THE PATTERN OF CHEST RADIOGRAPHIC FINDINGS IN PULMONOLOGY OF CHILDREN UNDER FIVE YEARS.

A CROSS-SECTIONAL STUDY CARRIED OUT AT THE RADIOLOGY DEPARTMENT, KENYATTA NATIONAL HOSPITAL.

A DISSERTATION TO BE SUBMITTED IN PART FULFILIMENT FOR THE DEGREE OF MASTER OF MEDICINE IN DIAGNOSTIC IMAGING AND RADIATION MEDICINE, UNIVERSITY OF NAIROBI

BY

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DECLARATION

I, Dr MACHARIA MUKUHI MARGARET declares that the work contained in here is my original idea and has not been presented at any other place to the best of my knowledge.

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APPROVAL BY SUPERVISORS

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DEDICATION

This dissertation is dedicated to my husband James Mubia and my sons Caleb and Daniel for being so understanding and giving me the support that I so much needed.

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ABBREVIATIONS

IVC	Inferior vena cava
NG TUBE	Nasal gastric tube
TTN	Transient Tachypnea of the Newborn
RDS	Respiratory Distress Syndrome
AP	Antero posterior
CXR	Chest radiograph
US	Ultrasonography
MRI	Magnetic Resonance Imaging
RNI	Radionuclide Imaging
PET	Positron Emission Tomography
PJP	Pneumocystic Jerovici pneumonia
CAM	Congenital Adenomatoid Malformation
LIP	Lymphocytic Interstitial Pneumonitis
TB	Tuberculosis
CT	Computed Tomography
KNH	Kenyatta National Hospital
URTI	Upper respiratory tract infection
CCF	Congestive cardiac failure
GERD	Gastro Esophageal reflux disease
TEF	Tracheal esophageal fistula
CTA	Computed tomography angiography
MRA	Magnetic resonance angiography
HRCT	High resolution computed tomography
ESR	Erythrocyte sedimentation rate
WBC	White blood count
LRTI	Lower respiratory tract infection
CRP	C- reactive proteins
HIV	Human immune deficiency virus

ABSTRACT

Background

Respiratory disease, primarily pneumonia, is the most common cause of morbidity and mortality in children less than 5 years old in developing countries resulting in an estimated four million deaths annually as stipulated in an interim programme for control of acute respiratory infections in Geneva, World Health Organization 1991. Chest radiography plays a vital role in the management of pulmonary conditions in children and is usually the initial and best available method for diagnosis.

Objectives

The objectives of this study were to determine the chest radiographic patterns in pulmonary disease in children less than 5 years, distribution by age and correlation with provisional clinical diagnosis.

Methodology

A cross-sectional study was carried out at Kenyatta National Hospital radiology department, over a period of six months between May 2011 and October 2011. All radiographs of children under 5 years at the Kenyatta National Hospital radiology department who met the selection criteria during the study period were included in the study after signing an informed consent.

The sample size was calculated using a formula based on the prevalence of respiratory infections in children less than 5 years. Each radiograph was reviewed by the researcher and a consultant radiologist. The radiological findings were recorded in the data collecting form for each participant. Data was eventually analyzed using the statistical package for social sciences (SPSS) computer software package and the results presented in form of charts and tables.

Results

During the 6 months study period, a total of 315 patients were recruited. The male: female ratio was 1.2:1. The age distribution ranged from 3 days to 59months with a mean age of 14.21 months and a median age of 10 months. Most children were between 6 months and 59 months of age accounting for 70% of the cases.

Bilateral lung pathology was seen in more than half of the children (54.6%) unlike unilateral disease which was in 26% of cases. Normal radiographs were reported in 19.4% of the participants.

The most predominant radiographic pattern was multiple patchy alveolar infiltrates at 42.86% followed by abnormal aeration (mainly hyperinflation) at 16.83% and peri bronchial and interstitial patterns at 15.56%. There were no radiographic patterns of lung cavities or lung masses. Disease complications were rare with pleural effusion being predominant at 7.94%. Hilar adenopathy was reported in six cases with pulmonary disease as a secondary sign.

Only two radiographic patterns showed significant statistical correlation with clinical diagnosis provided, with multiple patchy alveolar patterns having a p value of 0.004 while abnormal aeration pattern had a p value of 0.001.

Discussion

Chest radiography is the initial and often the only imaging modality used in the evaluation of respiratory conditions in children under 5 years. It constitutes 25-35% of the volume of any general radiology department.

This study emphasizes the need for radiological and clinical correlation in management of the patients considering the significant number of normal radiographs.

All the cases studied had infective conditions .No lung masses were seen as chest tumors are rare in children less than 5 years.

Conclusion

This study demonstrated that all the pulmonary conditions seen in children were amendable to medical treatment as opposed to surgical intervention demonstrating one of the applications of chest radiography in children less than 5 years.

A significant number of participants with normal radiographs had clinical disease hence the multidisciplinary action in patient management. Pulmonary complications were rare; therefore follow up routine radiographs are not required post treatment. Multiple patchy alveolar infiltrates was the predominant pattern.

Recommendations

Inter observer variability observed in the description of radiographic patterns could be studied further.

Lung aspirates studies and correlation with chest radiographic patterns if undertaken would greatly assist in the rational use of antimicrobial therapy.

BACKGROUND

Respiratory tract diseases are the most common cause of illness in children and one of the most common indications for imaging in children.[1] The respiratory tract filters out toxins and micro-organisms while allowing nutrients to be exchanged with waste from the circulatory system. Disorders of the respiratory tract, from masses that obstruct the airways, to changes in the permeability of the alveolar membrane may take minutes or years to develop.[2]

Pathology can be from abnormal development of the apparatus of respiration or effects of infection, trauma, malignancy and toxicity. Pathogens reach the lower respiratory tract via the airways, the pulmonary vasculature or by direct spread from extra pulmonary sites. Inhalation or aspiration of airborne organisms or aspiration of infected secretions or gastric materials is the commonest route for infections in the airways and lungs. Via this route, the response of the lungs and the resulting radiographic pattern depends on the virulence of the agent, the physical size of the organism, the quantity of the inoculums and the host immunity. [2]

Airway disease is by narrowing or blockage resulting from abnormal development, post inflammatory wall thickening, edema, thick viscid mucous, or by intrinsic /extrinsic compression by masses and foreign bodies.

Persistent infection causes destruction of the elastic tissue and musculature of bronchial walls leading to bronchiectasis. Radiographic findings are of abnormal aeration and perihilar lung markings.

Inflammation and injury to the small airways and alveolar membrane causes changes in membrane permeability resulting in replacement of the alveolar space by exudates, fluid or blood. Collapse and lung opacities with air trapping are the key radiographic findings. Inflammatory processes of the lung interstitium may lead to scarring and fibrosis. The airway of children is narrow and their respiratory reserve is small, hence any inflammation change causes tachypnea and respiratory distress.

Tenacious mucus in the airways results in obstruction and lobar collapse at an earlier stage than in adults.[3] Diagnostic workup of a child gasping for air always begins with history and physical examination.

The length of illness, the prodrome and the patient's prior medical and birth history should all factor into the critical categorization of the patient's disease. Respiratory rate, abnormal drooling, neck position, retractions, cyanosis, stridor and rhonchi are but a few of the signs the clinician relies on to determine the cause of respiratory distress. With few exceptions, chest radiograph is the first and often only imaging modality used to assess thoracic signs and symptoms.[1] Because the radiograph is of a relatively low radiation dose, inexpensive, widely available and relatively consistently performed, it provides an excellent survey of the lung parenchyma, cardiovascular, mediastinal, and chest wall structures.[1]

LITERATURE REVIEW

Chest radiographs are key in diagnosis of pneumonia which is more complex and difficult than it seems[4,5], as signs and symptoms are more nonspecific in infants and the young child than in adults.[5] Children cannot cooperate for proper physical examinations and when done, these examinations are less reliable compared to adults due to their lower tidal volumes making auscultation more difficult than in adults; hence the increased use of chest radiographs.[6,7]

Beyond the chest radiograph, there are no accurate laboratory tests to determine whether or not a child is likely to have pneumonia since tests such as increased ESR or WBC are neither sensitive nor specific.[6,8]

Studies have shown evidence that referring physicians do alter their management plans based on the information supplied by chest radiographs.[8,9] Chest radiographs help exclude potential surgical or medical etiologies with similar symptoms to pneumonia for example rib fractures in occult child abuse, stridor due to vascular rings, neuroblastoma eroding ribs, congenital hernia etc.[1]

Patterns of pulmonary opacities can be primarily alveolar or interstitial, focal or diffuse or of mixed pattern. They can be unilateral or bilateral, central/ parahilar or peripheral, or basal in location. An understanding of these opacification patterns, their distribution and probable causes provides a useful guide in interpretation of abnormal lung opacities in children.

The main clinical objective in patients with potential pneumonia is whether the patient is likely to have bacterial pneumonia and should be placed on antibiotics rather than determining the actual causative agent.[1] Viral lower respiratory tract disease typically shows bilateral symmetrical process of increased peribronchial opacities, hyper inflation and segmental atelectasis.([10],[11]) In contrast, bacterial pneumonia tends to be a unilateral process, segmental to lobar in distribution and represents true airspace opacification.[12] Air bronchograms are often identified. Pleural effusions are not uncommonly associated with bacterial pneumonia but are rarely associated with viral disease.

How accurate the classically described radiographic findings are in determining whether a child truly does have viral bacterial or other respiratory tract infection has been an issue. Most children with LRTI never have a specific etiology.[1] Clinical presentation and age plays a significant role in answering this question e.g. mycoplasma infection in school children.[13]

A number of publications that looked at this issue of predictive value of radiographic features have been published. In a 1986 publication, authors evaluated the ability of radiographic patterns of infection to predict whether or not a child had bacterial pneumonia based on clinical criteria and the rapid response to antibiotics.[14]

These authors reported that the radiographic presentation predicted which children met the clinical criteria for bacterial illness with an accuracy of 90%.

