TITLE

UTILITY OF CHEST RADIOGRAPHS IN MANAGEMENT OF PATIENTS IN INTENSIVE CARE UNIT AT KENYATTA NATIONAL HOSPITAL

RESEARCHER

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DECLARATION

I, **DR. PAUL GICHIRAH NYAGAH** declare that the work contained herein is my original idea and has not been presented at any other place to the best of my knowledge.

Signature.....

Date.....03/09/2014.....

APPROVAL BY SUPERVISOR

This research proposal has been submitted with my approval as a University supervisor.

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Date.....03/09/2014.....

DEDICATION

I dedicate this work to my wife Peris and daughters Paulette, Perla and Peace for continued support and prayers during the period of study.

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I wish to acknowledge the following persons who assisted me during this period.

My supervisor Dr. Callen Onyambu for her tireless support to ensure I finish this work on time.

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My siblings Leonard, Mary, Veronica and Boniface for their encouragement and prayers during my study period.

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ABBREVIATIONS

ALARA	As Low As Reasonably Achievable
AP	Antero posterior
ARDS	Adult respiratory distress syndrome
CNS	Central nervous system
COAD	Chronic obstructive airway disease
CPE	Cardiogenic pulmonary edema
CT SCAN	Computerized tomography scans.
CVC	Central venous catheter
CVS	Cardiovascular system
CXR	Chest radiograph
GIT	Gastro intestinal tract
ICU	Intensive Care Unit
KES	Kenya Shillings
KNH	Kenyatta National Hospital
ms	Milliseconds
NCPE	Non carcinogenic pulmonary edema
PA	Postero-anterior
PCWP	Pulmonary Capillary wedge pressure
PEEP	Positive end expiratory pressure
SGC	Swan ï ganz catheter
U/S	Ultrasound

ABSTRACT

Background and purpose - The chest radiograph is the most commonly requested and performed radiographic examination in the Intensive Care Unit (ICU) and often allows prompt detection of problems that could be missed by clinical evaluation and thus enables earlier treatment of clinically unsuspected abnormalities, documentation of disease progression and response to therapy.

Assessment of correct placement of lines, endotracheal tubes and catheters is primarily done by use of chest radiographs and if malpositioned, repositioning must be done without delay.

Objective- The aim of study was to evaluate the role of chest radiography in patients admitted in the intensive care unit at Kenyatta National Hospital (KNH) and evaluate the accuracy of tube placement. This information will be important in designing and implementing appropriate interventions in patient care for the KNH ICU and providing quality feedback.

Study Design - a prospective cross-sectional study

Setting - Kenyatta National Hospital Intensive Care Unit (KNH ICU).

Methods - During the study period, (December 2013-February 2014) all chest radiographs in the ICU, were reviewed by the principal investigator and a consultant radiologist. The findings were entered into the data collection form of each participant.

Data management and analyses ï Statistical analysis was done using statistical package for social scientists (SPSS) version 20.0. Descriptive statistics are presented using percentages and frequencies for categorical and nominal data while mean, standard deviation, median, minimum and maximum are used to summarize continuous/discrete variables.

Results- The study included 396 chest radiographs done in KNH ICU, among patients with median age 32 years (IQR 12-57) with males contributing 55.1% of films. The main presentations on admission to ICU were road traffic accident (36%, 143), severe chest infections (23%, 91) and major cardiovascular diseases (14%, 54). A total of 293 films had at least one medical device placement (CVC-208,ETT- 141, and chest tubes - 49) which was visualized on CXR and 98 were incorrectly placed(CVC-58 ,ETT-23 and chest tubes-17). There were 52 cases which developed complications post device placement with common complications associated with CVC. Aspiration pneumonia (50%) and atelectasis (15%) were among the commonest complications following device placement.

Conclusion- There is a significantly high rate of tube and catheter misplacement in KNH ICU and routine CXR has a role in identifying the malpositioned devices, associated complications and providing feedback for implementing quality assurance.

1.0 BACKGROUND

Physicians often order routine daily antero-posterior chest radiographs(CXR) for patients in intensive care unit(ICU) due to concerns about the severity of cardiopulmonary illness and complexity of medical interventions [1] and for detection of complications associated with indwelling devices, such as endotracheal tubes and central venous catheters. The frequency of complications, such as device malpositioning or pneumothoraces, has led some guidelines to recommend routine CXRs for all patients with acute cardiopulmonary problems or receiving mechanical ventilation [2]. Advantages of routine CXRs may include prompt detection and thus earlier treatment of clinically unsuspected abnormalities, documentation of disease progression or response to therapy, and educational value for trainees [3, 4]. In contrast, a restrictive strategy limits CXRs to specific clinical indications, such as a change in clinical status or following certain procedures. Arguments for adopting a restrictive approach include variable interpretation of CXRs depending on clinician and patient factors, low incidence of clinically unsuspected abnormalities, potential harm arising from unnecessary treatment of minor or false positive findings, cost, radiation exposure and adverse events arising from repositioning of the patient to obtain the CXR [5, 6].

The Kenyatta National Hospital (KNH) is a tertiary referral and teaching hospital with a bed capacity of 1882, out of which 21 beds are for the Intensive Care Unit (ICU). Averages of two patients are admitted into the intensive care unit every day. Total ICU admissions in 2012 were 1050 patients.

Chest radiographs (CXR) are done routinely to all patients before admission and may be repeated in some patients as requested.

The KNH ICU admits patients with either a medical or a surgical condition. Therefore the ICU admission diagnosis in our setup includes such entities like accidents (Trauma or burns), renal failure, cardiac disease, respiratory failure, adult respiratory distress syndrome and post surgery [1].

2.0 LITERATURE REVIEW

Chest radiographs are the most frequent radiological investigations performed in the ICU. The indications for the chest radiograph can be broadly divided into 2 groups, the routine evaluation and non routine study, for assessment following a change in clinical status or following a change in support devices.

Local research done by Omwenga Evans on role of chest radiographs in management of patients admitted to the intensive care units (Kenyatta National and Nairobi hospital-Nairobi 2000) a total of 138 CXRs were analyzed. Of 101 patients with pulmonary artery catheter, 24 patients (23.8%), 15.8% endotracheal tubes and 11.8 % central venous catheters were malpositioned. New findings in chest radiographs not diagnosed clinically included pneumonia (36.4 %), pulmonary edema (29.9 %), pleural effusion (18.8%), pneumothorax (9.6%) and rib fractures in 7.8% [23].The study reported delayed interventions despite radiographic findings [1]. This study confirms the usefulness of chest radiographs in elucidating the position of lines and tubes and helped the attending clinician to make appropriate adjustments. It also provides evidence for the need to perform daily routine portable x-ray examinations. An additional use of the data would be initiating quality assurance activities through feedback to ICU staff on the relatively high error rates in routine ICU care.

In a study on Utility of routine chest radiographs in a medical and surgical intensive care unit done by Natalie Chahine et al at Mount Sinai Hospital (Toronto, Canada 2001), a total of 645 CXRs were analyzed in 97 medical patients and 205 CXRs in 101 surgical patients and, 127 medical patients CXRS (19.7%) led to management changes. 66 surgical patients with an ICU stay of less than 48 hours, 15.4% of routine CXRs changed management. In both medical and surgical patients, the majority of changes were related to adjustment of medical devices [2]. This study also confirms the usefulness of chest radiographs in ICU patients.

Another prospective observational study to determine if daily routine CXRs reveal unexpected clinically relevant abnormalities in ICU patients by Graat et al (2006),754 patients were recruited with 2,457 CXRs performed and they concluded that daily routine CXRs rarely reveal abnormalities and should not be used in ICU patients. Study proposed this examination to be abandoned in ICU patients [34].

Low diagnostic and therapeutic values and abandoning of daily routine CXR in ICU was also recommended by Hendrikse et al in their study to determine the diagnostic and therapeutic value

of daily routine CXRs (2007) in which out of 559 admissions 1,780 CXRs were performed [35]. They concluded that the performance of daily CXR in ICU did not affect patient management, ICU length of stay, readmission rate, and ICU mortality.

Hall et al compared bedside clinical diagnosis with the diagnosis made from the routine CXR [21]. Of 538 routine CXRs, 8% presented new major findings, 58% of these were anticipated by the clinical examination, and only 3.4% of all routine CXRs presented findings not clinically anticipated. Findings supported use of daily CXRs in critically ill patients.

In another prospective study to evaluate the efficacy of a bedside CXR in patients with tubes and catheters admitted to the surgical and medical ICU, Henschke et al reviewed 140 patients who had a total of 1148 CXR films done. In 54% of examinations, 12% had malpositioned endotracheal tubes. Central venous catheters were present in 47% and 9% were malpositioned. 65% of the radiographs had findings or changes affecting the patient's management and they recommended use of bedside radiography [36].

The published studies appear contradictory for several reasons. Notably, the study population is diverse as are the indications for the CXR. The intensive care population is a heterogeneous group composed of medical and surgical patients; some patients are critically ill, whereas others are clinically stable but require monitoring.

More suggestions for improvement of this examination have been given and these includes use of qualified personnel to perform X-ray work, review by ICU radiologist and use of labels to indicate exposure factors and position of patient at time of exposure and even training of referring physicians. [7, 9, 10, 24, 34]

Adverse consequences associated with patient repositioning for the performance of CXR in the ICU includes patient discomfort, hypotension, oxyhemoglobin desaturation, and displaced endotracheal tubes (ETTs), naso-gastric tubes (NGTs), or vascular catheters. [15]

2.1 Chest Radiography: Technique and interpretation

Chest radiography is one of the most challenging examinations to perform because of the wide range of tissue densities present in the thorax and the inherently low-contrast of soft tissues structures.

Difficulties in positioning ICU patients and setting of exposure factors contribute to high film rejection rate.

The technique and interpretation of CXR often poses serious challenges and a systemic approach to it is the best way. Myto et al proposed a systemic approach using the alphabet that covers all areas. This borrowed heavily from the standard and universal approach adopted by Tally et al a:-

A---------- Airway

B----------Bone

C----------Cardiac shadow

D---------- Diaphragm

E and F----------Equal lung fields

G----------Gastric air bubble

H---------- Hilar region

Airway

These are the trachea and its branches: check the site, size, shape, and shadows, patency, areas of narrowing indicating sternosis or edema.

Bone

Attention should be given to site, size, shape, shadows and borders of the clavicles, ribs, scapulae, thoracic vertebrae, and humeri.

Bony lesions like fractures, sclerotic or lytic areas deformed bones should be noted.

Cardiac shadow

The site, size, shape, shadows and borders, most of the ICU chest are done in supine position and the cardiothoracic ratios are rarely assessed.

Diaphragm

Diaphragmatic outline should be clear and smooth; the right hemi diaphragm should be 2-3 centimeters above the left. The costophrenic angles should be clear.

Gastric air bubble

Should be under the left hemi diaphragm in an erect chest radiograph.

Hilar area

The left should be higher than the right by about 1 .5 centimeters, the densities and shapes should be similar.

2.2 LIMITATIONS OF CHEST RADIOGRAPHY

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.

Shadow patterns are rarely specific to a single disease pattern process; for example consolidation due to infection or following infarction may have identical appearances.

