mobile X-ray apparatus. The radiographs are taken to confirm or exclude a diagnosis, confirm the position of tubes and catheters used in NBU and to monitor treatment especially where ventilation is being used to look out for complications like barotrauma and air leaks (4,5). The chest radiography is one of the most challenging examinations to perform because of the wide range of tissue densities present in the thorax, the inherently low-contrast structures of soft tissues structures, the small size of the patient and the need to minimize exposure to ionizing radiation. These difficulties are further complicated by the requirement that images should be acquired at peak inspiration with appropriate positioning and where possible no artefacts and no patient motion (6). The appearance of portable chest radiographs (CXRs) may be affected by changes in ventilation, particularly when patients are mechanically ventilated. Synchronization of the CXR with the ventilator cycle can limit the influence of respiratory variation on the appearance of the CXR (6,7).

Plain chest radiographs are not without limitations. Felson reported that 20%-30% of significant information on a chest film may be overlooked by a trained radiologist and some disease processes may fail to appear on a plain film such as early ground glass opacities and small pleural effusions (8). Artifacts in neonatal chest imaging abound and can result from skin folds mimicking pneumothoraces, immobilization devices, oblique malpositioning projecting sternal centres over the lungs resulting in unusual opacities (2,8).

MATERIALS AND METHODS

All neonates with clinical diagnosis of respiratory distress were recruited into the study following ethical approval from the KNH-UoN ethical review committee and the guardians' informed consent via consecutive

sampling. Sample size was calculated to be 100 using the Fisher formula (9) at a disease prevalence of 7% (10). The radiographs for the study were performed on a portable Philips PRACTIX 160 X-ray machine manufactured in October 2006. The machine has a tube potential of 40-125 kilovoltage (kVp), exposure time of 1- 5.3 milliseconds (ms) and source to patient distance of 70 – 100 cm. Single film-screen combinations were used. The inclusion criteria were all neonates admitted to the NBU with respiratory distress and available chest radiograph. Exclusion criteria were neonates without clinical signs and symptoms of respiratory distress or with poor quality radiographs. The chest radiographs were assessed by two independent readers as per WHO guidelines (11,12). Findings that agreed were recorded in the data collection tool. Where there was no agreement, consensus was sought and then recorded. The following radiographic patterns were looked for: homogenous or alveolar consolidation, "other" infiltrate which included ground glass, reticulonodular and nodular opacities; and normal chest radiograph.

RESULTS

This study recruited 100 neonates during the study period from September 2010 to December 2010. Out of the 100 neonates in the study, 4 births did not occur in a health facility and 2 deliveries were referrals from peripheral health facilities, leaving a total of 94 neonates admitted with respiratory distress and delivered within KNH. The participants comprised 51 males (51%) and 49 females (49%) representing a Male-Female ratio of 1.04:1. The median age of neonates studied was 5.3 days with an age range from 1 to 30 days. Most (77%) of the neonates, were less than 7 days of age, and the remaining 23% were between 8 and 30 days of age.

The mean weight of the 100 neonates at birth was 2.1 kilograms (SD=0.9) and the range 0.8 to 4.6 kilograms. Seventy-seven percent of the neonates in the study were born at term and the remaining 23 infants were born before term. As shown in *Table 1*, all the preterm infants weighed less than 2.5 kg and 13 (56.5%) preterm neonates weighed less than 1.5 kg.

Prematurity showed a significant association with low birth weight, $p < 0.0001$.

Table 1

Birth weights of infants admitted to KNH newborn unit with respiratory distress

Birth weight	Preterm	Term infants	Chi square
Below 1.5 kg	13	12	$\chi^2(4) = 25.7$
1.5- <2.0 kg	6	9	P<0.0001
2.0- <2.5 kg	4	13	
2.5- <3.0 kg	0	12	
3.0 kg and above	0	28	

Thirty-nine percent had normal chest x-ray findings. Abnormal chest findings were seen in 61% and were more common in the premature (48%) infants compared to the term babies (36%). However, this was not statistically significant χ^2 (1) = 0.98; p = 0.34.

The frequencies of chest radiography findings are summarized in *Table 2* with parenchymal "other" opacification (47%) and homogenous consolidation (14%) being the common findings. A significantly higher proportion of neonates with RDS or pneumonia had visible opacities compared to TTN or other diagnoses.

(Fisher's exact test p-value 0.01)

Table 2

Frequency of chest radiography findings correlated with the 3 main clinical diagnoses

Radiographic pattern	RDS n=39, (%)	TTN n=16 (%)	Pneumonia n=15, (%)	Other diagnoses n=30, (%)	Totals n=100
"other" infiltrate	29 (74)	3 (19)	10 (67)	5 (17)	47
Alveolar consolidation	10 (26)	0	3 (20)	1 (3)	14
Normal chest	0	13 (81)	2 (13)	24 (80)	39

Examples of "other" infiltrates are seen in *Images 1* and *2* while alveolar consolidation is seen in *image 3* and *image 4*. *Image 5* shows a normal thymus.