In response to this publication, a second group published an article in 1988 in which they used the same clinical and radiographic criteria as described in the initial paper and compared clinical criteria as a predictor for microbiology with radiographic criteria as a predictor for microbiology.[15]

These authors demonstrated that the clinical criteria had a positive predictive value for bacterial pneumonia of only 18% with a negative predictive value of 81%.
The radiographic criteria performed slightly better with a positive predictive value of 30% and the negative predictive value of bacterial pneumonia of 92%. [15]

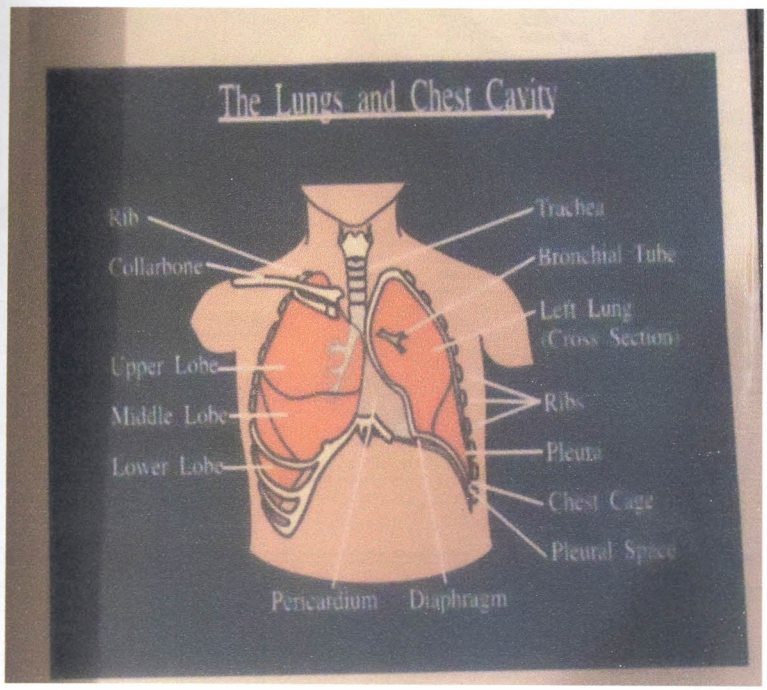
This study suggests that clinical and radiographic criteria substantially overestimates the number of children who have bacterial pneumonia; however only a small percent of children with bacterial pneumonia have the clinical and radiographic findings of viral lower respiratory tract infections. If the goal of obtaining a radiograph is to identify all those children who do not need to be placed on antibiotics, while ensuring that those who possibly have bacterial pneumonia do get placed on antibiotics, then the high negative predictive value of radiography in excluding bacterial pneumonia is valuable.

Korppi and co-workers studied radiological findings in 61 children with microbiologically verified pneumonia. Alveolar pattern was associated with bacterial infection in 74% with sole viral infection seen in 26% of the cases.[16]
R Virkki,T Juven,et al did a study on 254 children on differentiation of viral and bacterial pneumonia in children. This study provides evidence that bacterial infection is highly probable in cases of childhood community acquired pneumonia with alveolar infiltrates on the chest radiograph. Interstitial infiltrates are seen in both viral and bacterial pneumonias. With the exception of serum CRP levels, routine hematological tests have very little practical value in addition to a chest radiograph. It is evident that all children with radiological confirmed pneumonia should be treated with antibiotics, because in clinical practice, it is virtually impossible to distinguish exclusively between viral pneumonia and bacterial pneumonia.[17]

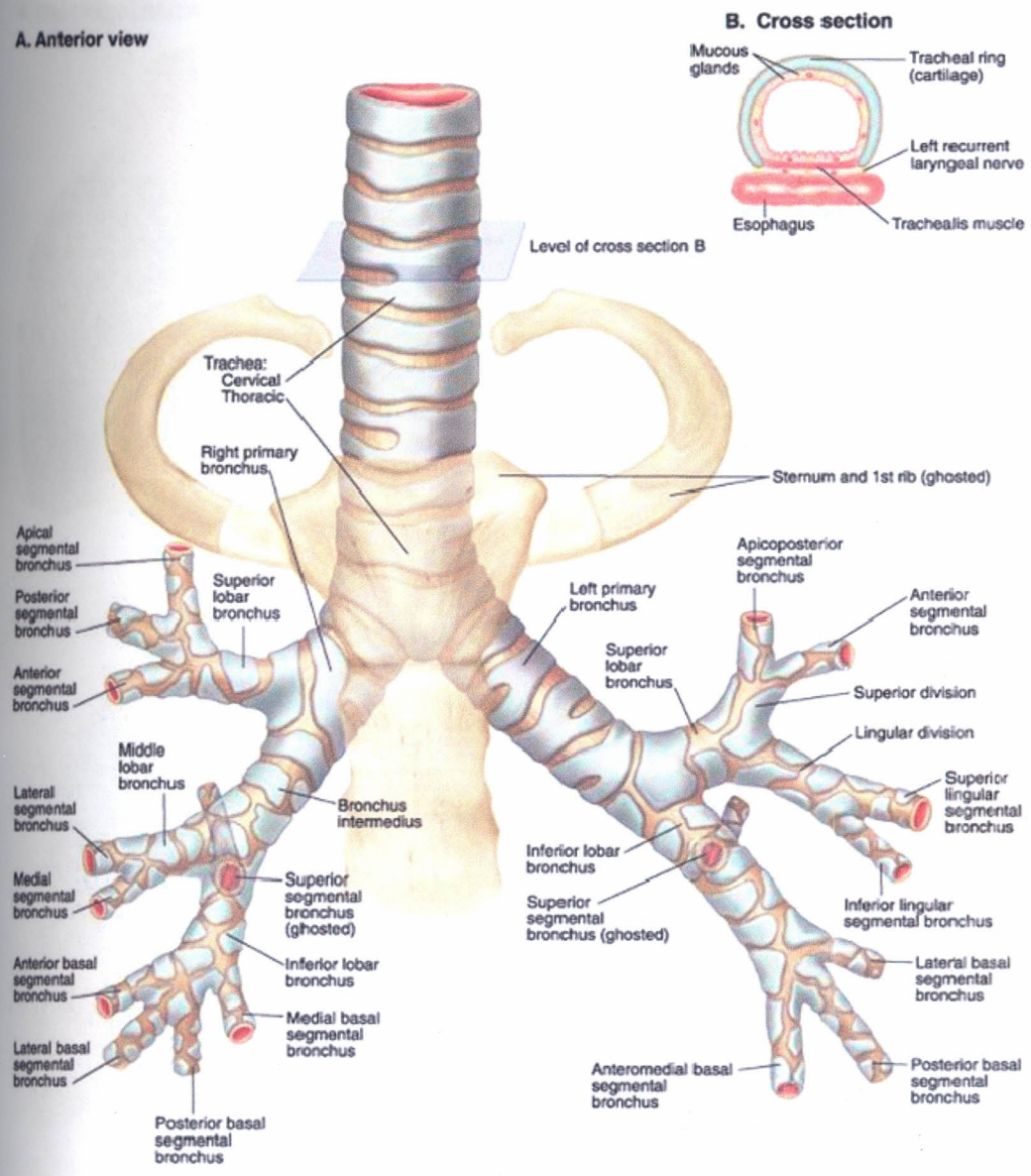
ANATOMY OF THE CHEST

The lungs are organs of respiration contained in the thoracic cage which consists of the ribs, thoracic spine and the sternum. They are surrounded by the visceral and parietal pleura. The two layers of the pleura are continuous at the hilum and below as the inferior pulmonary ligament. Each lung is divided into lobes by reflections of the visceral pleura called fissures. The right lung is divided into three lobes by the oblique and horizontal fissures while the left is divided into two by the oblique fissure. The lobes are further divided into segments by bronchial branching. The fissures are frequently incomplete with anatomical variations and contain localized defects which form pathway for collateral air drift and disease spread.

The central airways consist of the trachea, main bronchi, segmental and respiratory bronchioles. The gas exchange tissues (acini or primary lobule) each consists of a respiratory bronchiole, an alveolar duct and an alveolar sac. 3-5 of these acini form a secondary (Reid's) lobule[18]



BRONCHIAL ANATOMY



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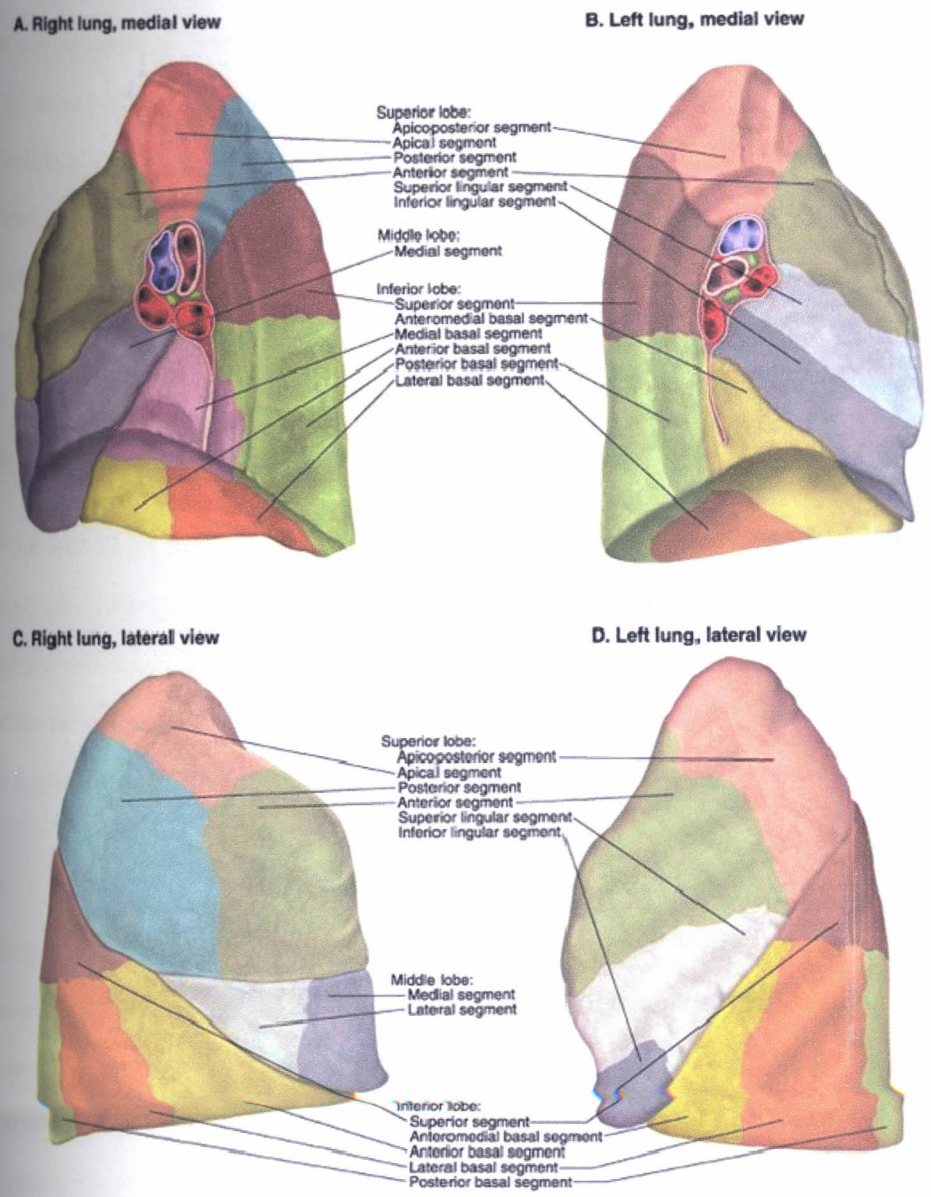
BRONCHOPULMONARY SEGMENTS



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PEDIATRIC CHEST DISEASE CONDITIONS.

The pediatric group includes neonates, infants, older children and adolescents. This study was carried out in children less than five years of age.

In the neonatal period, evaluation of tubes and lines is often the main reason for the chest radiograph.[3] Endotracheal tube should be 1-1.5cm above the carina.