Some of these lesions can be demonstrated using other imaging modalities for example computer tomography (CT) and ultrasound (U/S). U/S for pleural effusion and High resolution CT for interstitial lung disease. [25]

The appearance of portable chest radiographs may be affected by changes in ventilation, particularly when patients are mechanically ventilated. Synchronization of the CXR with the ventilator cycle limit the influence of respiratory variation on the appearance of the CXR.[26]

Recognizing subtle signs of air in abnormal anatomic spaces and using special views like lateral decubitus, lordotic and oblique views and serial imaging to resolve equivocal findings are difficult to be performed in ICU settings [27].

Consultation between ICU clinicians and radiologists is also imperative, because radiographs may provide more specific evidence of a problem than clinical or laboratory findings. [6]

3.0 JUSTIFICATION

Use of routine CXRs include prompt detection and thus earlier treatment of clinically unsuspected abnormalities, documentation of disease progression or response to therapy.

Support devices are associated with a wide variety of complications ranging from suboptimal placement to life-threatening events. Physical examination even by experienced operators is an unreliable guide to correct device placement, and therefore it is appropriate to obtain a chest radiograph after placement of an endotracheal tube, central venous line, Swan-Ganz catheter, nasogastric tube, feeding tube, or chest tube for confirmation.

Proper positioning and assessment of abnormalities and complications of above devices have a significant impact on the management of critically ill patients in the ICU. The timely assessment of new or rapidly evolving findings is critical. Optimal radiographic technique, availability of images to the clinicians, and rapid reporting by the radiologist all may serve to maximize the efficacy of bedside chest radiography in the ICU. Sometimes, changes in cardiopulmonary status may only be appreciated on chest radiographs (CXRs). Complications from ventilatory assistance, such as barotrauma, occur frequently and must be detected promptly.

Previous local research done by Omwenga (2000) at Kenyatta national and Nairobi Hospital on the role of CXR in management of patients admitted in ICU found delayed to no intervention despite some new findings [1]. The bed capacity by then at KNH ICU was 10; currently the bed capacity has increased to 21. More than a decade later there is a need to comprehensively evaluate the current trends on the diagnostic role of CXR in management of ICU patients.

Omwenga A.E. conducted his study in both KNH and Nairobi Hospital ICU. These are 2 institutions with different resource capabilities. My study will be restricted to the KNH ICU.

Study is also to document whether there is delay in intervention after radiologists report the films.

4.0 EVALUATION OF CATHETERS, TUBES, CANNULAS AND DRAINAGE DEVICES.

(i) Central venous catheters

Catheters are used to monitor the patientôs hemodynamic state, administration of fluids and drugs and for total parental nutrition. The most common catheters used are the central venous catheters (CVC) and the Swan ï ganz catheters (SGC) [24, 34].

The intravascular volume status of critically ill patients is crucial to their management. Central venous pressure can be obtained directly through central vein catheters placed either by subclavian veins or the internal jugular veins approach; they get to the superior vena cava through the innominate veins. Large volumes of fluid can be infused over longer period of times with little chance of thrombosis [30,34].

The central venous catheters (CVC) are normally placed in and parallel to the walls of the superior vena cava (SVC) and not supposed to reach the right atrium, otherwise arrthymias, endocardial damage and perforation can occur. [33, 34]

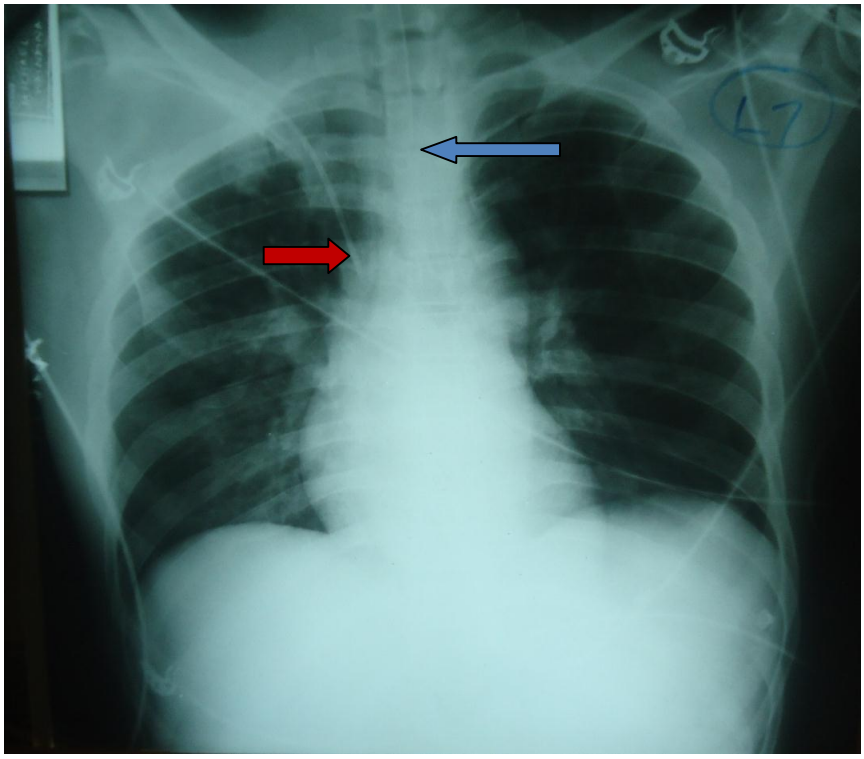
These catheters can also be malpositioned or misplaced by entering into the internal mammary, pericardiophrenic, azygos or superior intercostals veins. When misplaced to the internal mammary vein, lateral CXR projection film will show its tip pointing towards the sternum.

Left sided catheter with the tip impinging perpendicularly or angled against the right lateral wall of the SVC might lead to perforation and ectopic infusion. [34]

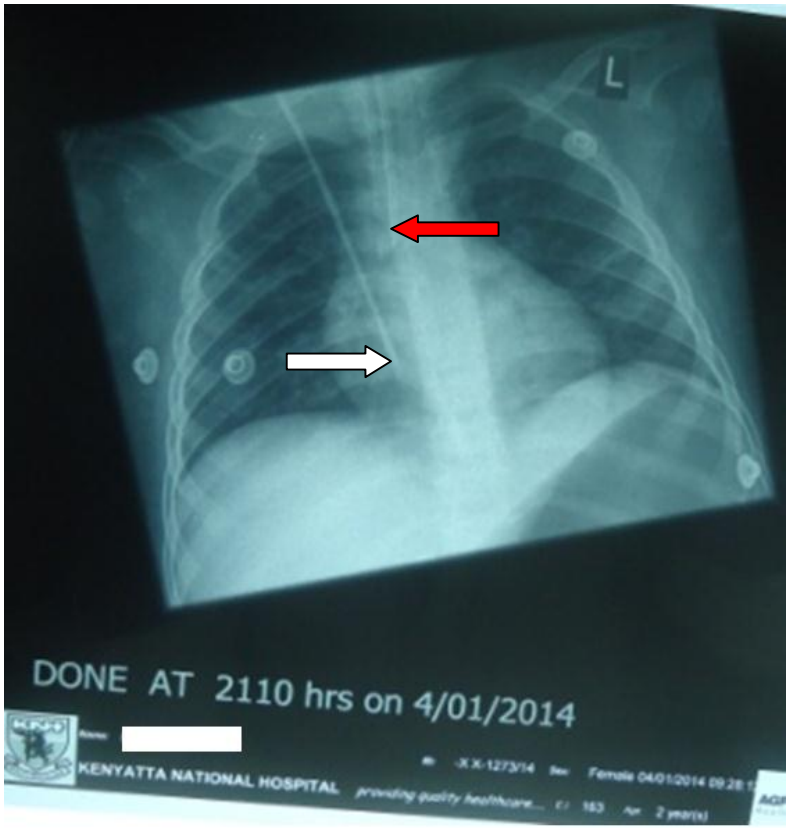
These misplacements apart from giving misleading pressure measurements can lead to chemical phlebitis and thrombosis from the irritating substances infused through the catheters [32, 34].

Coiling of the catheters with the tip directed upstream are considered misplaced or malpositioned because they create turbulence and favour thrombosis. Such patients with thrombosis may develop sepsis, superior vena-cava syndrome or loss of central venous access.

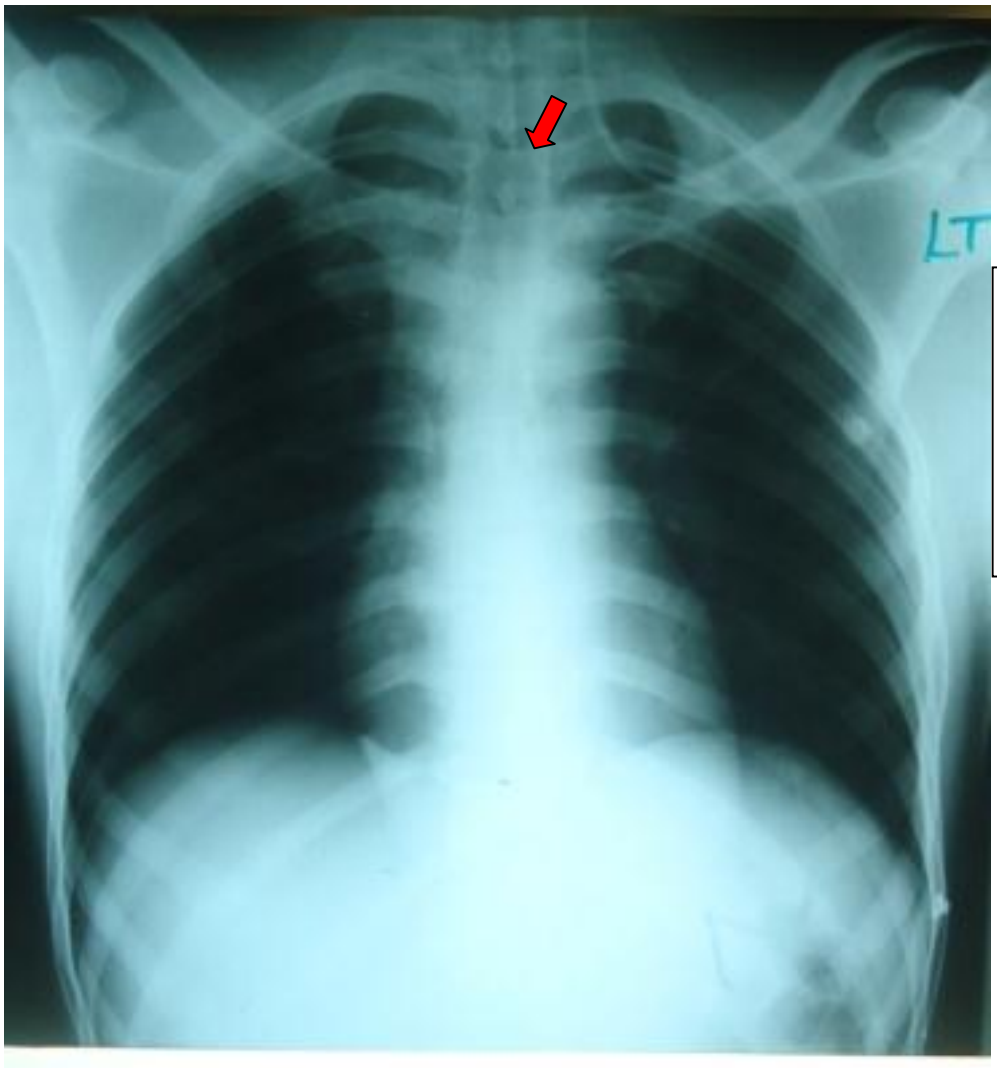
The incidence of malposition depends on the site of insertion and is more when a left approach is used than the right. On the right the safer approach is through the internal jugular vein. When occurring, usually the pneumothorax is a complication of a subclavian catheter[8,14,27].