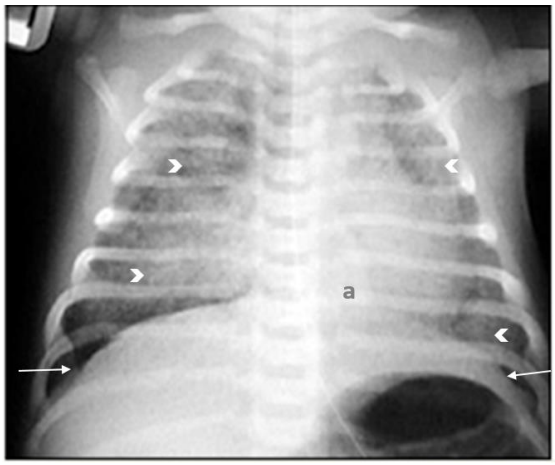

Image 1: CXR showing hyperinflated lungs with flattened hemidiaphragms (arrows) with widespread coarse nodular opacities (block arrowheads) and a segmental retrocardiac atelectasis (a) in a case of meconium aspiration syndrome.

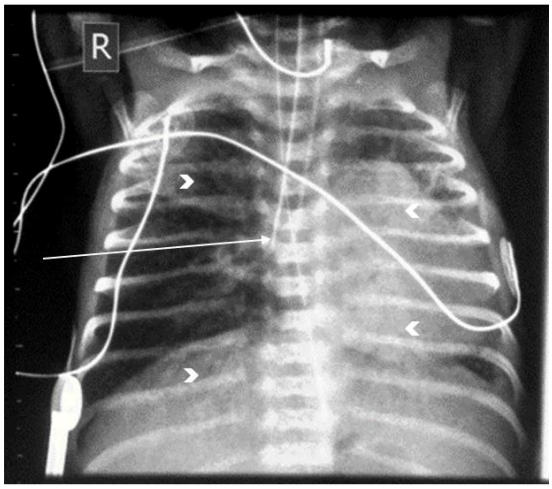

Image 2: CXR showing inhomogenous ground-glass opacification with air bronchograms (block arrows). There is a malpositioned endotracheal tube (ETT) with a tip in the right main bronchus (arrow) with hyperinflated lungs seen in the flattened hemidiaphragrams and widened intercostal spaces (more right side) and mediastinal shift to the left. The ETT was corrected but unfortunately patient died two days later.

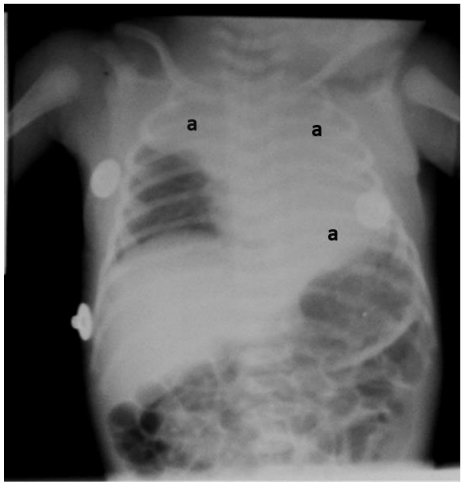

Image 3: CXR Showing low lung volumes, total opacification of the left lung and right upper lobe concerning for atelectasis (a) in a neonate clinically diagnosed with respiratory distress syndrome.

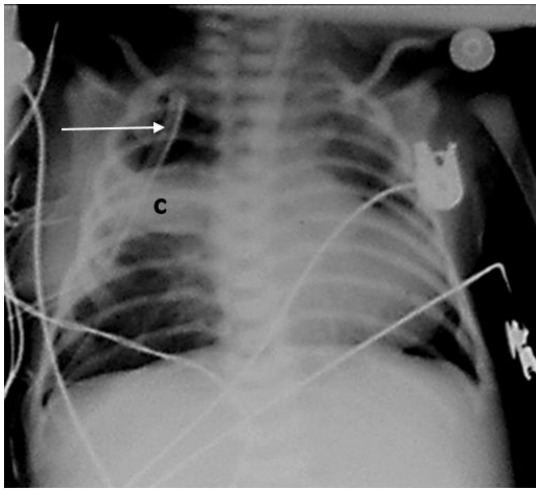

Image 4: CXR showing at chest tube in the right apical region (arrow) with a segmental consolidation (c) of the right mid lung zone.