Umbilical arterial line should lie just lateral to the left side of the spine with the tip ideally at T6-T10 or acceptably at L3-L5.

Umbilical vein catheter courses cephalad on the right side of the abdomen into the ductus venosus, then the inferior vena cava, then right atrium. The tip should be at T8-T9. NG tube and nasal jejunal tube positions should also be assessed with their tips at the stomach and proximal jejunum respectively.

A chest radiograph (CXR) helps differentiate between pulmonary disease conditions in neonates and infants that are amenable to surgery from those that need medical treatment.[3]

Transient tachypnea of the newborn or wet lung is as a result of delayed clearance of fluid normally present in the fetal lung especially of infants delivered by cesarean section. Mild symptomatology with radiographic signs of diffuse haziness and fluid in the fissures are seen in otherwise healthy newborns. The hallmark of diagnosis is clinical and radiological resolution of the disease process in 48-72hrs.

Respiratory distress syndrome is the most common life threatening respiratory disorder in the newborn. It is a result of alveolar surfactant deficiency that leads to lung trauma and hyaline membrane formation. Risk factors include prematurity, multiple gestation, poorly controlled maternal diabetes, fetal asphyxia, and maternal or fetal hemorrhage. It is characterized by severe respiratory distress worsening in the first 18-24hrs. Reticular shadowing, ground glass appearance and alveolar type consolidation in severe cases are the common radiological features. Other features seen are due to complications of the disease.[3]

Bronchopulmonary dysplasia (BPD) is a chronic lung disease that occurs in infants treated with positive pressure mechanical ventilation and oxygen. Barotrauma and oxygen toxicity occur leading to chronic inflammation. It is characterized by oxygen dependency at 28 days. Radiographic patterns are of patchy or linear strands of increased density with localized areas of unequal and hyper- aeration. Meconium aspiration is another common cause of respiratory distress. It is caused by gasping respirations in utero. A CXR shows patchy areas of collapse and consolidations with hyperinflation. Pneumothorax and pneumomediastinum are common complications.

Neonatal infections can be acquired by vertical transmission through the placenta e.g. syphilis, tuberculosis, and listeriosis. Group B streptococcus may also be transmitted by inhalation in the birth canal. Other causative organisms include Staphylococcal aureas, E coli and H.influenza.[3] Other causes of respiratory disease and distress include pulmonary agenesis or hypoplasia, haemorrhage, CAM, congenital lobar emphysema and bronchopulmonary sequestration. Congenital diaphragmatic hernia is a surgical cause of respiratory distress. Persistent fetal circulation is a common cardiac cause of neonatal respiratory distress.

THE OLDER CHILD CHEST

The thymus makes the mediastinum abnormally wide or misshapen. Thymic rebound may simulate an enlarging mediastinal mass; if in doubt an US can help confirm it. There are several pulmonary causes of respiratory disease in older children.[3] These include infections by various bacteria, viruses, fungi and mycobacterium which present as radiographic patterns of pulmonary opacities outlined below. Other features are of complications like pleural effusion. Foreign body, petroleum products inhalation, asthma and aspiration pneumonia are other common causes of respiratory disease and symptomatology in older children. Congenital causes of pulmonary disease include CAM, Tracheal-esophageal fistula, congenital lobar emphysema, diaphragmatic hernia, bronchopulmonary sequestration, Macleod syndrome, Scimitar syndrome, pulmonary agenesis/hypoplasia and bronchial atresia.

Pulmonary tumors are rare in children; however chest wall tumors are more common than primary lung tumors e.g. Askin tumors. Lung metastases are relatively common with known primaries including hypernephroma, rhabdomyosarcoma, Ewings tumor or osteosarcoma.[3] Interstitial lung diseases like cystic fibrosis and Kartageners syndrome, though rare, may occur.

Human Immunodeficiency Virus(HIV) infection.

The lung is a common site of involvement in the immunocompromised child. Over half of the children dying from the Acquired Immunodeficiency Syndrome(AIDS) have pulmonary disease.[2] About 87% of pediatric cases of HIV infection are from vertical transmission while 13% are from contaminated blood products.[2] Due to interventions and therapies on prevention of mother to child transmission of HIV, the number of new pediatrics HIV cases has reduced over time.Infections with atypical organisms may occur or common pathogens may exhibit an abnormal response due to reduced cellular and humoral immunity. There is considerable overlap in the radiographic appearances of the various differing infections.[3] Some of these infections include Pneumocystic Jerovici Pneumonia (PJP), Tuberculosis (TB), lymphocytic interstitial pneumonitis (LIP) , chicken pox, measles and the common bacteria.

In TB, radiographic findings of hilar adenopathy , pleural effusion and cavitation are extremely helpful in making this diagnosis.PJP gives bilateral airspace densities that may rapidly progress to respiratory failure. Air leak complications may occur.LIP is a chronic condition of diffuse interstitial infiltration of the lung by lymphocytes, plasma cells and histiocytes. Radiographic patterns are of diffuse nodular lung densities and enlarged hilar nodes similar to TB. A diffuse reticular pattern, coalescence of opacities or a normal chest radiograph are usual presentations.[3] Smooth muscle tumors presenting as nodular masses in the lung and along airways have been reported in HIV infected children, e.g leiomyomas, leiomyosarcomas.[2]

IMAGING MODALITIES

The decision on choice of imaging modality depends on the availability and the type of information sought [19]. Maximum information with the least radiation dose should be the principle.

Conventional chest radiographs

This should be the initial imaging study in all patients with chest disease. It constitutes 25%-35% of the volume of any general radiology department[19]. In children less than 5 years, anteroposterior (AP) and lateral radiographs (done after radiological review) are the mainstay of thoracic imaging. A dedicated chest unit capable of obtaining radiographs at short exposure, with high kvp and fast film screen combination is required. Thyroid shield should be used. Immobilization of the child should be done by a helper. ALARA principle should be applied and exposures taken by an experienced radiographer.

Chest radiographs can be digital or analog. Proper technique on frontal radiographs is determined by assessment of penetration, rotation, inspiration and motion.

Special techniques;

i. Lateral decubitus is used to detect small effusions, pneumothoracis and checking valve bronchial obstructions.
ii. Expiratory radiographs are usually used to detect small air trapping as in a small pneumothorax.
iii. Apical lordortic view improves visualization of the lung apices otherwise obscured by clavicles and the first costochondral junction.
v. Chest fluoroscopy is used to assess dynamics in patients with suspected diaphragmatic paralysis.

The neonatal chest is cylindrical in shape and small rotations can cause misinterpretations. Normal cardiothoracic ratio can be as large as 65% due to the thymus. A hole in the incubator may mimic a lung cyst or a pneumatocele while redundant skin causing a skin fold may simulate a pneumothorax [3].

Ultrasonography

This is an effective and easily performed complimentary examination to chest radiographs in evaluating puzzling areas of increased opacification thereby eliminating the need for other expensive or invasive studies [20, 21].

In neonates, transducers of 5-10 MHz linear array are used. In older children, 4-7 MHz or 2-4 MHz linear array or sector transducers are used. Approaches used include; transternal, parasternal and intercostal.

Ultrasonography is used in the definition of peripheral lung opacities, pleural abnormalities, characterization of pleural effusions and the completely opacifed hemi -thorax.

Assessment of normal thymic mass, chest wall masses and osseous involvement can also be done. Ultrasonography can also be used in intervention procedures and Doppler studies in suspected pulmonary sequestration.

Computed tomography(CT)

CT chest cannot replace CXR though it has superior density discrimination, wide dynamic range and an added value of cross sectional imaging. CT provides detailed anatomy of the chest wall, mediastinum and lung parenchyma [22].

A study done in 1980 by Kirks & Korobkn at the department of radiology Duke university medical center, analyzed 50 patients and showed that CT is of particular value in the evaluation of extra-pleural masses, parenchymal metastatic disease and posterior mediastinal tumors.[22]

Ionizing radiation is the main disadvantage.

MAGNETIC RESONANCE IMAGING

This has the advantages of superior contrast resolution, good tissue characterization, multiplanar imaging and rarely requires the use of contrast media. In children it is useful in the evaluation of the mediastinum, bony thorax and lung parenchyma, particularly in defining the extent of the disease and spinal cord involvement. Due to its use of non-ionizing radiation, it can replace CT in some cases of pediatric chest evaluation.[23]

RADIONUCLUIDE IMAGING (RNI)

Milk scan is an RNI study done in infants and younger children for gastro- esophageal reflux and pulmonary aspiration.[24] Positron emission tomography (PET) is superior to CT in the assessment of mediastinal nodes with a sensitivity of 83% and a specificity of 94%. CT-PET helps in more accurate anatomical localization of the hot spots .[25]

Ventilation/perfusion scans are done for pulmonary embolism which is rare in children.Gallium-67 has strong affinity for inflammation/infection and some malignancies especially lymphoma. RNI scans can also be used in pulmonary agenesis and hypoplasia.

UPPER GI STUDIES

These can be used to diagnose GERD as a cause of aspiration pneumonia. They are important in the diagnosis of TEF which usually manifests with pulmonary disease.

ANGIOGRAPHY

Conventional angiography is rarely done in children for pulmonary disease. CTA or MRA could be used in suspected pulmonary sequestration to demonstrate draining vessels.

BRONCHOGRAPHY & BRONCHOSCOPY

Bronchography has since been replaced by HRCT. Bronchoscopy is sometimes used in the diagnosis of foreign body inhalation and lobar collapse.

Case definition of patterns of pulmonary opacities and probable causes

These patterns and illustrative radiographs described below are adopted from Fundamentals of Diagnostic Radiology by William Brant.[19]

1. Focal alveolar consolidation (FIG A)

Occur when the alveolar airspace is replaced by a substance, usually fluid.

Most probable causes are bacterial pneumonia such as Streptococcus pneumonia, Haemophilus pneumonia and rarely Mycoplasma.

Nonbacterial infection and other conditions e.g. TB, Actinomycosis, pulmonary infarction, pulmonary hemorrhage and pulmonary contusion can also give this pattern.