Left image: Shows AP film with correctly position of the central venous catheter: the tip is projected in the distal superior vena cava lumen (red arrow) and parallel to it just above the right atrium and ETT normally placed at T3 level(blue arrow)



Left:-Shows an AP chest film showing the tip of endotracheal tube at the carina (red arrow) and central line catheter in right atrium (white arrow).



Left:-Supine chest film showing misplaced central line catheter. Catheter was introduced from left internal jugular vein but landed into left subclavian vein (red arrow).

(ii)Swan- Ganz catheters

Swan- Ganz catheters are two or three lumen catheters, the smallest of which is situated close to the tip and connected with an inflatable balloon, making the catheter flowing downstream towards the superior venacava (SVC), the right heart, the main pulmonary branches, where it remains at rest.

They are used to measure several cardiovascular parameters including the pressures and sample blood from the right atrium, right ventricle, and pulmonary artery.

It can also estimate the left atrial pressure by measuring the pulmonary artery wedge pressure also referred to as pulmonary capillary wedge pressure or pulmonary artery occlusion pressure. This involves inflating a balloon at the tip of the catheter, allowing the balloon to occlude a branch of the pulmonary artery, and then measuring the pressure during occlusion.

In addition, inspection of the pressure waveforms can detect cardiac tamponade, cardiac constriction, restrictive cardiomyopathy, mitral and tricuspid valvular regurgitation, intracardiac shunts (e.g., atrial or ventricular septal defects) and intravascular volume status. [24, 29, 31, 34]

The normal radiological position of the tip of this catheter should be within the main pulmonary artery or right or left pulmonary arterial branch.

(iii)Endotracheal Tubes

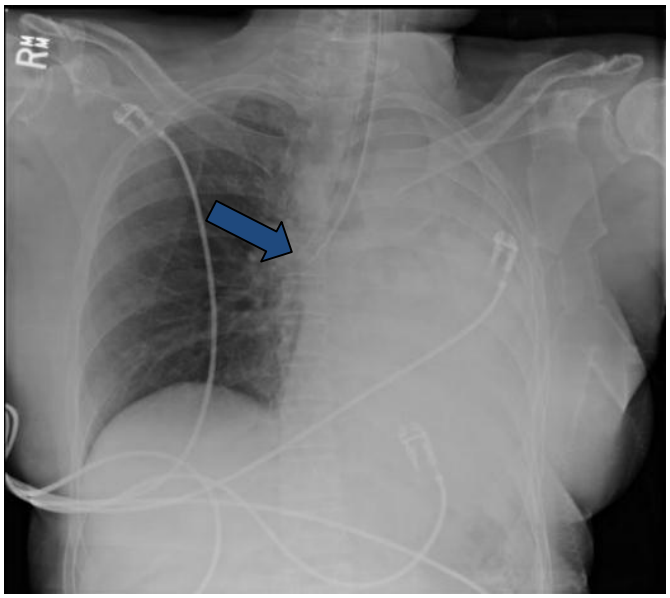
Endotracheal tubes (ETT) or tracheostomy tubes are cuffed conduits placed in the trachea either through the oropharynx or through a surgically created tracheostomy.

These tubes maintain airway patency and allow for mechanical ventilation of patients with respiratory failure, suction of bronchial secretions and prevent aspiration in the unconscious patient. Assisted ventilation can lead to barotrauma of the lungs. Resultant alveolar rupture can lead to pneumothorax, pulmonary interstitial emphysema (PIE) and pneumomediastinum [10-12].

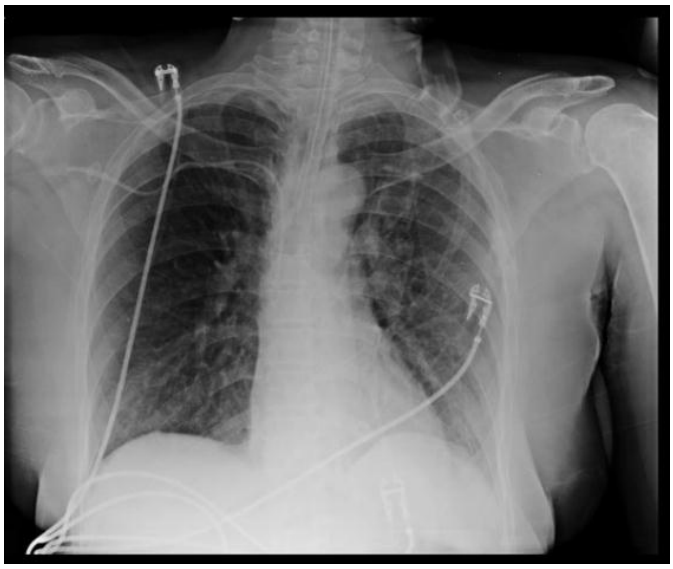
Tracheostomy is generally performed in patients who are intubated for longer than 1-3 weeks or who have upper airway obstruction. When evaluating an endotracheal tube on a chest x-ray it is important to identify the location of the tip.

Radiologically the tracheal tip should project not less than 2cm to and not more than 7cm above the carina on anteroposterior film. This corresponds to T3- T4 vertebral spine level. Neck flexion causes a descent of the tube by 2cm while neck extension causes the tube to ascend. [24, 34]

Tracheal tube placed proximally is at a risk of damaging the laryngeal structures and increasing the chances of accidental extubation while a distally placed tube is at a risk of entering the main bronchi on either side leading to lung atelectasis. Other complications include endotracheal tubes in the esophagus and tracheal tear with subsequent complications such as cervical abscess; mediastinitis, and soft tissue emphysema [10, 24, and 34].



Left:-ETT in right main stem (blue arrow) with notable opacifications of left hemi thorax



Same patient with ETT pulled back, now in proper position

(iv)Chest tubes

Chest tubes are used to drain air or fluid in the pleural cavity. Pneumothorax is the most common serious pleural complication in the ICU. The development of pneumothorax is most closely associated with the underlying disease, especially ARDS, and the occurrence of high airway pressures in ARDS. Patients who received mechanical ventilation had an incidence of pneumothorax of 4 to 15% [6, 8, and 24].

Iatrogenic pneumothorax following procedures is also an important etiology. Thoracic procedures including thoracocentesis, central venous catheter placement, bronchoscopy, pericardiocentesis, and tracheostomy, may pose a risk of pneumothorax.

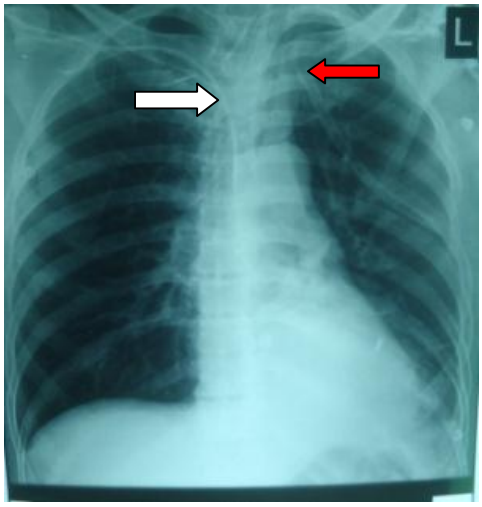
Chest tubes are inserted anteriorly when they have to drain air and posteriorly when they have to drain fluid.

In the presence of a pneumothorax both inner and outer edge of the tube should be recognizable because of the presence of air internally and externally to it. This does not happen when the tube is draining fluid or when it is misplaced in the consolidated lung or the soft tissues of the chest especially in the obese people.

When misplacement occurs, computerized tomography of the chest has been found to be a useful alternative imaging modality or oblique views to show the tube in a fissure, lung or soft tissues of the chest [24].

The chest tube remains in place until the lung is re-expanded or the fluid is drained. Occasionally patients require more than one chest tube.

Misplacement is suspected when the drained fluid is small or pneumothorax persists and CXRs are usually obtained to check chest tube position.



Left:-Shows AP film with correctly position of the central venous catheter: the tip is projected in the distal superior vena cava lumen and parallel to it just above the right atrium (white arrow). Also note correctly placed left chest tube for draining a pneumothorax (red arrow).

(v)Esophageal feeding tubes

Feeding of the critically ill patient is done by a nasogastric tube or by intravenous alimentation. Feeding tube is a long polyurethane or silicone tube that is passed through the nasal (nasogastric) or mouth (orogastric) passages through the oesophagus into the stomach. Nasogastric tubes come in various sizes that are; 8, 10, 12, 14, 16 and 18 French gauge. The main indications for NG tube insertion are for enteral feeding and medical administration, as well as for decompression of the GI tract. Care should be taken in cases where there may be ear, nose and throat abnormalities or infections, esophageal strictures and varices and esophageal diverticulae.

In the ICU, the tubes are inserted by trained ICU nurses and sometimes by anesthetists. External measurement from the tip of the nose to a point halfway between the xiphoid and the umbilicus distance gives a rough idea of the required length. An appropriately sized tube is chosen and the tip is lubricated by smearing aqua gel or local anesthetic gel. For the nasogastric tube insertion, the wider nostril is chosen and the tube slid down along the floor of the nasal cavity. Conscious patients often gag when the tube reaches the pharynx and asking them to swallow their saliva or a small amount of water may help to direct the tube into the oesophagus. Once in the oesophagus, it may be easy to push it down into the stomach. The tip of the tube should be in the stomach and its position must be confirmed after its initial insertion. Two ways of verifying tubes position are by pH test in which gastric contents are aspirated and checked using pH paper. The other method is by use of abdominal radiograph where the tip of the tube can be seen as a white radio-opaque line within the stomach. Chest radiographs are important in checking thoracic malposition and complications of nasogastric tube. They can get misplaced entering the tracheo-bronchial system and such an occurrence has a high likelihood of causing tracheal damage and chemical pneumonia.

They can also perforate the esophagus leading to pleural effusion, pneumomediastinum, abscess, empyema, mediastinal widening or mediastinal air- fluid level and even death.

A 2006 study evaluating the position of more than 2000 NG tubes was conducted using X-ray as the gold standard. Malpositioning was present in 1.3-2.4% of cases[44]. Of these, 26% led to

complications such as pneumonia and pneumothorax and two patients died due to the misplacement.

Another study evaluating 1822 tubes revealed that 3.2% of the tubes were misplaced in the respiratory tract [45]. The estimated risk of misplacement is thought to be as high as 13-20% in high-risk patients [46, 47]. Identified risk factors for malpositioning of NG tubes include decreased level of consciousness, weak cough reflex and endotracheal intubation[46,48].Utilization of a cuffed tracheal tube does not prevent NG tubes being misplaced into the respiratory tract[49,50].Therefore, mechanically ventilated patients are at higher risk of getting an NG tube misplaced, since these patients are orally intubated or tracheotomized, have reduced cough reflex and often have a lower level of consciousness due to critical illness or medical sedation[51].

5.0 PATHOLOGY

i. Pneumonia

Mechanical ventilation associated pneumonia (VAP) is the most frequent nosocomial pneumonia reported in patients in the ICU, with an incidence varying from 10 % to 30 % and an estimated rate of 1 % to 3 % per day of mechanical ventilation (3, 17).