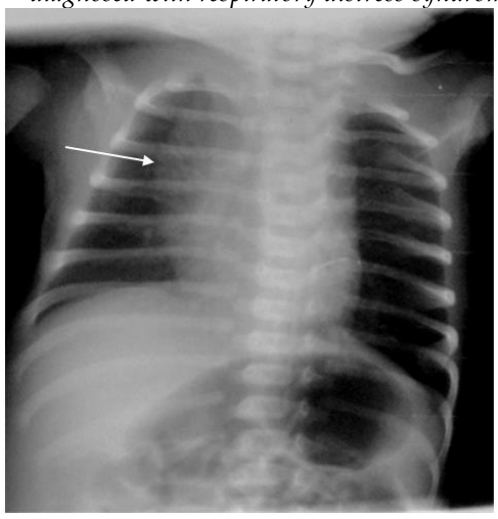

Image 5: CXR Showing widened superior mediastinum, in a case of a normal thymus (arrowed).The lung fields are clear but hyperinflated.

The comparison of the main chest radiograph patterns seen in the preterm neonates compared to the term infants showed similar findings. The proportion of premature infants with lung parenchyma "other" opacification was 48% compared to 47% in term infants. The percentages of preterm infants with homogenous consolidations and ground glass patterns were also like those of term infants as presented in Table 3. These findings were not statistically significant (Fisher's p-value 0.56)

Table 3

Comparison of Chest radiography patterns among premature and term infants

Radiographic Pattern	**Prematurity**	**Term infants**
"Other" opacification	11(48)	36(47)
Homogeneous consolidation	4(17)	10(13)
Ground glass pattern	2(9)	8(10)
Total	**23(100)**	**77(100)**

DISCUSSION

The aim of this study was to describe the chest radiograph findings among neonates admitted with respiratory distress at KNH-a tertiary level hospital in a developing country. This study shows that respiratory distress occurred more commonly within the first week of life as 77% of the study participants were in their first seven days of life. Higher prevalence of respiratory distress in the first week of life have similarly been reported in a Kenyan District hospital by Mwaniki and colleagues(13). Kasirye-Bainda also reported similar results within the KNH newborn unit (14).

Very low birth weight babies accounted for one-quarter of all children with respiratory distress, contributing disproportionately to admissions with respiratory distress. Possible explanations for high number of children with very low birth weight and

respiratory distress include prematurity with the consequent association of lung immaturity. Studies have reported that prematurity is significantly associated with low birth weight, $p < 0.0001$(15).

Prematurity, a well-established risk factor for respiratory distress, was diagnosed in 23% of all children with RDS in our study. As indicated in previous studies, respiratory distress among the preterm newborns was commonly related to diffuse pulmonary disease with approximately one-half of all the preterm infants having abnormal chest x rays. The commonly seen pattern in these preterm infants was granular opacities (10,15).

This study reviewed 100 neonates in respiratory distress. Chest radiographs revealed abnormalities in 61% of the patients, representing most of the patients with RDS (74%) and pneumonia (67%) and only 19% of the TTN cases. Despite the presence of few comparable radiological studies among neonates with respiratory distress in Kenya, the patterns reported in this study are consistent with previous reports. Out of the 15 neonates with respiratory distress caused by pneumonia, 67% had consolidation on chest radiography and 74% of the 39 cases of RDS had infiltrates. Our findings are comparable to a study documenting radiological evidence consistent with TTN/ RDS spectrum among all 8 young infant admissions with respiratory distress and consolidation on chest x-rays at a rural Kenyan district hospital(16). A prospective study set in a teaching hospital in Nigeria among 108 infants with respiratory distress has also reported that 24 (34.3%) out of the 70 children with negative cultures had radiologic evidence of pulmonary infiltration consistent with pneumonia(17).

In addition, the chest radiograph patterns reported in this study were also similar to that of studies from other low- and middle-income countries. In a study of 308 neonates presenting with respiratory distress at a university hospital in Brazil, 38.7% of neonates had indicators of bacterial infection and 19.7% had radiographic changes suggestive of pneumonia such as foci of patchy infiltrates in one or both lungs and reticulogranularity or haziness in both lungs (18).

The study limitations include interobserver variations in the interpretation of chest radiographs which was not documented in this study. Studies have shown that misclassification errors are common especially when interpreting "other" infiltrates. Attempts were made to minimize these errors in the study through consensus between the interpreters (GNM and BMM). This study being carried out in a tertiary hospital means its findings though comparable to studies done elsewhere are not generalizable as the population of neonates admitted to KNH newborn unit could potentially differ from most neonates admitted in lower-level facilities in the country. The findings are, however, applicable to admissions to similar newborn units in developing countries and in the absence of radiological studies on newborn respiratory distress in low-income setting these data contribute to the existing body of knowledge in the developing countries.