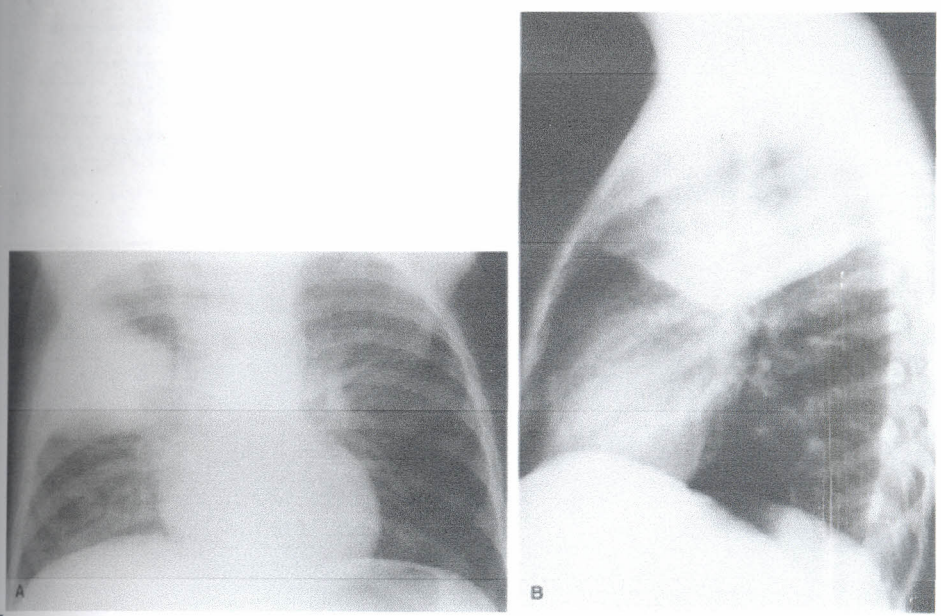


FIG A

2. Multiple patchy alveolar opacities (FIG B)

This reflects filling of the alveolar space with exudates, fluid or blood, inhomogenously. It is seen in infections like staphylococcal, mycoplasm, fungal, and opportunistic organisms.

Other conditions like aspiration of hydrocarbons, near drowning, immune-mediated *pneumonitis* in milk allergy, hypersensitivity pneumonitis, pulmonary hemorrhage and pulmonary edema could also give this same pattern.

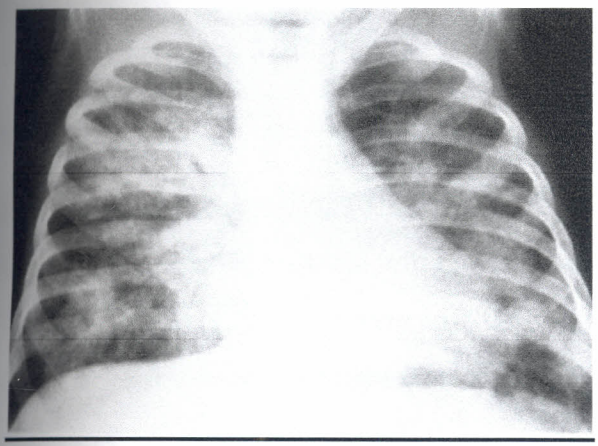


FIG B

3.Peribronchial and interstitial patterns(FIG C)

These are mainly prominent nodular peribronchial opacities.

Mainly seen in URTI which are viral in nature affecting primarily the bronchi.

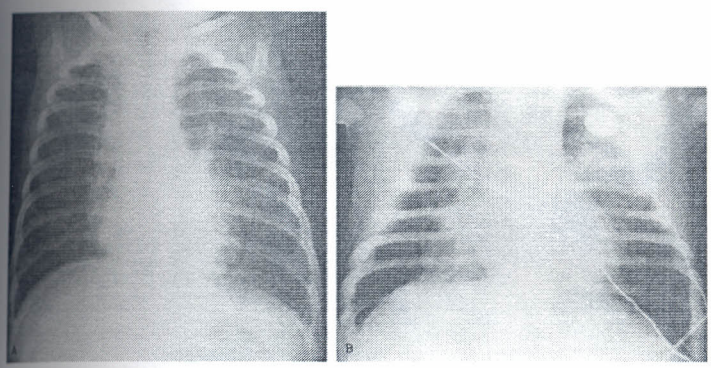


FIG C

4. Para hilar peribronchial opacities (FIG D)

This is as a result of peribronchial inflammation and edema associated with bronchitis.

Usually are bilateral,ill defined hazy soft tissue opacities in the hilar region that give a shaggy cardiac border appearance when extensive. They are mostly seen in acute infections e.g. viral, Mycoplasma, Chlamydia, or pertusis.

Chronic inflammatory conditions such as asthma, cystic fibrosis, immunological deficiencies and chronic aspiration may also give this picture.

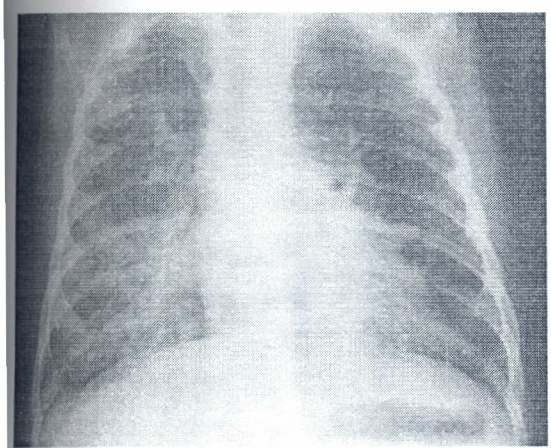


FIG D

5. Hazy, reticular or reticular nodular pattern(FIG E)

The main abnormality is thickening of the interstitium due to accumulation of fluid, cells, or fibrous tissue.

Commonest causes are viral, mycoplasma or fungal infections.

Other conditions include pulmonary edema from heart disease, ARF, near drowning, ICP, drug overdose, inhalation or ARDS.

Interstitial pneumonitis, connective tissue diseases and malignant conditions e.g. leukemia or lymphoma or lymphatic metastasis could also show this pattern.

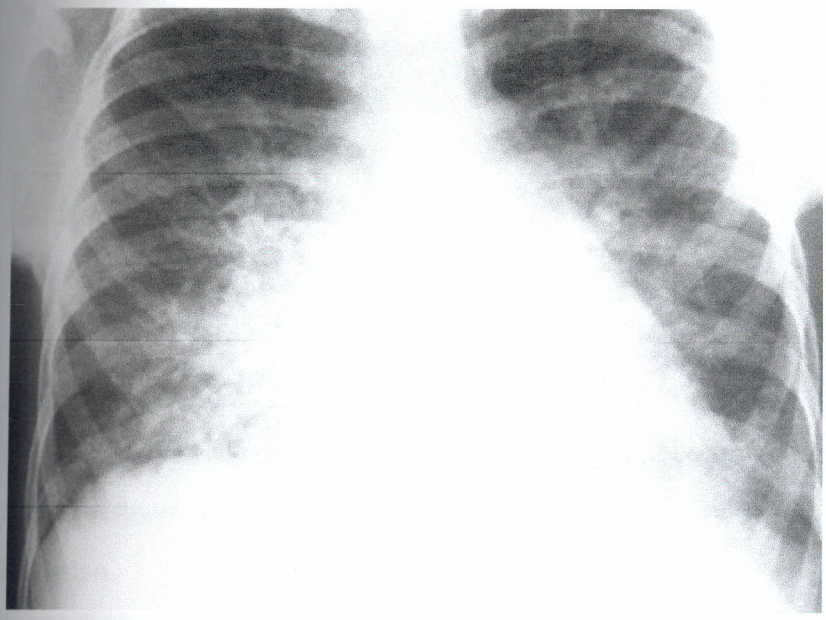


FIG E

6. Interstitial patterns with milliary nodules(FIG F)

Consists of tiny (millet like) nodules, <5mm that are distributed throughout the lungs.

Causes include infections like TB or histoplasmosis. Idiopathic hemosiderosis and metastatic diseases may also show a similar pattern.

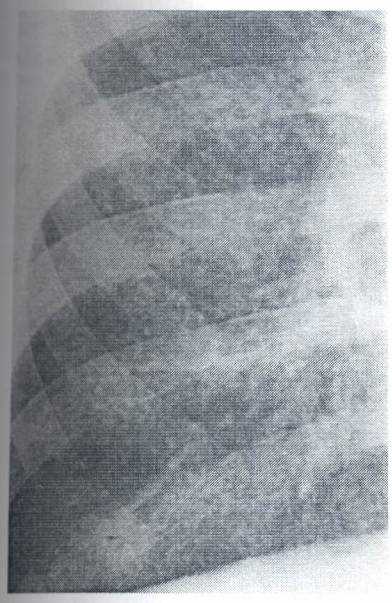


FIG F

7. Focal atelectatic opacity (FIG G)

Resembles bacterial consolidation but shows signs of volume loss, mediastinal and fissure shift. Usually follows acute viral infections, reactive airway disease, asthma and foreign body inhalation.

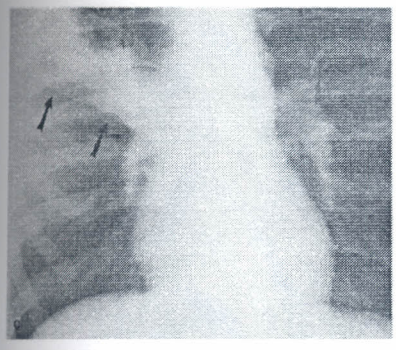


FIG G

8. Pleural effusion (FIG H)

There is thickening of the pleura along the lateral and apical portions of the lungs. Subpulmonic effusions are also shown by lateral displacement of the curvature of the diaphragm.

When unilateral, effusions are usually associated with pneumonia, empyema, tumor, pancreatitis and trauma.

Bilateral effusions can be due to renal disease, lymphoma, neuroblastoma, CCF, volume overload and connective tissue diseases.

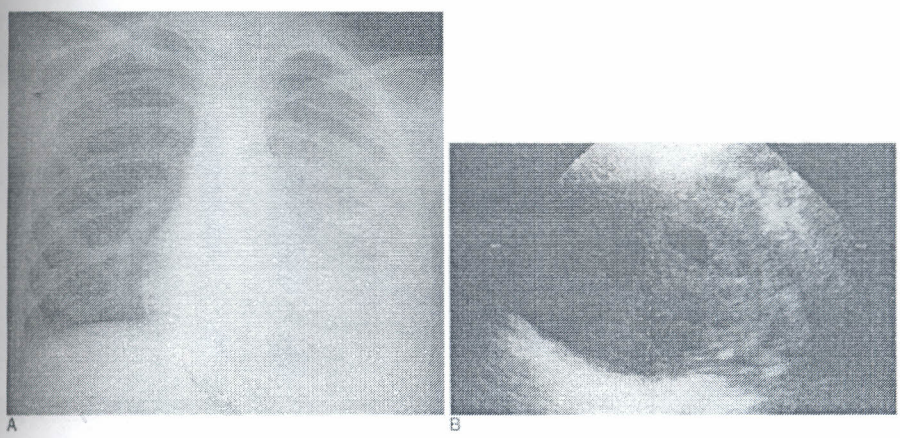


FIG H

9. Ground glass opacification (FIG I)

Classical features in RDS show lungs that are small in volume with fine granular pattern and air bronchograms that extend to the periphery. This worsens with time.