Oropharyngeal colonization by Gram-negative bacteria generally occurs within the first 24 hours of ICU admission causing bronchopneumonia (17). The clinical manifestations are nonspecific. Radiological appearances varies and usually consolidations are multi-focal (centred in distal airways), heterogeneous and distributed along course of airways, scattered opacities and lung volume loss is common. Pleural effusion may be present. Bilateral opacifications and the silhouette sign are often found but are nonspecific. Worsening of a previous radiologic opacity only corresponded to pneumonia in one third of the cases (9, 15, and 19).

Pulmonary infiltrates that disappear within a few days may be due to pulmonary edema, atelectasis or aspiration, while radiologic changes of resolution in pneumonia evolve more slowly.

ii. Atelectasis

Atelectasis is relatively frequent in the ICU and is associated with general anesthesia and prolonged surgery. It is more common during the postoperative period, especially in patients undergoing thoracic or upper abdominal surgery. Most of the infiltrates which appear within the first 48 hours after surgery are due to atelectasis especially if aspiration has been ruled out [3]. Atelectasis is most often seen in the lower left pulmonary lobe (66 %) compared with the lower right lobe (22%) [5, 7, 17].

Radiologic manifestations may include normal chest x-ray, slight loss of volume without a visible infiltrate (microatelectasias), parallel or oblique linear opacities to the diaphragm, single or multiple rounded or irregular opacities, lobar consolidation or even total pulmonary collapse.

Portable chest x-ray has poor sensitivity in detecting opacities at the pulmonary bases.

iii. Aspiration

Aspiration is common in ICU patients since the patients frequently present with depression of the central nervous system, neuromuscular diseases and gastrointestinal tract disease. Radiological findings indicating aspiration varies and depends on the quantity aspirated. New bilateral infiltrates may suggest aspiration, especially with basal localization in erect patients or in the upper lobes of supine patients [7]. The presence of any localized patchy infiltrate may be a manifestation of aspiration. The evolution of the infiltrates is a great help in establishing the diagnosis. A pulmonary infiltrate which clears within 2 to 3 days is a common finding in aspiration [5].

iv. Pulmonary Edema

The chest x-ray can detect pulmonary edema but does not specify the cause. The most specific sign is the presence of opacifications in the air space. It is observed in 58% of the patients with edema due to an increase in permeability and in only 13% of those with hydrostatic edema [21].

Cardiogenic Pulmonary Edema:

An increase in the pulmonary vasculature with a cephalic disposition is seen in patients with cardiogenic pulmonary edema. These findings are characteristic of chronic cardiac insufficiency but are not a reliable manifestation of cardiac failure in ICU patients since the x-ray is performed in a supine position. Dilatation of the upper lobe vessels, interstitial edema (vascular and peribronchial thickening) and Kerley lines may be seen in the periphery. Progression of cardiogenic edema shows diffuse alveolar edema with a central distribution which is difficult to distinguish from diffuse infection or pulmonary hemorrhage. Presence of cardiomegaly, septal thickening and pleural effusion is frequently found in congestive heart failure. The distribution of the edema may be altered by the position of the patient due to the effect of gravity and by the presence of underlying pulmonary diseases and are usually absent in noncardiogenic pulmonary edema.

Diffuse alveolar edema with a central distribution

Noncardiogenic Pulmonary Edema:

Due to an increase in pulmonary permeability and may be secondary to smoke inhalation or toxic metals, drowning, fat embolism, heroin intoxication, uremia, aspiration, neurologic alterations and allergic reactions [5].

The most representative entity of noncardiogenic pulmonary edema is ARDS. This syndrome occurs because of an alteration in pulmonary vascular permeability. It is characterized by a diminution in pulmonary compliance, pulmonary capillary wedge pressure less than 18 mm Hg and poor response to oxygen administration, all being triggered by known causes of respiratory distress (sepsis, shock, pneumonia, trauma, aspiration and pancreatitis).

Pulmonary infiltrates are not seen during the first 12 hours and generally appear at 24 hours. Initially, noncardiogenic pulmonary edema is indistinguishable from pneumonitis or cardiac failure with progressive interstitial edema and presents a diffuse distribution in the two lungs.

v. **Pleural Effusion**

Pleural effusion is a collection of fluid in the pleural space. Fluid gathers in the lowest part of the chest, according to the patient's position. If the patient is upright when the x-ray is taken, a pleural effusion will obscure the costophrenic angle and hemidiaphragm. If a patient is supine a pleural effusion layers along the posterior aspect of the chest cavity and becomes difficult to see on a chest x-ray film. The effusion is usually an exudate. They may resolve within one or two weeks. Patients with pneumonia frequently present parapneumonic pleural effusion and empyema [10, 12, and 21].

vi. Pulmonary Embolism

Chest radiograph may be normal or show nonspecific changes such as an elevation of the hemi diaphragm, atelectasis or diffuse infiltrates of peripheral localization. These infiltrates may vary and disappear rapidly due to edema or hemorrhage and when they persist this is due to infarction. Frequent radiologic findings in these patients are those of wedge-shaped opacity or an increase in the size of the pulmonary artery. This may be accompanied by small to moderate, unilateral, pleural effusions in 50% of the cases, with remission within a few days [5].

vii. **Drug-Induced Pulmonary Lesions**

Many drugs may produce adverse effects in the lung. The diagnostic criteria include a history of drug exposure, radiologic alterations, histology evidence of pulmonary lesion and the exclusion of other possibilities of pulmonary involvement (infections, radiation, thromboembolism, oxygen toxicity, worsening of pre-existing pulmonary disease) [12]. High resolution computerized tomography (HRCT) is superior to chest x-ray, since it not only helps to achieve the diagnosis but also allows follow up to be performed.

viii. **Eosinophilic Pneumonia**

The diagnosis of eosinophilic pneumonia is based on the presence of pulmonary infiltrates, more frequently of peripheral distribution and in the upper lobes [11, 12]. On HRCT consolidated ground glass images may be seen in the periphery and upper lobes [12].

ix. **Diffuse Alveolar Damage**

It is a nonspecific manifestation of acute pulmonary lesion which may occur in severe infection, trauma, aspiration, collagen diseases, illegal drug use and acute interstitial pneumonia.

Chest x-ray shows homogeneous or heterogenic opacities involving lung-dependent regions. HRCT demonstrates consolidation in the airspace and ground glass opacities involving lung-dependent regions [11].

x. Alveolar Hemorrhage

Bilateral ground glass images are observed on HRCT [11, 12].

xi. **Pneumonitis by Hypersensitivity**

This is an infrequent form of pulmonary lesion. It is associated with the use of methotrexate, cyclophosphamide, fluoxetine and amitriptyline. Radiologically are indistinguishable from pneumonitis by hypersensitivity secondary to organic antigen inhalation [12].

xii. **Nonspecific Interstitial Pneumonitis**

This is the most common finding in drug-induced lesions as well as in collagen diseases and in pneumonia by hypersensitivity. Drugs associated with this lesion include amiodaraone, methotrexate, nitrofurantoin, bleomycin and hydrochlorothiazide. Radiologically, bilateral ground glass, reticular opacities and bronchiectasis of basal localization are seen [11, 12].

xiii. **Organizing Pneumonia (BOOP)**

Bronchiolitis obliterans organizing pneumonia (BOOP), also known as cryptogenic organizing pneumonia, may be idiopathic or secondary to other conditions such as collagen diseases, aspiration, organ transplantation, radiotherapy, AIDS, hematologic diseases and drugs. Drugs associated with BOOP include bleomycin, cyclophosphamide and methotrexate (11, 12). This pneumonia is generally reversible following drug withdrawal or steroid therapy.

6.0 OBJECTIVES

6.1 BROAD OBJECTIVES

To determine the utility of routine chest radiographs in patients in intensive care unit.

6.2 SPECIFIC OBJECTIVES

1. To determine common indications for requesting chest radiographs in ICU patients.
2. To determine correctly placed and malpositioned lines and tubes and action undertaken.
3. To evaluate complications associated with placement of supportive devices.
4. To evaluate common conditions seen on CXR in ICU patients.
5. To compare clinical and radiological diagnosis.

7.0 HYPOTHESIS

Routine chest radiographs have a role in management of patients in the intensive care unit.

8.0 STUDY PROCEDURES

i. STUDY DESIGN

Prospective cross sectional study.

The CXR findings were reviewed by the researcher and a consultant radiologist on daily basis for 3 months and results recorded in data collection forms. Questionnaire were completed for each CXR performed, addressing the indication for the radiograph, whether it changed the patientôs management and how it did so. Patient recruitment was done consecutively for all admissions into ICU.

ii. STUDY AREA DESCRIPTION

The study was done at Kenyatta National Hospital, ICU.

KNH ICU has a bed capacity of 21.

On average two patients are admitted per day in the ICU.

Chest radiographs are done routinely to all patients before admission and may be repeated some patients as requested.

iii. STUDY POPULATION

Chest radiographs were taken in anteroposterior projection as requested by clinicians and radiographers are required to indicate the projection (appendix A)

- INCLUSIONS CRITERIA

All chest radiographs of patients admitted in KNH ICU were analyzed.

Informed consent was obtained before recruitment for all patients and for the unconscious patients consent was obtained from their relatives/guardians.

- EXCLUSIONS CRITERIA

a) Refusal to consent by patient or relatives/guardian

b) Radiographs that were determined to be ónot of diagnostic qualityôas outlined under methodology (section v). This constituted only 2% of all films.

iv. SAMPLE SIZE DETERMINATION

Sample size was determined using the following demographic formula by Hawkins, D.L. [38];

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

Where n = desired minimum sample size,

z = confidence level at 95% corresponds to a Z-score value of 1.96,

s = Standard of deviation of 0.5 and

d = Margin of error (Confidence Interval) at 5%

$$n = \frac{1.96^2 \times 0.5(1 - 0.5)}{0.05^2}$$

Therefore 385 chest radiographs are needed.

v. METHODOLOGY

Chest radiographs were taken in anteroposterior projection as requested by clinicians and radiographers were required to indicate the projection. Patients were positioned in supine or semi-recumbent positions (appendix A)

Radiological request forms used in KNH are paper based and for the chest radiographic examination the request form contained clinical history and the reason for the examination. These request forms were completed by the referring physician in ICU.

Qualified radiographers do perform the radiography in the ICU using portable radiography machine after receiving the request.

The technologist sought and expected assistance of nursing ICU personnel in positioning these unstable patients, adjusting and removing support apparatus from the radiologic field.

Chest radiographs are obtained at 125cm target-film distance.

The principal investigator reviewed the CXR and formed an opinion. The images were then presented to a qualified consultant radiologist for his/her opinion. The consensus opinion was then taken as the radiological diagnosis. This radiological diagnosis was entered as the diagnosis in the data collection forms. For every film analyzed the following information was recorded (appendix A):-

a) Demographic data as it appeared in the request form that includes patient number, sex, age, date and time of examination.
b) Time when film was reported.
c) Diagnostic quality of the film:-The images was graded for diagnostic quality using a five point grading system as follows:
    1) Not of diagnostic quality
    2) Poor, barely adequate diagnostic quality
    3) Fair, acceptable diagnostic quality
    4) Good, above average diagnostic quality
    5) Excellent diagnostic quality

Images were determined ónot of diagnostic qualityô if any of the following were present:-

-Inability to see the thoracic spine through the cardiac shadow.