The study has established that radiological abnormalities commonly occur in neonates presenting with respiratory distress at tertiary level hospital in Kenya. Among these neonates with abnormal chest radiographs, specific patterns were shown to be more prevalent among particular commonly occuring diagnoses including pneumonia and RDS. On the basis of these findings, the study provides evidence for use of chest radiography in establishing abnormalities associated with common clinical diagnosis in respiratory distress, especially in cases where either neonates do not respond to empirical therapy or the clinical features do not provide adequate

information to allow clinicians make a definitive diagnosis on the cause of respiratory distress.

REFERENCES

1. Kenya Demographics and Health Survey [Internet]. 2014. Available from: https://dhsprogram.com/pubs/pdf/fr308/fr308.pdf
2. Mulholland K. Global burden of acute respiratory infections in children: implications for interventions. Pediatr Pulmonol. 2003;36(6):469–74.
3. Agrons GA, Courtney SE, Stocker JT, Markowitz RI. From the archives of the AFIP: Lung disease in premature neonates: radiologic-pathologic correlation. Radiographics. 2005;25(4):1047–73.
4. Carfagnini F., Greco L., Vivacqua D., Rasetto G., Poerio A. BM. Imaging in Neonates. Neonatal Surg [Internet]. 2019;25–49. Available from: https://link.springer.com/chapter/10.1007/978-3-319-93534-8_3#citeas
5. Czarnecki ŁM. Assessment of chest X-ray images in newborns with respiratory disorders. Kardiochirurgia i Torakochirurgia Pol. 2015;12(1):83–6.
6. Sutton D. Textbook of Radiology and Imaging. 7th ed. Lippincott Williams & Wilkins; 2014.
7. Arthur R. The neonatal chest X-ray. Paediatr Respir Rev. 2001;2:311–23.
8. Goodman L. Felson's Principles of Chest Roentgenology, A programmed text. 4th ed. Elsevier Saunders; 2014.
9. Charan J, Biswas T. How to calculate sample size for different study designs in medical research? Indian J Psychol Med [Internet]. 2013;35(2):121–6. Available from: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3775042/
10. Kumar, A., Bhat BV. Epidemiology of respiratory distress of newborns. Indian J Pediatr [Internet]. 1996;63(1):93–8. Available from: https://www.ncbi.nlm.nih.gov/pubmed/10829971
11. World Health Organization. Standardization of interpretation of chest radiographs for the diagnosis of pneumonia in children / World Health Organization Pneumonia Vaccine Trial Investigators' Group [Internet]. 2001. Available from: http://www.who.int/iris/handle/10665/66956
12. Cherian T, Mulholland E, Carlin J, Ostensen H. Standardized Interpretation of Paediatric Chest Radiographs for the Diagnosis of Pneumonia in Epidemiological Studies Variability in the Interpretation of Chest Radiographs ! Standardized Method for Identifying Radiological Pneumonia Would Facilitate Read. Bull World Heal Organ. 2005;83(5):353–359.
13. Mwaniki MK, Gatakaa HW, Mturi FN, Chesaro CR, Chuma JM, Peshu NM, et al. An increase in the burden of neonatal admissions to a rural district hospital in Kenya over 19 years. BMC Public Health [Internet]. 2010;10(1):591. Available from: http://www.biomedcentral.com/1471-2458/10/591
14. Kasirye-Bainda E, Musoke FN. Neonatal morbidity and mortality at Kenyatta National Hospital newborn unit. East Afr Med J [Internet]. 1992;69(7):360–5. Available from: https://pubmed.ncbi.nlm.nih.gov/1396189/
15. Lobo L. The neonatal chest. Eur J Radiol [Internet]. 2006;60(2):152–8. Available from: https://www.sciencedirect.com/science/article/abs/pii/S0720048X06003068
16. English M, Ngama M, Musumba C, Wamola B, Bwika J, Mohammed S, et al. Causes and outcome of young infant admissions to a Kenyan district hospital. Arch Dis Child. 2003;88(5):438–43.
17. Rabasa AI, Okolo AA. Early Diagnosis of Septicaemia in Infants with Respiratory Distress in the Tropics. Trop Doct. 1996;26(2):62–4.
18. Mussi-Pinhata MS, Nobre RA, Eulogio MF, Jorge SM, Ferlin MLS, Goncalves AL. Muissi-Pinhata 2004. J Trop Pediatr [Internet]. 2004;50(1):6–11. Available from: https://academic.oup.com/tropej/article/50/1/6/1689350