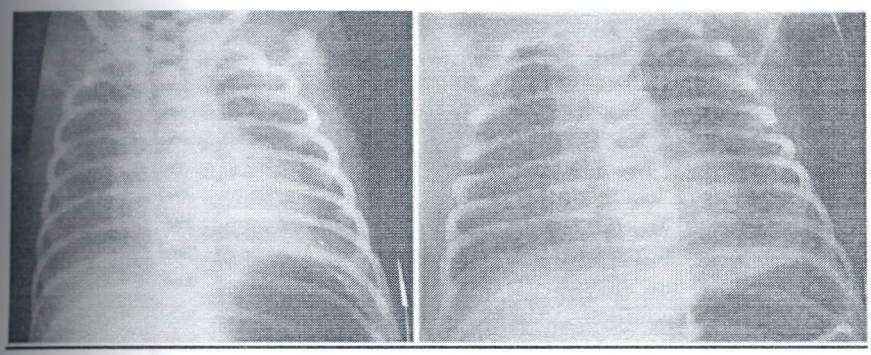


FIG I (worse 3 days later)

10.Lung cavities(FIG J)

These are usually post inflammatory as seen in lung abscesses or pneumatoceles.

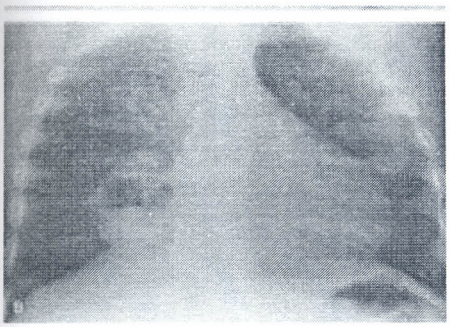


FIG J

11. Lung masses (FIG K)

Occur in round pneumonia, abscess, post inflammatory granuloma bronchogenic cyst, pulmonary sequestration or rarely neoplasm.

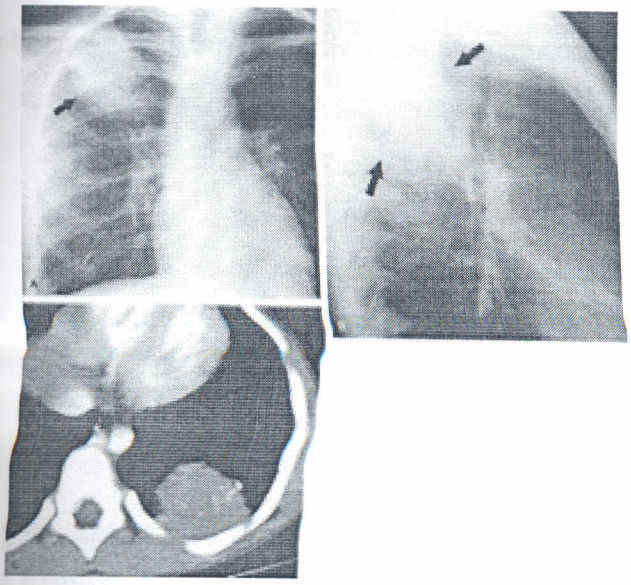


FIG K

12. Aeration abnomarlities (FIG L)

These include hyperinflation of the lungs, emphysematous changes and pnemothoracis with mass effect features e. g mediastinal shift.

Causes may be congenital, foreign body inhalation, mucous plug, TB, neoplasm and trauma.

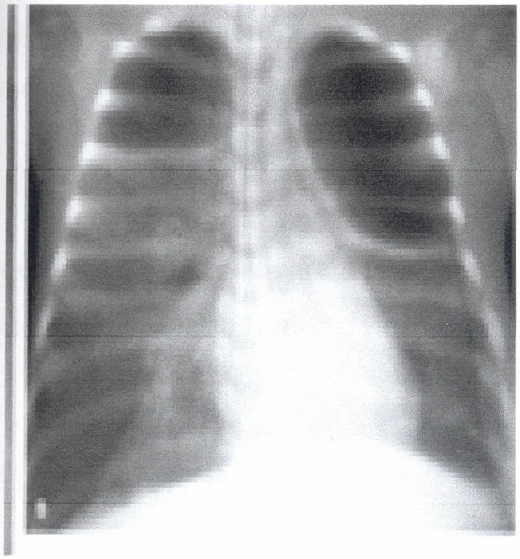


FIG L

OBJECTIVES

BROAD OBJECTIVE

To determine the pattern of chest radiographic findings in pulmonary disease of children under five years.

SPECIFIC OBJECTIVES

1. To determine the pattern of chest radiographic findings in children less than five years presenting with pulmonary disease at Kenyatta National Hospital.
2. To determine correlation between chest radiographic patterns and provisional clinical diagnosis.

RESEARCH QUESTION

What is the pattern of chest radiographic findings in children under five years presenting with pulmonary disease at Kenyatta National Hospital?

PROBLEM STATEMENT

Respiratory tract disease in children is a significant cause of morbidity and mortality in children under 5 years. A high index of suspicion, timely and proper use of chest radiographs to aid in diagnosis is essential.

JUSTIFICATION

Respiratory disease in children is quite common in clinical practice and contributes significantly to morbidity and mortality in this age group.

Majority of plain radiographs done in children are of the chest.

Studies have been done of the different imaging modalities in different settings; however no similar study has been done locally.

METHODOLOGY

DURATION OF THE STUDY.

This study investigated the pattern of radiographic findings in pulmonary disease in children under 5 years at KNH during the six month period between April 2011 and September 2011.

Study population.

This study included all children less than 5 years with suspected clinical pulmonary disease referred for chest radiograph by their primary physician in KNH during the period of study. This included inpatients and outpatients.

INCLUSION CRITERIA

All chest radiographs requested for pulmonary disease in children under 5 years during the period of study were included for both inpatient and outpatients.

EXCLUSION CRITERIA

Chest radiographs for children above 5 years and for cardiac pathology were excluded.
Also poor quality radiographs according to text book standards and WHO standardization criteria ([26]) were excluded.

Study site. Department of Radiology, Kenyatta National Hospital.

Study design. This is a cross sectional study. All chest radiographs of children less than 5 years referred for pulmonary disease were identified and those for above 5 years and for other organ pathology excluded.

Chest radiographs were interpreted by the principal researcher using text book standards and WHO tool on standardization of interpretation of chest radiographs for pneumonia in children.[26]

Two radiologists reviewed the radiographs independently and made their conclusions. To determine examiner variability, randomly selected radiographs were given to one of these radiologists for re-reading without their knowledge. For examiner validation, a radiologist with pediatrics experience then made interpretations of any radiographs where these two did not agree. Only then were the results documented.

Data management

Data was collected using a standard questionnaire (appendix A). This was cleaned and exported for statistical analysis.

Raw data was entered in tables and charts in a computer and analysis was done using the Statistical Package for Social Sciences (SPSS).

Descriptive statistics and frequency distributions were used to characterize the study population and present the study findings.

Representative images of some of the patterns are presented.

Sample size

Sample size was calculated using the Fisher's exact formula

$$n=\frac{z^2p(1-p)}{d^2}$$

$$=\frac{(1.96)^2X0.27X0.73}{(0.05)^2}$$

n= 303 patients

Where;

n=the desired sample size

p=the proportion in the target population estimated to have characteristics being measured (prevalence of respiratory infections in children under 5 years) [27]

z=the standard normal deviate at the required confidence level.

d=the level of statistical significance set.

Study limitations

The findings of this study may be constrained by time and season. Technical difficulties in acquiring quality radiographs in this age group was a challenge.

Study utility

Results of this study will be shared with the relevant institutions and departments to further improve health care.

The findings of this study will help sensitize radiologists to the common pediatric chest radiographic patterns and possible pulmonary pathologies.

Need for competence in pediatric chest radiographs interpretation bearing in mind the limitations of clinical history and physical examination in this age group will be underscored.

ETHICAL CONSIDERATIONS

1. Before execution of this study, this research proposal was presented to and ethical approval sought from the University's Ethical and Research Committee in writing.
2. Permission was granted by the KNH/UON Research and Ethics Committee.
3. No additional cost was incurred by the patient as these investigations are part of their management.
4. Patients' names were not be included in the data collecting forms hence confidentiality was maintained.

RESULTS

This chapter presents the findings of the analysis on patterns of chest radiographic findings among 315 children under five years presenting with pulmonary disease at KNH. These results are organized into the following sections: patients' demographic characteristics, pattern of chest radiographic findings, provisional clinical diagnosis and correlation between chest radiographic patterns and provisional clinical diagnosis.

Patients' demographic characteristics

Figure1. Sex distribution of children with pulmonary disease.

Figure 1 shows the sex of children presenting with pulmonary disease at KNH. Out of the 315 patients in the study 172 (54.6%) were male and 143 (45.4%) were female. There was a significant difference between the proportion of male and female patients recruited in the study (difference = 9.2%, 95% CI 1.4% to 17.0%, p-value = 0.021).

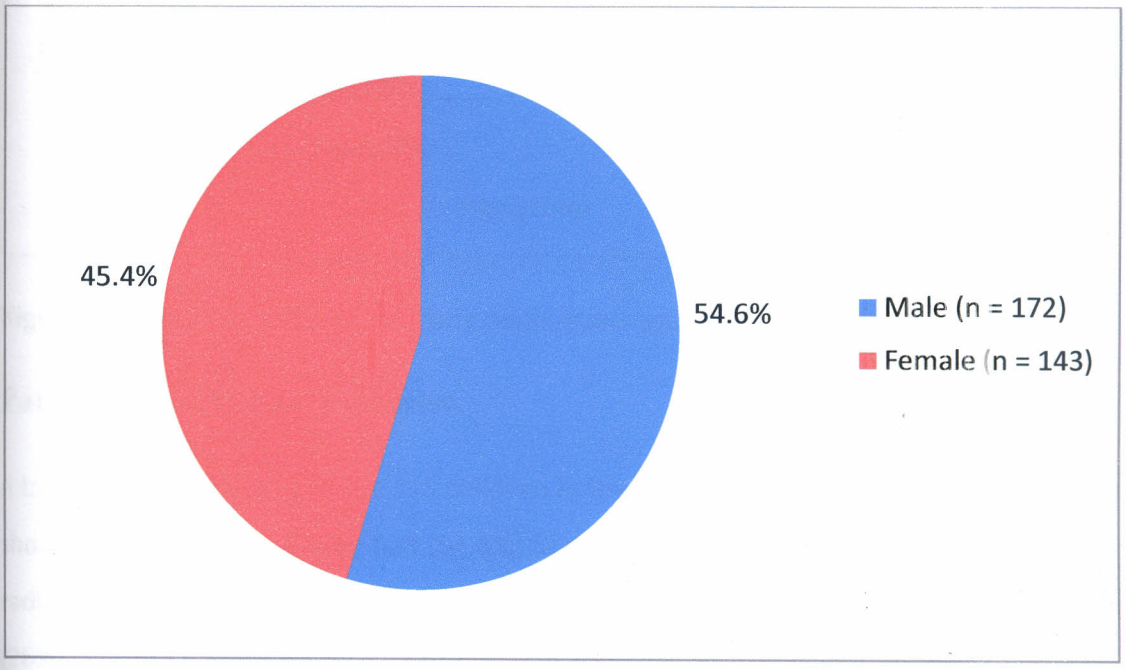


Figure 1: Sex distribution of children with pulmonary disease at KNH

Figure 2. Age

The age of patients recruited in the study ranged from 3 days to 59 months. The mean age was 14.21 months (SD 13.87) and the median age was 10 months (interquartile range 5 to 19 months). Figure 2 shows that a significantly large proportion (70.2%) of the patients were aged between 6 and 59 months of age compared to 29.8% (n = 94) of children aged 3 days to 6 months.