-Inability to follow the course of central lines, catheters, drain tubes and other medical devices.

-Inability to identify the tip location of the above lines, catheters and devices.

-Respiratory or other motion artifact of severe nature.

-Grid cut-off or other grid artifact of severe nature.

-Non-inclusion of the complete extent of the lung parenchyma.

Images of ñexcellent diagnostic quality ñhad all the qualities of ónot of diagnostic qualityô reversed.

d) Technical data that includes exposure parameters (mAs, kVp) distance and patient position and X-ray projection will be recorded by technician (appendix A).

e) Experience of the radiographer in terms of years of service.

f) Records of presenting complaints during admission, reasons for ordering the examination, radiological diagnosis, positions of catheters and tubes and follow up findings were included.

vi. EQUIPMENT

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 Kvp, exposure time of 1ms-5.3ms and source to floor distance of 70cm to 200cm.The system uses a single film screen combination.

vii. DATA ANALYSIS

Data was collected using a structured questionnaire. Data entry was then conducted using the statistical package for social science (SPSS) version 20.0.Data cleaning was performed to check for errors and inconsistent (conflicting) answers, missing entries and duplicate entries and to ensure high quality data. Descriptive statistics was presented using percentages and frequencies for categorical or nominal data while mean, standard deviation, median, minimum and maximum for continuous/discrete variables.

viii. ETHICAL CONSIDERATIONS

a) The patients names did not appear anywhere in the data collections forms in order to maintain confidentiality. Instead the patientôs data was coded using unique serial numbers.

   For referral purposes only the patients IP/ OP number was recorded. No additional examinations were done on a patient other than the one requested by the primary physician

b) The ALARA principle that is keeping the radiation exposure As Low As Reasonably Achievable was maintained for all the patients. Only the standard radiological procedure for CXR was applied to all patients.

c) Permission to carry out the study was sought from the Ethical and Research Committee of Kenyatta National Hospital and University of Nairobi. The study commenced soon as the study was approved by the committee.

d) The copies of the study will be given to Kenyatta National Hospital and University of Nairobi for future reference and to facilitate possible improvement in patient management.

ix. LIMITATIONS OF THE STUDY

a) Intensive care unit patients are critically ill and for those who could not communicate, informed written consent was obtained from their relatives/guardians
b) ICU patients have much hardware attached to the chest making positioning procedure difficult.
c) These patients could not stand and chest films were often taken while the patient is supine. The anteroposterior (AP) projection results in the magnification of anterior structures such as the clavicle, sternum, and heart that can often be significant. Furthermore, on an AP view the medial border of the scapula is projected several centimeters further into the lung. Supine positioning also widens the mediastinum and heart due to gravitational effects. In addition, supine positioning changes the physiology of the pulmonary vasculature, putting more flow to the upper lobes and making diagnosis of cephalization difficult.
d) Shortages of qualified radiographers who are sometimes assisted by Kenya Medical Training College students. There was no indication that exposures done by students were more likely to be ónot of diagnostic qualityô
e) No film processing machine in ICU and once exposed, the films have to be taken to KNH radiology department for processing.

9.0 RESULTS

The study involved investigation of 396 chest radiograph films from patients admitted to KNH ICU during the three-month period from December 2013 to February 2014. The findings of the analysis of the utility of the chest radiographs in ICU admissions are presented in this chapter.

Patient characteristics

Figure 1 shows the gender distribution of patient contributing chest X-ray films. Of all the films 218 films (55.1%) were from male patients while 178 films (44.9%) were for females (Male-to-female ratio 1: 1.2).

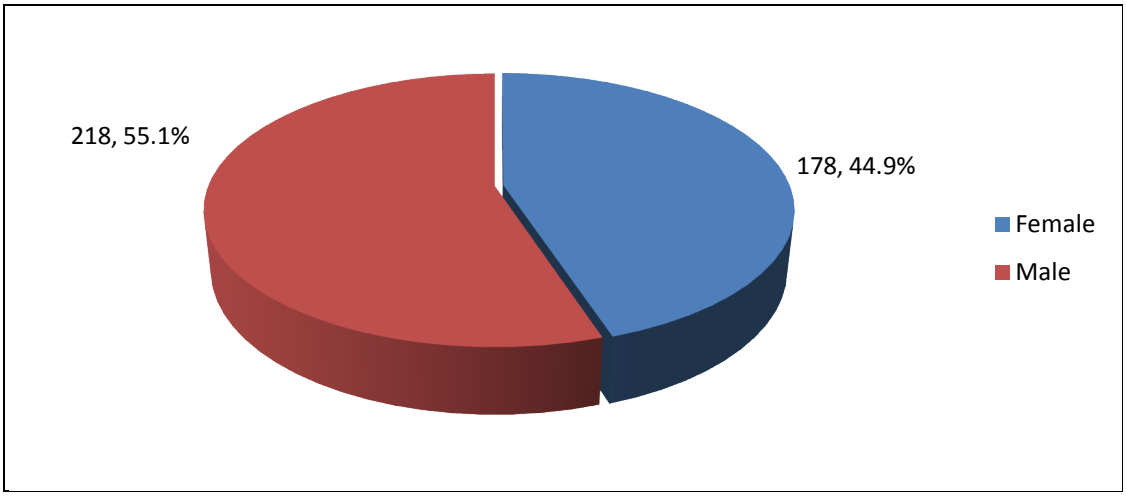


Figure 1: Gender distribution of patients providing chest radiograph films in KNH ICU

Age distribution

The median age of ICU patients was 32 years (IQR 12-57). The age of participants ranged from 1.5 years to 83 years. Age documentation in ICU was incomplete for 76 (19.2%) adult patients. **Figure 1** presenting age distribution shows that of the 320 (80.8%) patients with documented age, most were in the age groups 5 to 17 years (25.6%) or 60 years and above (18.4%).

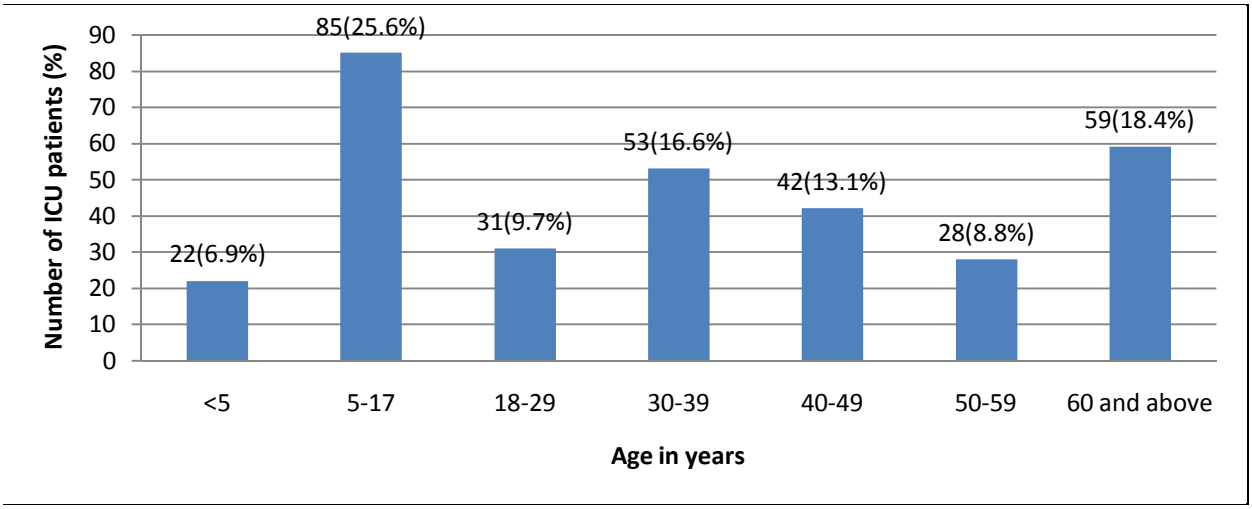


Figure 2: Age distribution (in years) of ICU patients at KNH undergoing chest radiography

Patient's positioning

Figure 3 shows the patient position during chest X-ray examination. Approximately three-quarters (72.2%) of all patients were examined in the supine position and the remaining patients were examined in semi-recumbent position.

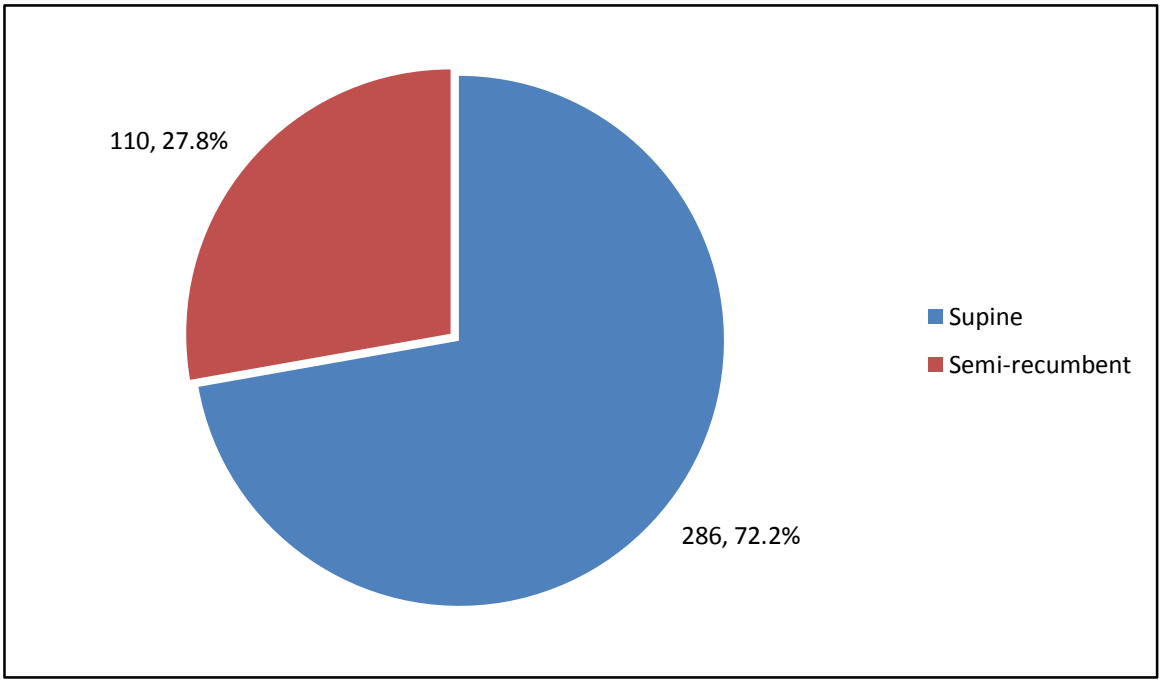


Figure 3: Patient positioning during chest X-ray in KNH ICU admissions

Chest radiograph projection

All chest radiographs (n = 396) were obtained in antero-posterior projection. **Table 1** summarizes the exposure factors for chest radiography in the study sample. The mean (SD) film tube distance was 112.1 (3.4) cm. Tube output ranged from 46 to 62 Kv, with a mean output of 55.8 Kv (4.5). The mean mAs was 2.9 (SD 0.7).