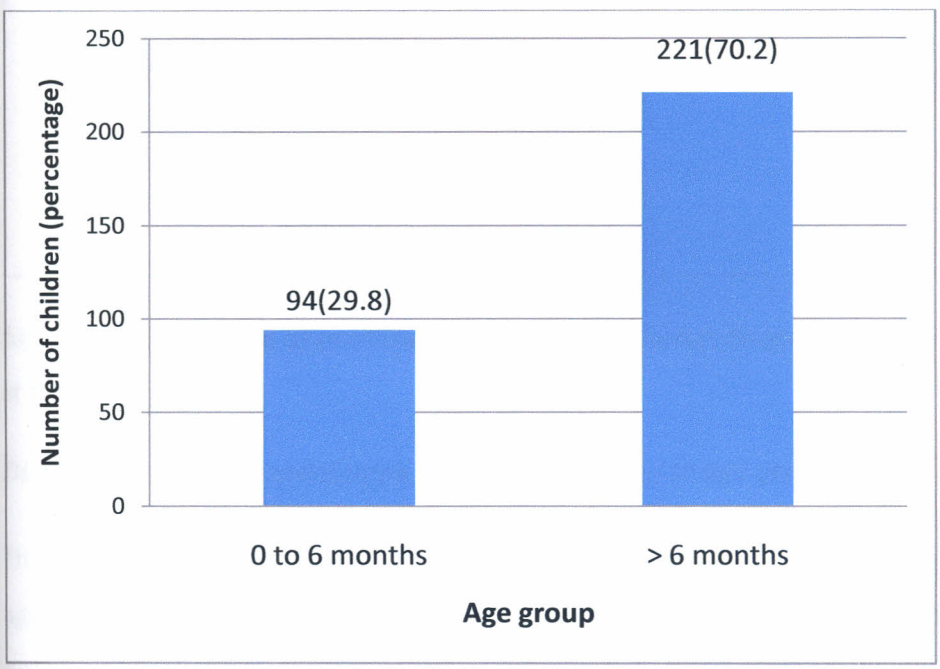


Figure 2: Percent distribution of study participants according to age group

Pattern of pulmonary disease.

A total of 61 (19.4%) out of the 315 children in the study had normal chest radiographs as shown in Figure 3. More than half (54.6%) of the children with pulmonary disease had chest radiograph disease process showing bilateral distribution in both lungs while the remaining 82 (26%) children presented with chest patterns showing unilateral distribution.

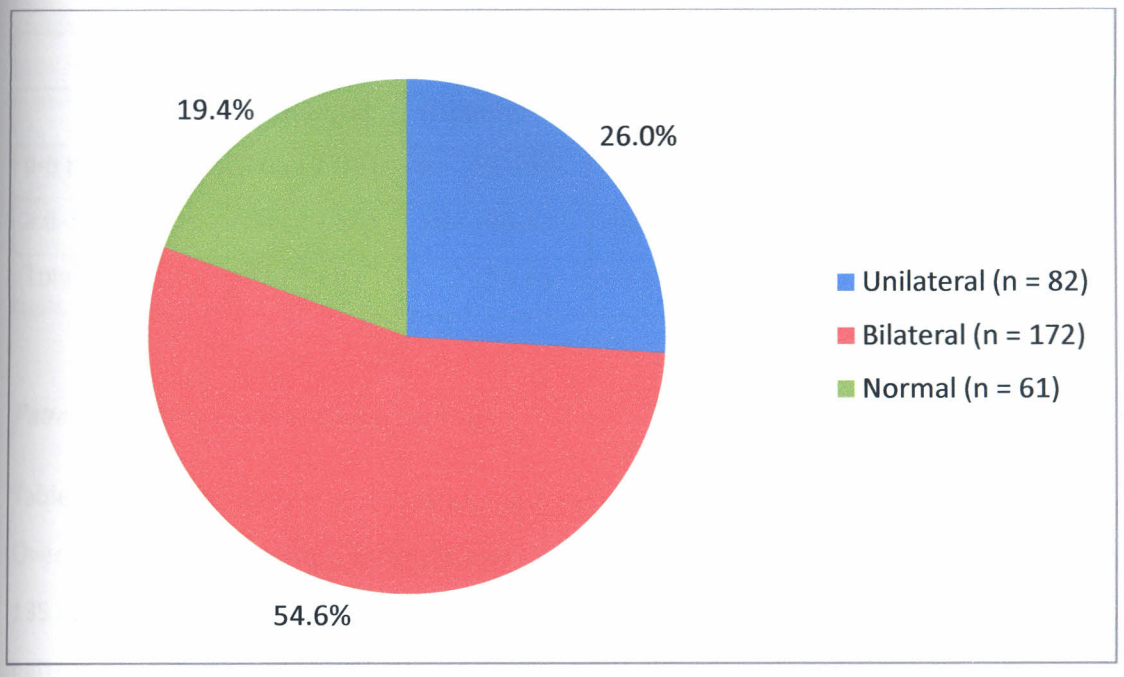


Figure 3: Distribution of pulmonary pathology in chest radiographs of children less than 5 years at KNH

Distribution of chest radiograph findings according to age group

The distribution of chest radiography findings showed a significant association with patients' age (Table 1). Most (69.15%) of the children below the age of six months had bilateral radiographic changes compared to approximately half (48.42%) of older children also showing bilateral involvement of radiographic findings (chi square = 11.49, p = 0.003). Conversely, older children were significantly more likely to have unilateral radiographic changes (29.86% versus 17.02%) or normal radiographs (21.72% versus 13.83%) compared to children less than 6 months.

Table 1: Distribution of chest radiograph findings among children less than 6 months and older children with pulmonary disease

	Distribution of chest x-ray finding			Chi square	P value
	Unilateral	Bilateral	Normal		
0-6 months	16 (17.02)	65 (69.15)	13 (13.83)	11.49	0.003
> 6-59 months	66 (29.86)	107 (48.42)	48 (21.72)		
Total	82 (26.0)	172 (54.6)	61 (19.4)		

Pattern of chest radiographic findings

Table 2 below shows the patterns of chest radiographic findings among children in this study. Overall, the most common findings were multiple patchy alveolar consolidations visualized in 135 (42.86%) radiographs, followed by aeration abnormalities, peribronchial and interstitial pattern reported in 53 (16.83%) and 49 (15.56%) children, respectively. Hyperinflation occurred in 47 (14.92%) children and was the most common type of aeration abnormality reported among children in this study against emphysematous changes and pneumothorax in 1.59% and 0.32% respectively.

There were differences in radiographic findings among children aged below six months and those older than 6 months. While multiple patchy alveolar consolidation was the most common finding among older children (6 to 59 months) the predominant finding in the children below 6 months was aeration abnormalities occurring in 37 (39.36%) chest radiographs. Hyperinflation was the most common aeration abnormality in both age groups.

All the three cases of ground glass opacification were in children less than 6 months and the single case of pneumothorax in a child aged 17 months (Table 2).

Provisional diagnoses

Overall, pneumonia was the most common diagnosis occurring in 110 (34.92%) children, followed by presentation with a persistent cough or difficulty in breathing (n = 71, 22.5%) and thirdly was TB (n = 60, 19.05%). There were important differences in the clinical presentation of children according to age as shown in the following section.

a) Diagnoses in children below six months

There were a total of 94 young infants (0 to 6 months) in the study. The most common diagnoses in this age group were pneumonia, persistent cough or difficult breathing, and respiratory distress occurring in 34 (36.2%), 18 (19.2%) and 15 (16.0%) children, respectively (Figure 4.4).

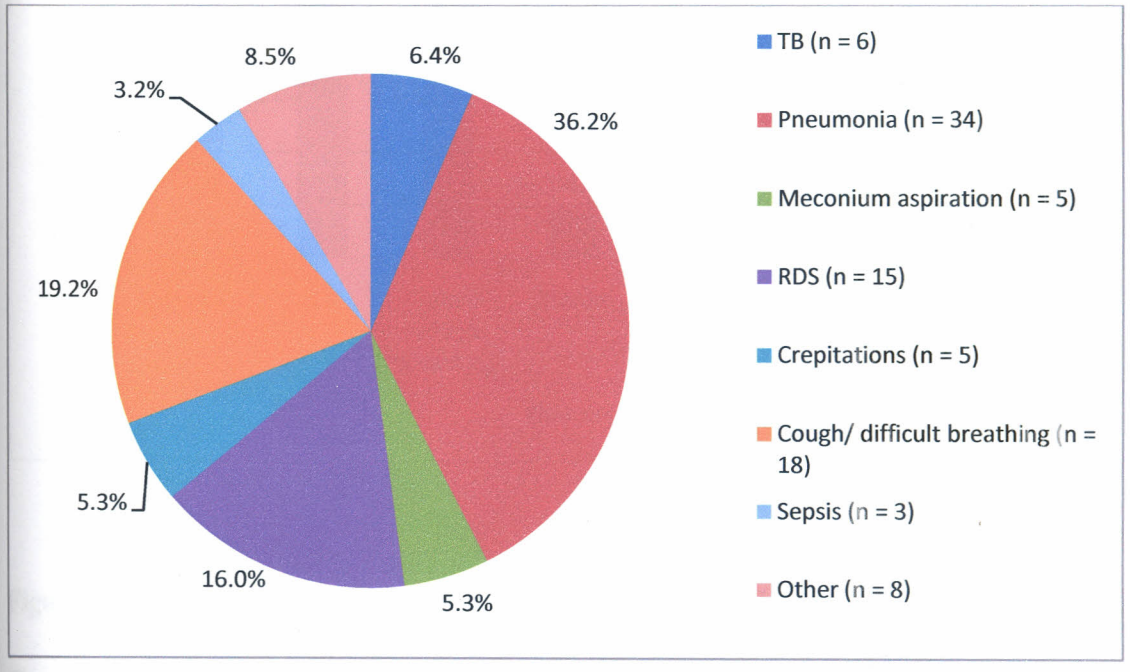


Figure 4: Clinical presentation of young infants (0-6 months) with pulmonary disease at KNH

b) **Diagnoses in older children (6 to 59 months)**

There were 221 children between the ages of 6 and 59 months. Unlike in the younger age group TB was an important diagnosis in this age group and was the second most common diagnosis affecting 54 (24.4%) children. As shown in Figure 4.5 below the leading diagnosis in children between the ages of 6 and 59 months was pneumonia (n = 76, 34.4%) and persistent cough or difficult breathing occurred in 53 (24%) children. RDS and sepsis were rare in this age group.

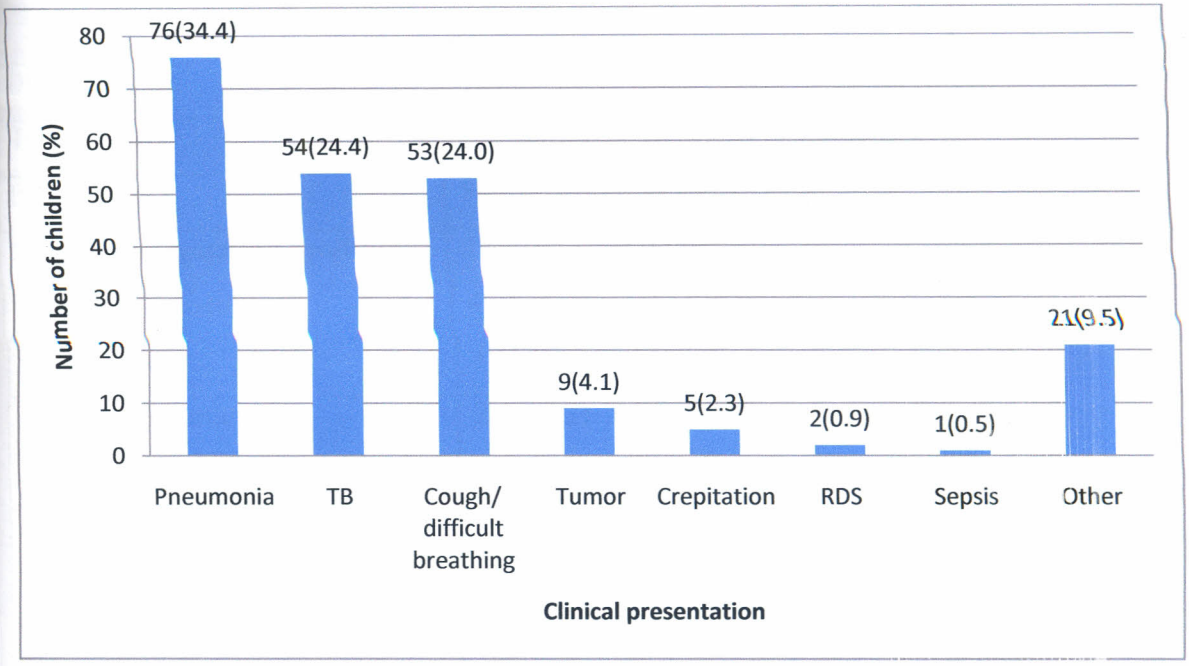


Figure 5: Clinical presentation of children with pulmonary disease aged 1 month to 59 months

Correlation between chest radiography and provisional diagnosis

The correlation between the leading diagnoses and chest radiography patterns were estimated using the chi square test or Fisher's exact test depending on the cell frequencies and are presented in the following section.

breathing (2.82%) and was most common among cases of respiratory distress (11.76%). There was however, no significant association between focal alveolar consolidation and the provisional clinical diagnosis (p = 0.606).

Table 4: Correlation between focal alveolar consolidation and provisional diagnosis

	Focal alveolar consolidation		P value*
Diagnosis	Yes	No	
Tuberculosis	4 (6.67)	56 (93.33)	0.606
Pneumonia	8 (7.27)	102 (92.73)	
Respiratory distress	2 (11.76)	15 (88.24)	
Crepitations	1 (10)	9 (90)	
Exclude metastases	1 (11.11)	8 (88.89)	
Cough or difficulty breathing	2 (2.82)	69 (97.18)	
Other	3 (10.34)	26 (89.66)	
Total	21 (6.86)	285 (93.14)	

*Fisher's exact test

C) Peribronchial and interstitial pattern

Peribronchial and interstitial pattern was visualized on the chest radiographs of 49 children. Table 5 shows the distribution of this pattern according to diagnosis. Thirty percent (3 out of 10) of children with crepitations had peribronchial and interstitial pattern. This pattern was not seen in children presenting with sepsis or tumors as primary diagnoses.

Table 5: Correlation between peribronchial and interstitial pattern and provisional diagnosis

			P value*
Diagnosis	Yes	No	
Tuberculosis	10 (16.67)	50 (83.33)	
Pneumonia	20 (18.18)	90 (81.82)	
Meconium aspiration syndrome	1 (20)	4 (80)	
Respiratory distress	3 (17.65)	14 (82.35)	
Crepitations	3 (30)	7 (70)	
Cough or difficulty breathing	8 (11.27)	63 (88.73)	
Other	4 (13.79)	25 (86.21)	
Total	49 (16.23)	253 (83.77)	

*Fisher's exact test

d)Parahilar peribronchial opacities

As shown in Table 6 below, parahilar peribronchial opacities were seen in 15 chest radiographs. Parahilar peribronchial opacities occurred only among children with the following diagnoses: TB, pneumonia, crepitations and persistent cough or difficult breathing. The pattern was visualized most commonly among children with pneumonia (10%).

Table 6: Correlation between parahilar opacities and provisional diagnosis

	Parahilar peribronchial opacities		P value*
Diagnosis	Yes	No	
Tuberculosis	1(1.67)	59 (98.33)	0.071
Pneumonia	11 (10)	99 (90)	
Crepitations	1 (10)	9 (90)	
Cough or difficulty breathing	2 (2.82)	69 (97.18)	
Total	15 (5.98)	210 (94.02)	

e) Hazy, reticular, reticulonodular pattern

In Table 7, the distribution of hazy, reticular and reticulonodular patterns are presented according to patients' provisional diagnosis. The 9 children with this radiological pattern had diagnosis of pneumonia (n = 5), TB (n = 2), crepitations (n = 1) or other diagnosis (n = 1). The pattern did not show a significant association with any of these diagnosis (p = 0.685).

Table 7: Hazy, reticular, reticulonodular pattern and its association with diagnosis

	Hazy, reticular, reticulonodular pattern		P value*
Diagnosis	Yes	No	
Tuberculosis	2 (3.33)	58 (96.67)	0.685
Pneumonia	5 (4.55)	105 (95.45)	
Crepitations	1 (10)	9 (90)	
Other	1 (3.45)	28 (96.55)	
Total	9 (4.31)	200 (95.69)	

*Fisher's exact test

f) Focal atelectatic opacity

There were seven patients with focal atelectactic opacities. These patients had diagnoses of TB, pneumonia, cough or difficulty in breathing. These provisional diagnoses did not show a significant association with atelectatic opacity pattern.

Table 8: Focal atelectatic opacity and its correlation with provisional diagnosis

	Focal atelectatic opacity	
Diagnosis	Yes	No
Tuberculosis	2 (3.33)	58 (96.67)
Pneumonia	3 (2.73)	107 (97.27)
Cough or difficulty breathing	2 (2.82)	69 (97.18)
Total	7 (2.9)	2347.1)

g)Pleural effusion

Pleural effusions were visualized on 25 chest radiographs (Table 9). Ten percent of patients with TB had pleural effusions. Effusions were also frequently (20.69%) seen among children with other diagnosis. Diagnoses included in "other diagnosis" were recent chest tube removal, seroactive, sickle cell crisis, emphysema, PCP, and a tuberculoma.

Table 9: Pleural effusion and its correlation with provisional diagnosis

	Pleural effusion	
Diagnosis	Yes	No
Tuberculosis	6 (10)	54 (90)
Pneumonia	7 (6.36)	103 (93.64)
Crepitations	1 (10)	9 (90)
Exclude metastases	1 (11.11)	8 (88.89)
Cough or difficulty breathing	4 (5.63)	67 (94.37)
Other	6 (20.69)	23 (79.31)
Total	25 (8.65)	2641.35)

h)Ground glass opacity

Table 10 shows that there were three patients diagnosed with ground glass opacities. The provisional diagnosis for these patients were respiratory distress (n = 1), persistent cough or difficulty breathing (n = 1) and other diagnosis (n = 1).

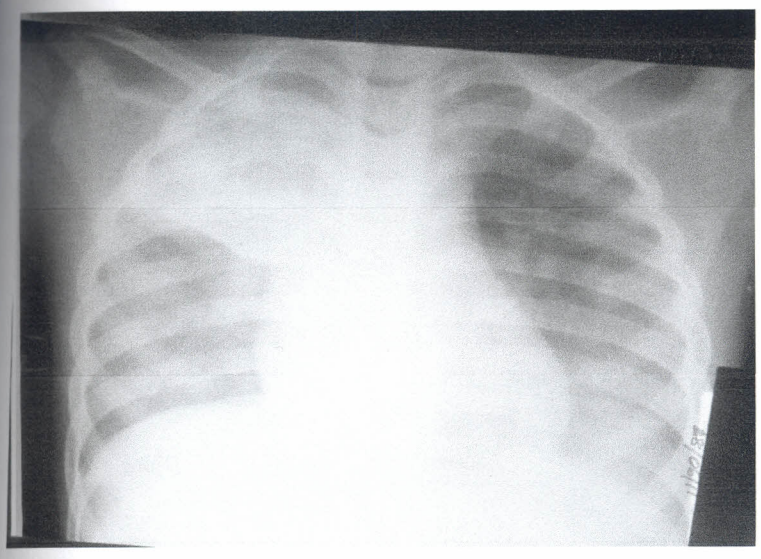
Table 10: Ground glass opacity and its association with provisional diagnosis.

	Ground glass opacity	
Diagnosis	Yes	No
Respiratory distress	1 (5.88)	16 (94.12)
Cough or difficulty breathing	1 (1.41)	70 (98.59)
Other	1 (3.45)	28 (96.55)
Total	3 (2.56)	1147.44)

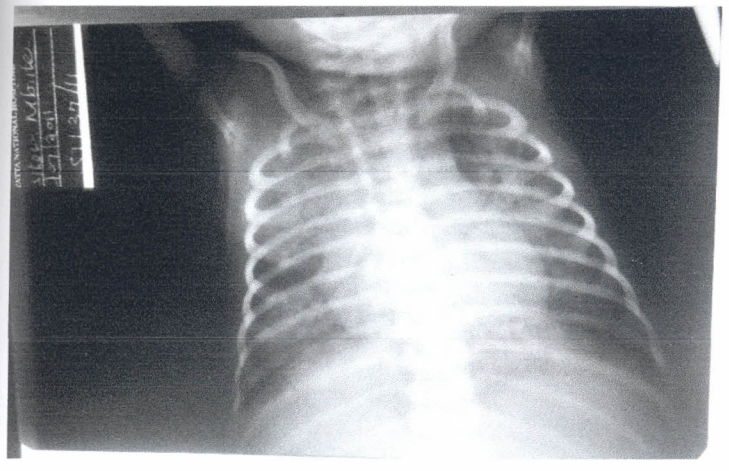
i)Aeration abnormalities

Table 12 shows that visualization of abnormal aeration patterns on chest radiography was statistically significantly associated with patients' provisional diagnosis (p =< 0.001). The abnormal aeration pattern was common among patients with a diagnosis of MAS (60%) or respiratory distress (58.82%). In addition 5 out of the 10 patients with crepitations also had abnormal aeration detected on chest radiography.