Table 1: Chest radiograph exposure factors for ICU patients at KNH

	N	Mean	SD	Min	Max
Exposure factors					
Film tube distance (cm)	396	112.1	3.4	100	118
Tube output(Kv)	396	55.8	4.5	46	62
mAs	396	2.9	0.7	1.4	4.2

A total of 160 (40.4%) films obtained among ICU admissions at KNH were performed by students pursuing diploma courses in radiography and 151 (38.1%) of radiographs were conducted by qualified radiographers with at least 3 years experience in radiography (**Table 2**).

Table 2: Experience of radiographers performing chest radiographs among ICU patient at KNH

	n	%
Radiographer experience (years of service)		
KMTC Diploma radiography students	160	40.4
Below 3 years	85	21.5
Above 3 years	151	38.1
Total	**396**	**100**

Approximately one-half 213 (53.8%) of the films obtained in KNH ICU were classified as being fair, of acceptable diagnostic quality and 157 (39.7%) as good and above average diagnostic quality (**Table 3**). Eight (2%) films were not of diagnostic quality. Of these 8 films, one radiograph was taken by a student radiographer, two by qualified radiographers with less than 3 years experience and 5 by radiographers with at least 3 years radiography experience.

Table 3: Diagnostic quality of films in ICU patients at KNH

	n	%
Diagnostic quality of film		
Not of diagnostic quality	8	2.0
Poor, barely adequate diagnostic quality	12	3.0
Fair, acceptable diagnostic quality	213	53.8
Good, above average diagnostic quality	157	39.7
Excellent diagnostic quality	6	1.5
Total	**396**	**100**

Figure 4: Shows the presenting complaints on admission to KNH ICU. The leading causes of admission were trauma due to road traffic accidents 143 (36%), cough and difficulty in breathing due to severe chest infection 91 (23%) and cough/chest pain due to cardiovascular disease 54 (14%).

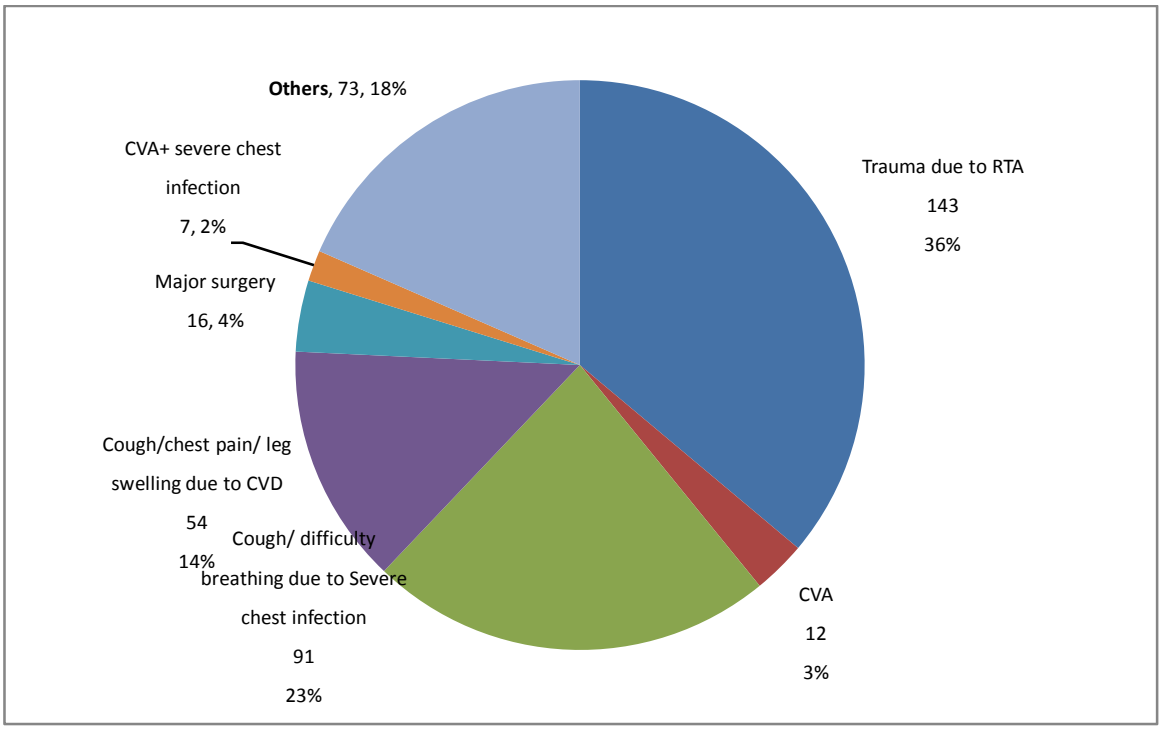


Figure 4: Presenting complaints on admission to KNH ICU

A significant number of ICU admissions 73 (18%) were done for **other** reasons. Trauma resulting from falls from heights 13 (17.8%), stab wounds 9 (12.3%), Guillain Barre Syndrome 9 (12.3%) and gunshot wounds 8 (11%) were the most common causes of ICU admission in this group of patients (**Table 4**).

Table 4: Details of **other** presenting complaints in ICU admissions at KNH

	n	**%**
Fall from height	13	17.8
Guillain Barre syndrome	9	12.3
Stab wound	9	12.3
Gun shot	8	11.0
Coma	6	8.2
Inhalation burns	6	8.2
Tetanus	6	8.2
Posterior fossa mass	4	5.5
Caustic pencil ingestion	3	4.1
Myopathy	3	4.1
Acute renal failure	2	2.7
Burns, epileptic	2	2.7
Sepsis	2	2.7
Total	**73**	**100.0**

Lung parenchyma opacifications was the most common 146 (36.9%) radiological finding on chest radiographs of ICU patients as shown in **Table 5**. The other common problems visualized on CXR were pneumothorax 49 (12.4%) and cardiomegaly 37 (9.3%) and approximately one-quarter (27.8%) of films had other findings.

Table 5: Common conditions seen on CXR in ICU patients

	n	%
Pleural effusion	9	2.3
Pneumothorax	49	12.4
Lung collapse	6	1.5
Pulmonary edema	21	5.3
Pulmonary edema and cardiomegaly	18	4.6
Cardiomegaly	37	9.3
Lung parenchyma opacifications	146	36.9
Other findings	110	27.8
Total	**396**	**100.0**

Of the 146 chest films showing lung parenchyma opacifications, 52 (35.6%) were lung contusions and 50 (34.3%) were atypical pneumonias (**Table 6**).

Table 6: Specific findings in chest radiographs showing lung parenchyma opacifications

	n	%
Aspiration atypical pneumonia	4	2.74
Aspiration pneumonia	23	15.75
Atypical pneumonia	50	34.25
Bronchopneumonia (severe)	4	2.74
Lobar pneumonia	13	8.9
Lung contusion	52	35.62
Total	146	100

There were 110 (27.8%) films with other radiologic findings. Multiple rib fractures accounted for 14 (12.7%) cases among the other findings and COPD accounted for 7(6.4%) films (**Figure 5**). The remaining films were normal.

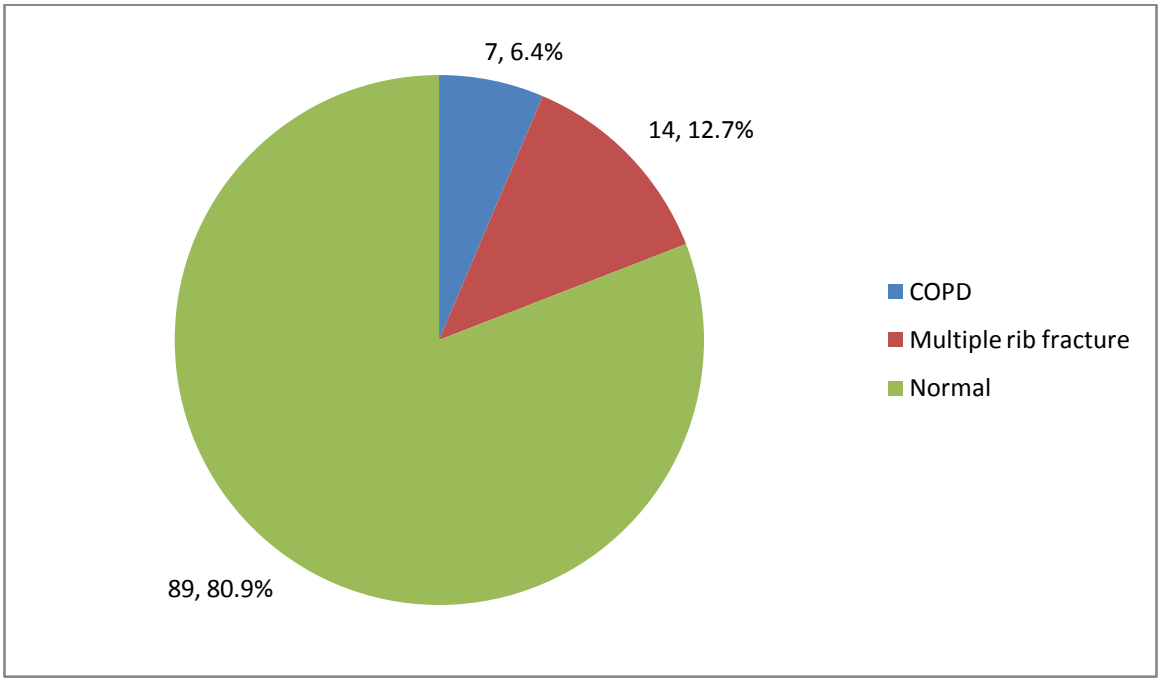


Figure 5: Other findings on chest radiographs of ICU patients at KNH

Chest radiographs were commonly requested 234 (59.1%) as part of post intervention evaluation (**Figure 6**). Routine examination and evaluation of clinically suspected lesions each accounted for 17.7% of the chest radiograph requests.