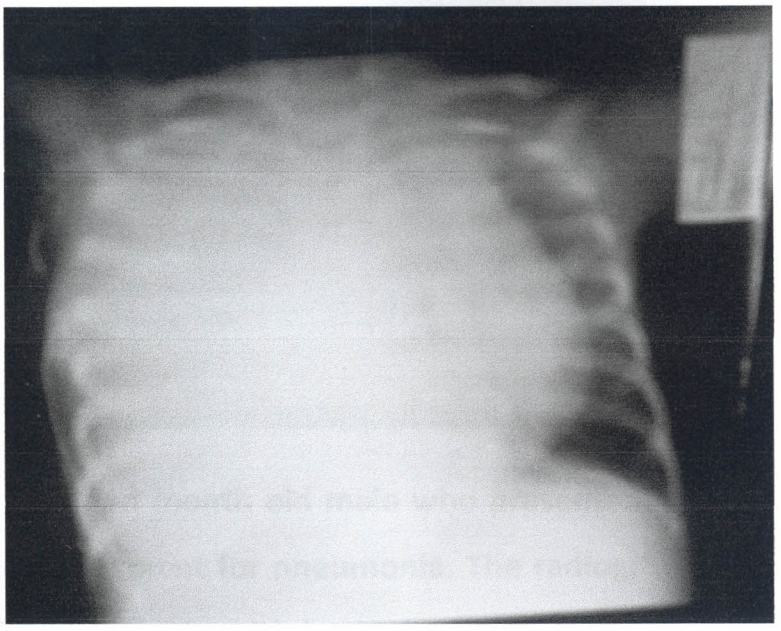
ILLUSTRATIONS



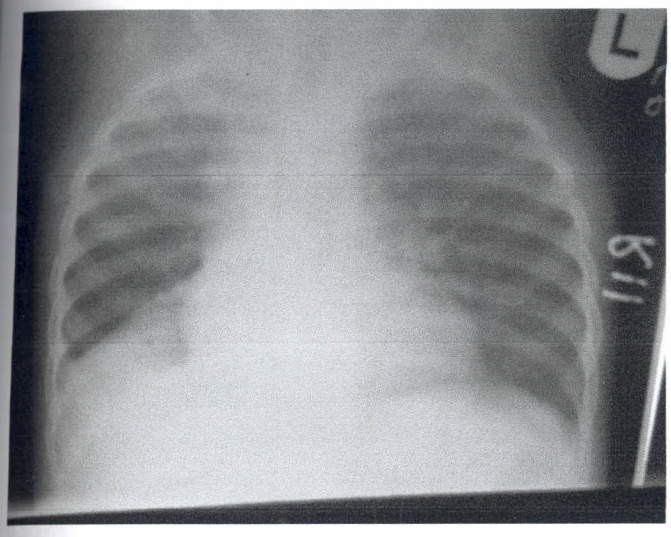
5 month old male who presented with a provisional diagnosis of meningo encephalitis and severe pneumonia. Chest radiograph showed right upper lobe focal alveolar consolidation.



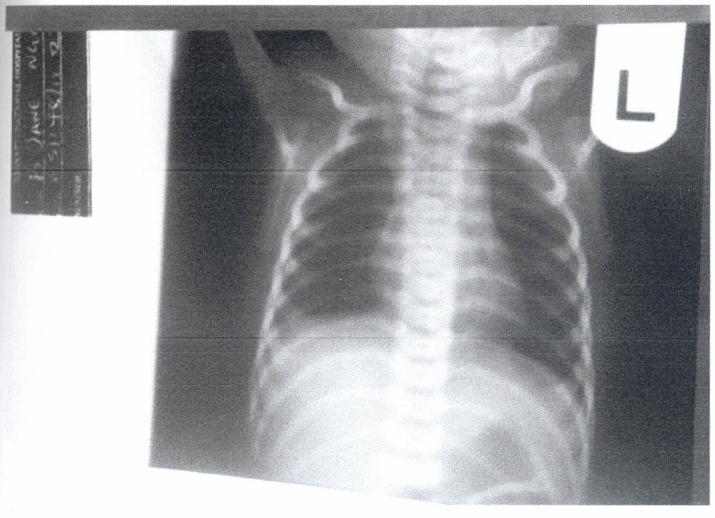
Two weeks old female with history of birth asphyxia, wet chest and difficulty in breathing. The radiograph showed multiple patchy lung opacities.



4 month old male with a clinical impression of severe pneumonia. Chest radiograph showed massive right pleural effusion.



Nineteen month old male who presented with a 2 weeks history of cough and on treatment for pneumonia. The radiograph showed right lower lobe collapse and bilateral multiple patchy opacities.



One day old female who presented with a history of respiratory distress. The chest radiograph showed bilateral hyperinflation of the lungs.

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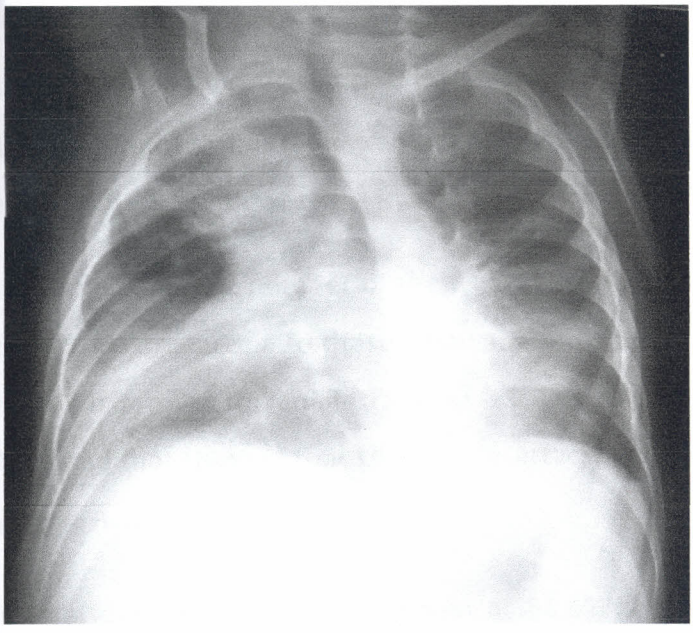

17 month old male who presented with persistent tachypnea and bilateral crepitations. Chest radiograph revealed right hydropneumothorax.

Hilar adenopathy as a secondary sign of pulmonary infection was reported in 1.9% of cases. A study done by R.Virkki, T Juven, H Rilalainen et al also reported hilar lymphadenopathy in cases with pulmonary disease.[17]

On history and clinical evaluation, pneumonia was described in 34.92% of the participants followed by presentation with chronic cough at 22.5% and thirdly TB at 19.05%. TB was an important diagnosis in older children (6-59 months) coming second to pneumonia.

There was a significant statistical association between clinical diagnosis and the multiple patchy alveolar pattern with a p value=0.004. This pattern occurred in children with pneumonia, persistent cough and TB as clinical diagnoses. Abnormal aeration pattern also showed statistical significant association (p value=0.001) with the clinical diagnosis of meconium aspiration and respiratory distress.

CONCLUSION AND RECOMMENDATIONS

It is evident that pulmonary conditions are an important cause of morbidity in children under 5 years and radiography plays a major role in management.

A significant number of patients (19.4%) with clinical disease had normal radiographs emphasizing the need for multidisplinary collaboration in the wholesome management of the patient. There was also significant statistical correlation of the clinical diagnosis and two of the radiographic patterns described.

Except for pleural effusion, pulmonary disease complications were rare and routine follow up radiographs were not requested for except post chest tube insertion. This could be explained by the early health care seeking behavior and clinical management.

Timing of the radiograph request and the actual time of exposure varied at times and this could affect the disease process and hence the observed pattern in response to empirical treatment given.

Inter observer variability was observed in the description of radiographic patterns though this was not part of the study objective. However all the radiologists agreed on the presence or absence of lung pathology. This can be studied further.

Correlation of chest radiographic patterns with lung aspirates and bacteriology studies was not done in this study. This if studied further could help define the common causative agents that are commonly related to specific patterns and thereby assist in the rational use of antimicrobial agents.

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APPENDIX A : PATIENT CONSENT FORM

I am Dr Margaret M Macharia, a postgraduate student at the department of Diagnostic Imaging and Radiation Medicine, University of Nairobi. As part of my postgraduate studies, I am required to undertake a research project.

My study is based on the radiographic patterns of pulmonary conditions in children less than 5 years, the commonest cause of illness in this group. This will involve review of chest radiographs taken as part of the child's management process. With your permission I would like to use the chest radiograph done on your child for my study.

You and your child's rights will be respected and confidentiality maintained at all times. No names will be recorded in the course of the study except for serial numbers for referral purposes only. Participation in this study is purely voluntary and you can withdraw from the study at any point in time if you so wish, without jeopardizing your child's right to medical care.
You are free to ask any question pertaining to this study.

Thank you for your co-operation.

Patient x-ray number _____

Signature _____

Date _____

I certify that the patient has understood and consented participation in the study.

Dr. Margaret Macharia

Signature _____

Contact - 0710863800

Asante sana kwa ushirikiano wako.

Nambari ya mgonjwa: _____ Sahihi: _____

Tarehe: _____

Nimekubali kwamba nimeelezewa kikamilifu kuhusu utafiti huu na nakubali kushiriki.

Dr. Margaret Macharia

0710863800

Sahihi: _____ Tarehe: _____

Supervisors.

DR AYWAK .A A.

Department of Diagnostic Imaging and Radiation Medicine,

University of Nairobi

DR BEATRICE MULAMA

Department of Radiology, Kenyatta National Hospital.

ETHICS AND RESEARCH COMMITTEE.

KNH/UON-ERC

P.O. Box 20723, Nairobi

APPENDIX B: QUESTIONNAIRE

Patient study no.....

Patient's No (IP/OP).....

Patient's X-RAY No.....

DEMOGRAPHIC INFORMATION OF THE PATIENT

Sex: 001 Male 002 Female

Age (months) .....

Clinical history provided.....

.....

.....

....

RADIOGRAPHIC FINDINGS

01 Focal alveolar consolidation

02 multiple patchy lung opacities

03 Peribronchial and interstitial pattern

04 Para hilar peribronchial opacities

05 Hazy,reticular or reticular nodular pattern

06 Millary nodules

07 Focal atelectatic opacity

08 Pleural effusion

) Ground glass opacificatio

) Lung cavities

l Lung masses

2 Aeration abnormalities(hyperinflation, emphysematous, pneumothorax)

3 Others; specify

4 unilateral

5 bilateral

6 Normal

APPENDIX C

ESTIMATED BUDGET

ALLOCATION	BREAK DOWN	AMOUNT IN KSH
1.STATIONARY	4 Reams Printing paper @1000/-	4,000
	Biro pens (1 box)@1000/-	1,000
	15 folders @200	3,000
2.Ethics board	Ethics fees	1,000
3.Secretarial services	Typist fees	5,000
	photocopy	3,000
4.Printer	Printer and Cartridges	8,000
	SSPS software	2000
5.Data collection and analysis	Statistician services	20,000
6 Selected images	Scanning of images	3,000
	Digital transfer of images	2,000
7.Printing and binding	Proposal	2,000
	Final report	6,000
	TOTAL AMOUNT	**62,000**

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