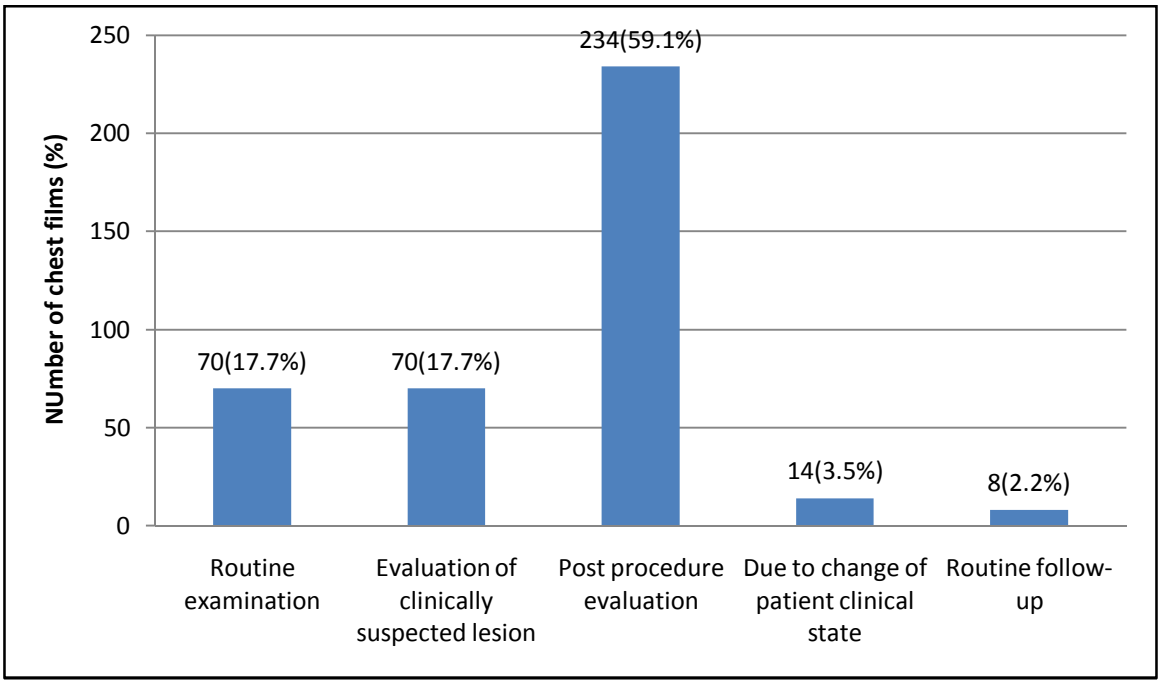


Figure 6: Reasons for chest radiograph requests in ICU patients at KNH

Catheter and tube placement

Out of the 398 patient films from ICU a total of 293 (74%) films had at least one tube or catheter inserted and visualized on chest radiograph. Of the 293 visualized tubes, 98 (33.4%) tubes had a misplaced tip visualized on the films and 195 (66.5%) were correctly placed. Among all the inspected films 192 (48.5%) had a single tube or device inserted 97 (24.5%) had two devices and 4 (1.0%) had three tubes or devices inserted (**Figure 7**).

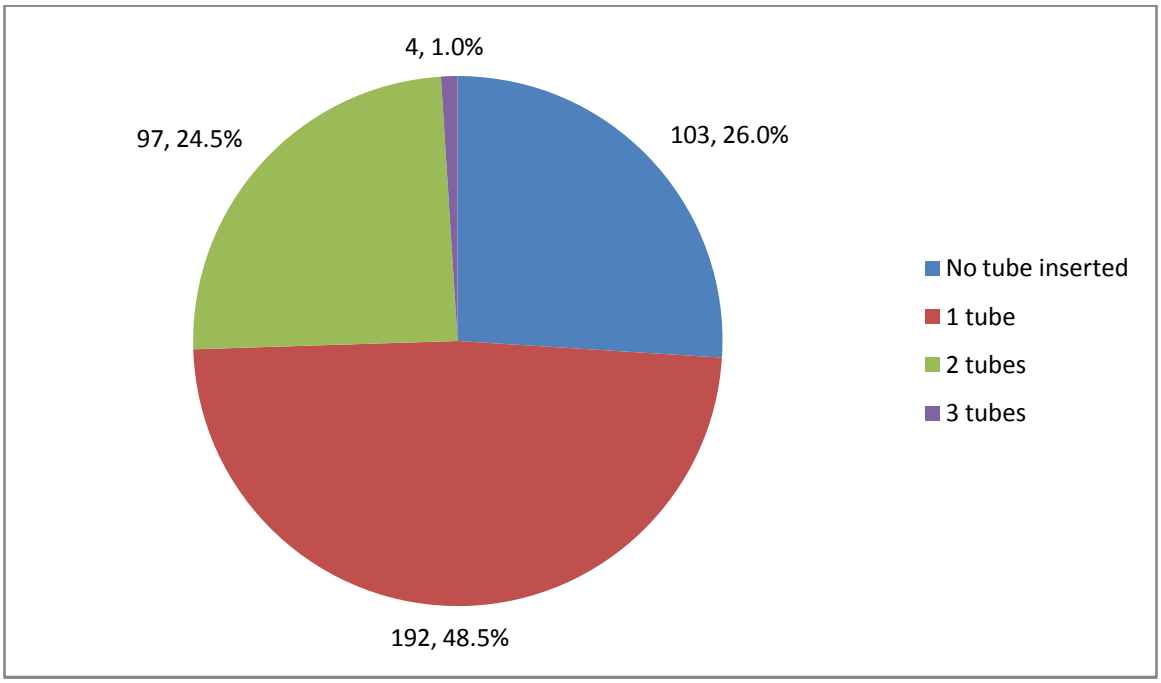


Figure 7: Catheter or tube insertion in ICU patients at KNH and visualization of devices on chest radiography

Four types of devices were inserted in ICU patients: 298 (75.3%) had NGT inserted with no malposition within the thorax, 208 (52.5%) patients had CVC lines inserted, 141 (35.6%) had ETT and 49 (12.4%) chest tubes. **Figure 8** shows the distribution of devices inserted and the proportions of correctly and incorrectly placed devices on chest radiograph visualization. Incorrect placement of chest tubes 17 (34.7%) was more common followed by CVC 58 (27.9%) and ETT 23 (16.3%) malposition.

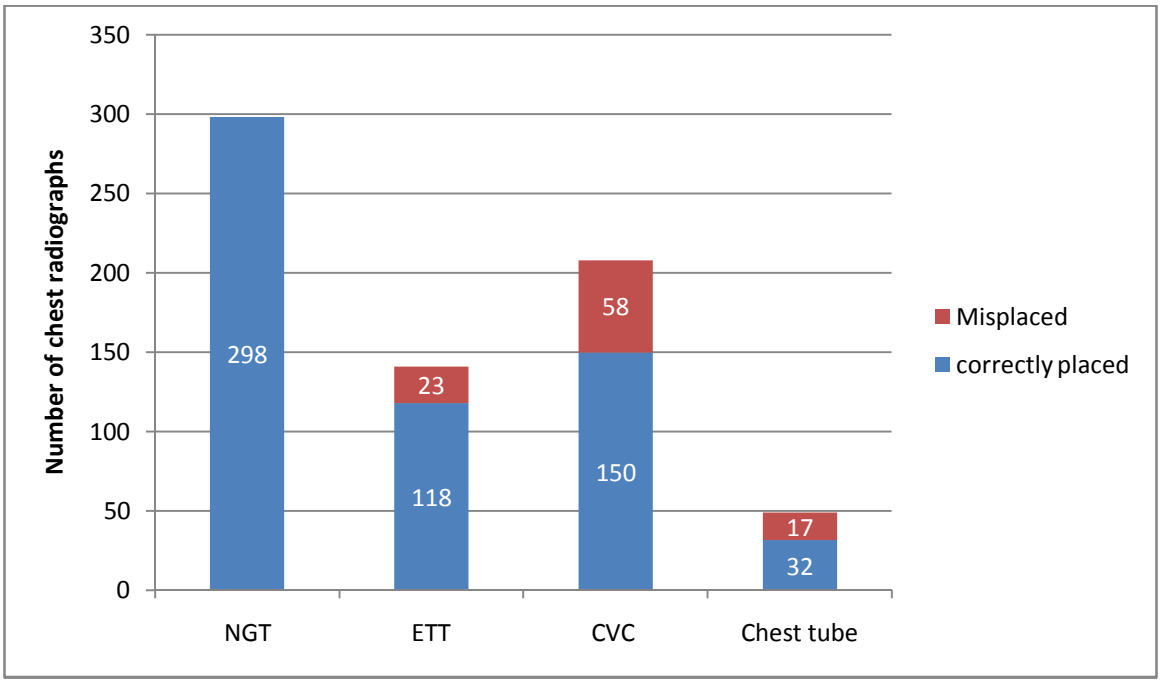


Figure 8: Positions of commonly inserted catheters in ICU patients.

Corrective intervention was implemented within 12 hours for all misplaced ETT and chest tubes. As shown in **Table 7** the repositioning of approximately one-half of the misplaced ETT and chest tubes were done within six hours (47.8% and 47.1%). For CVC, 15 (30%) of catheters were repositioned more than 12 hours later and no intervention was documented in 6 (12%) films.

Table 7: Timing of corrective intervention in tube misplacement visualized on CXR

	ETT		**CVC**		**Chest tube**	
	N	%	n	%	n	%
Time taken to intervene						
One to six hours	11	47.8	11	22	8	47.1
Six to twelve hours	12	52.2	18	36	9	52.9
More than 12 hours	-	-	15	30	-	-
No intervention	-	-	6	12	-	-

Out of the 293 films with a device inserted 52 (17.7%) had post device insertion complications (**Table 8**). The most common complication was aspiration pneumonia (n = 26, 50%), followed by atelectasis (n = 15, 28.8%). Pneumothorax occurred in 6 (11.5%) cases. Thirty-four complications arose as a result of insertion of a single device while the remaining 18 were associated with multiple device placements.

Table 8: Complication associated with placement of devices in ICU patients at KNH

	ETT	CVC line	Chest tube	**Total**
Post-device placement complications in patients with single devices				
Pneumothorax	0	4	0	**4**
Atelectasis	8	2	0	**10**
Pneumomediastinum	0	0	5	**5**
Aspiration pneumonia	6	2	7	**15**
Sub total	**14**	**8**	**12**	**34**
Post-device placement complications in patients with two devices (ETT+CVC line)	ETT+CVC			
Pneumothorax	2			**2**
Atelectasis	5			**5**
Pneumomediastinum	0			**0**
Aspiration pneumonia	9			**11**
Total				**52**

Table 9: Follow up CXR findings in chest radiographs of ICU patients at KNH

	n	**%**
New finding	4	1.0
Improving - normally placed tube	125	31.6
Worsening -malpositioned tube	89	22.5
Worsening- normally placed tube	178	45.0
Total	**396**	**100.0**

Intervention was indicated in 271 (68.4%) of the films visualized in ICU patients (**Table 10**). Most commonly the intervention involved either medication change 101 (37.3%) or placement/ repositioning of medical devices.

Table 10: Intervention following chest X-ray of ICU patients

	n	%
Interventions in patients' management	271	64.8%
Medication change	101	37.3
Placement of extra medical devices	98	36.2
Medication change and change in respiratory response	30	11.1
Medication change and placement of extra medical devices	20	7.4
Change in respiratory response	12	4.4
Medication change and change in respiratory response and change in ventilation setting	4	1.5
Medication change and change in ventilation settings Change in ventilation settings	3	1.1
Change in respiration and ventilation setting	3	1.1
Total	**271**	**100.0**

Repositioning of devices was the predominant intervention performed following chest radiograph visualization of misplacement. As presented in **Table 11**, repositioning of CVC lines, chest tubes and ETT was done in 38.7%, 15.1% and 12.3% of interventions respectively. Between 9.4% and 14.2% of interventions involved insertion of new catheters.

Table 11: Device placement / repositioning following chest radiography

	n	%
CVC insertion	15	14.2
ETT insertion	10	9.4
ETT and CVC insertion	11	10.4
Positioning chest tube	16	15.1
Positioning CVC	41	38.7
Positioning ETT	13	12.3
Total	106	100.0

Table 12 shows that certain radiological findings were highly correlated with specific clinical presentations. All the lung collapses on chest radiographs occurred in patients with severe chest infection. Pleural effusions, pneumothoraces and lung contusions were commonly associated with RTA while most lung parenchyma opacifications were due to severe chest infections.

Table 12: Correlation between clinical findings and radiological diagnosis among ICU patients

	Clinical presentation						
	RTA	CVA	Severe chest Infection	CVD	Major surgery	CVA+Severe chest infection	Others
CXR radiological diagnosis							
Pleural effusion	9	0	0	0	0	0	0
Pneumothorax	25	0	0	0	0	0	24
Lung collapse	0	0	6	0	0	0	0
Pulmonary edema	11	0	3	5	0	0	2
Pulmonary edema/ cardiomegaly	1	4	0	13	0	0	0
Cardiomegaly	0	4	0	17	16	0	0
Lung parenchyma opacifications	45	1	65	16	0	0	19
Other findings	52	3	17	3	0	7	28
Total	**143**	**12**	**91**	**54**	**16**	**7**	**73**

10.0 ILLUSTRATIONS

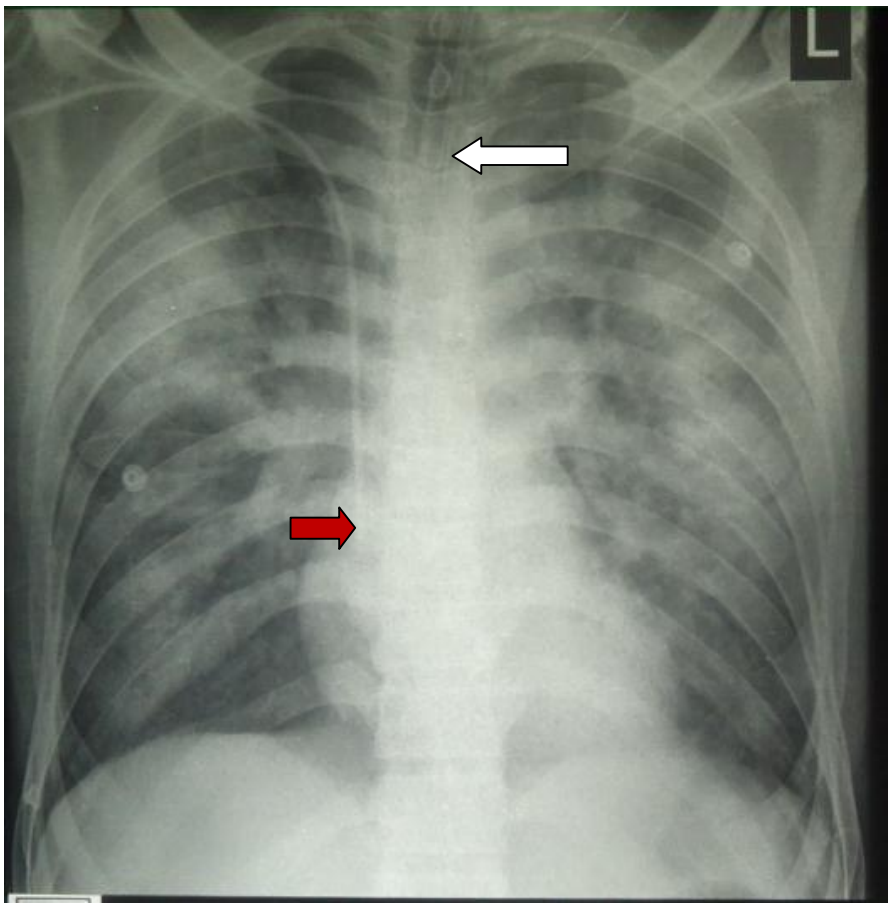


Figure 9 : Shows an AP supine chest film, showing central line catheter place in right atrium (red arrow) in a patient with bilateral pulmonary edema .ETT is correctly placed at T2 level (white arrow).

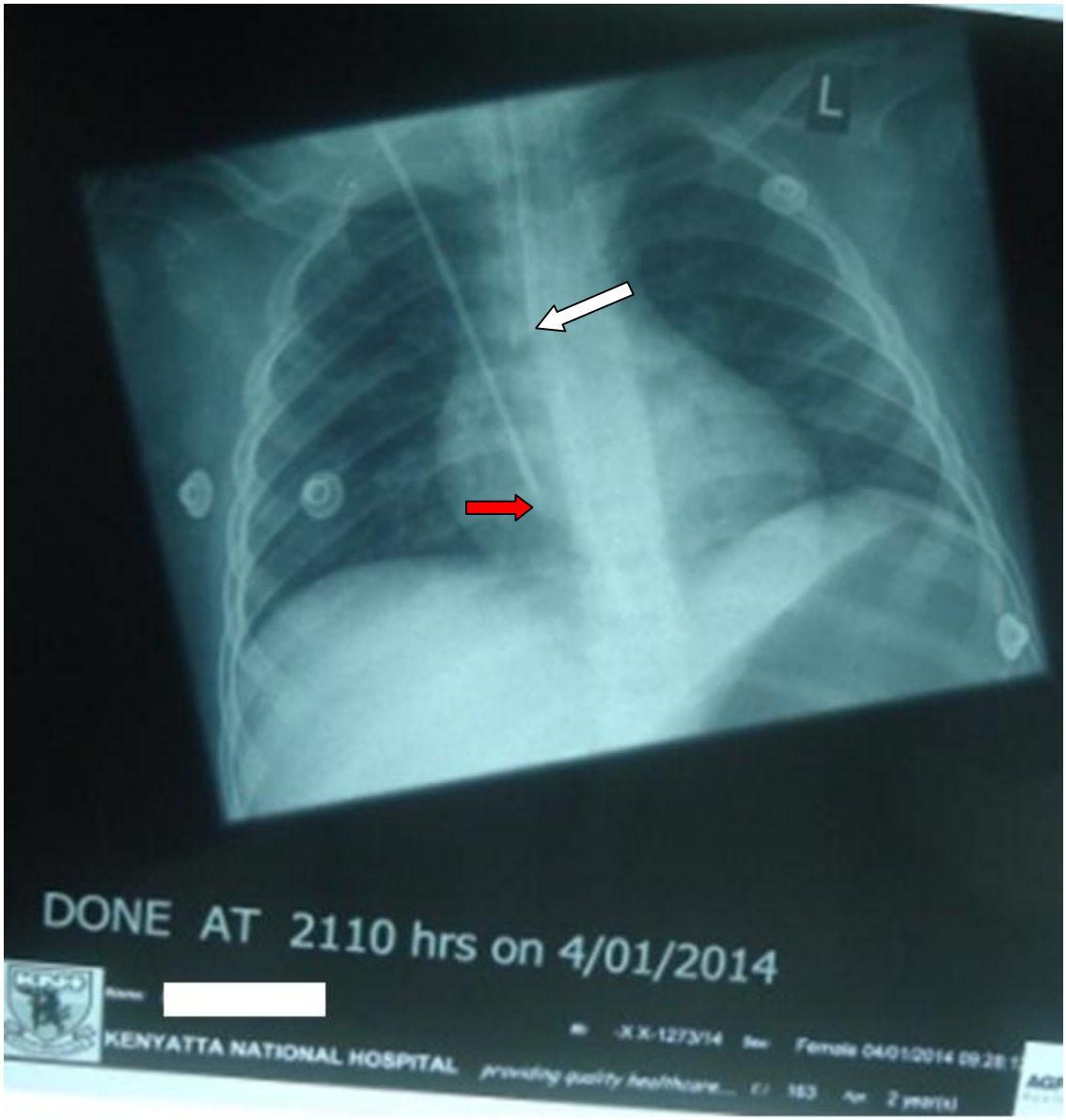


Figure 10: Shows an AP chest film showing wrongly placed tip of endotracheal tube at the carina (white arrow) and also wrongly placed central line catheter in right atrium (red arrow).

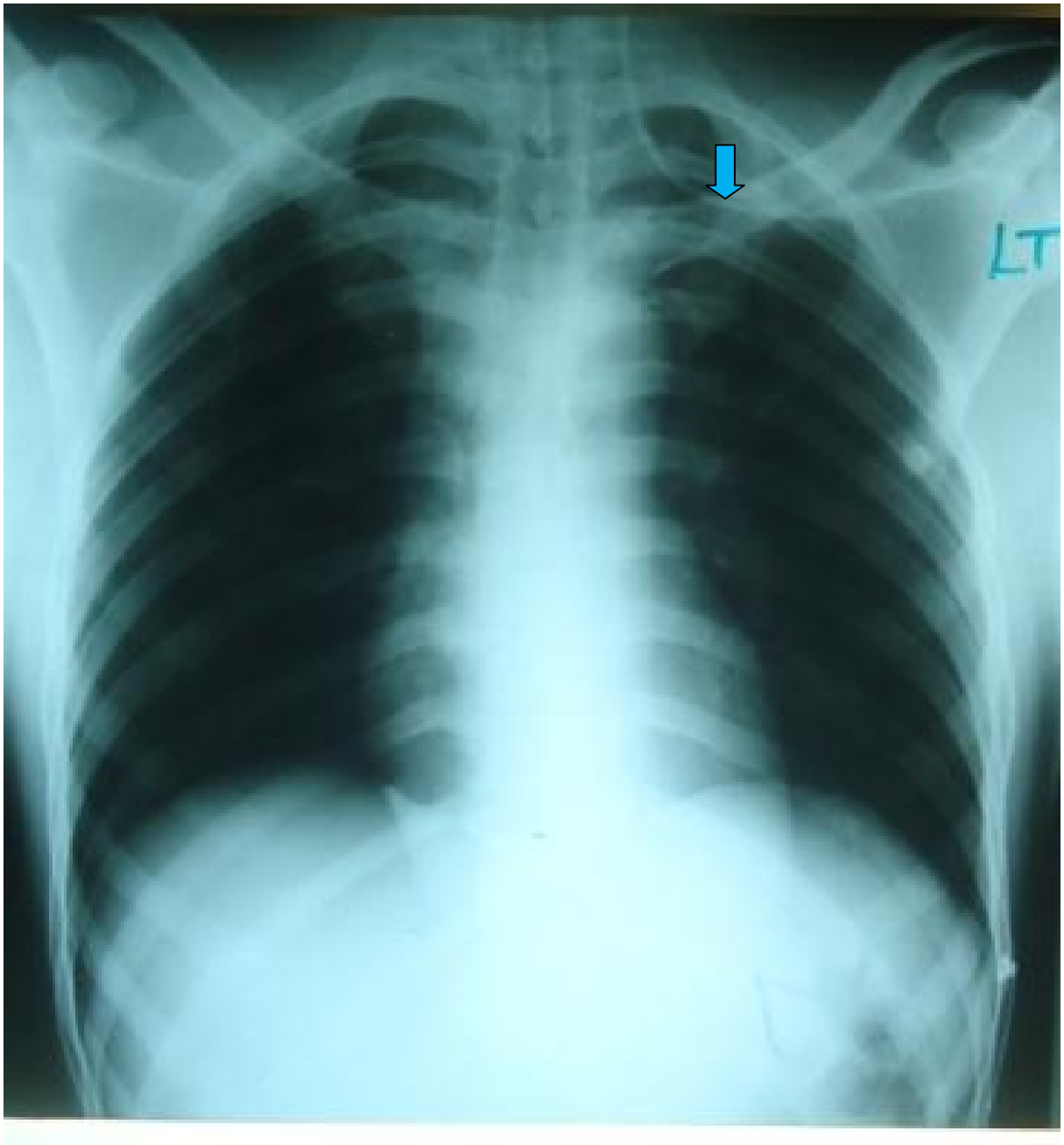


Figure 11: Supine chest film showing misplaced central line catheter. Catheter was introduced from left internal jugular vein but landed into left subclavian vein (blue arrow).

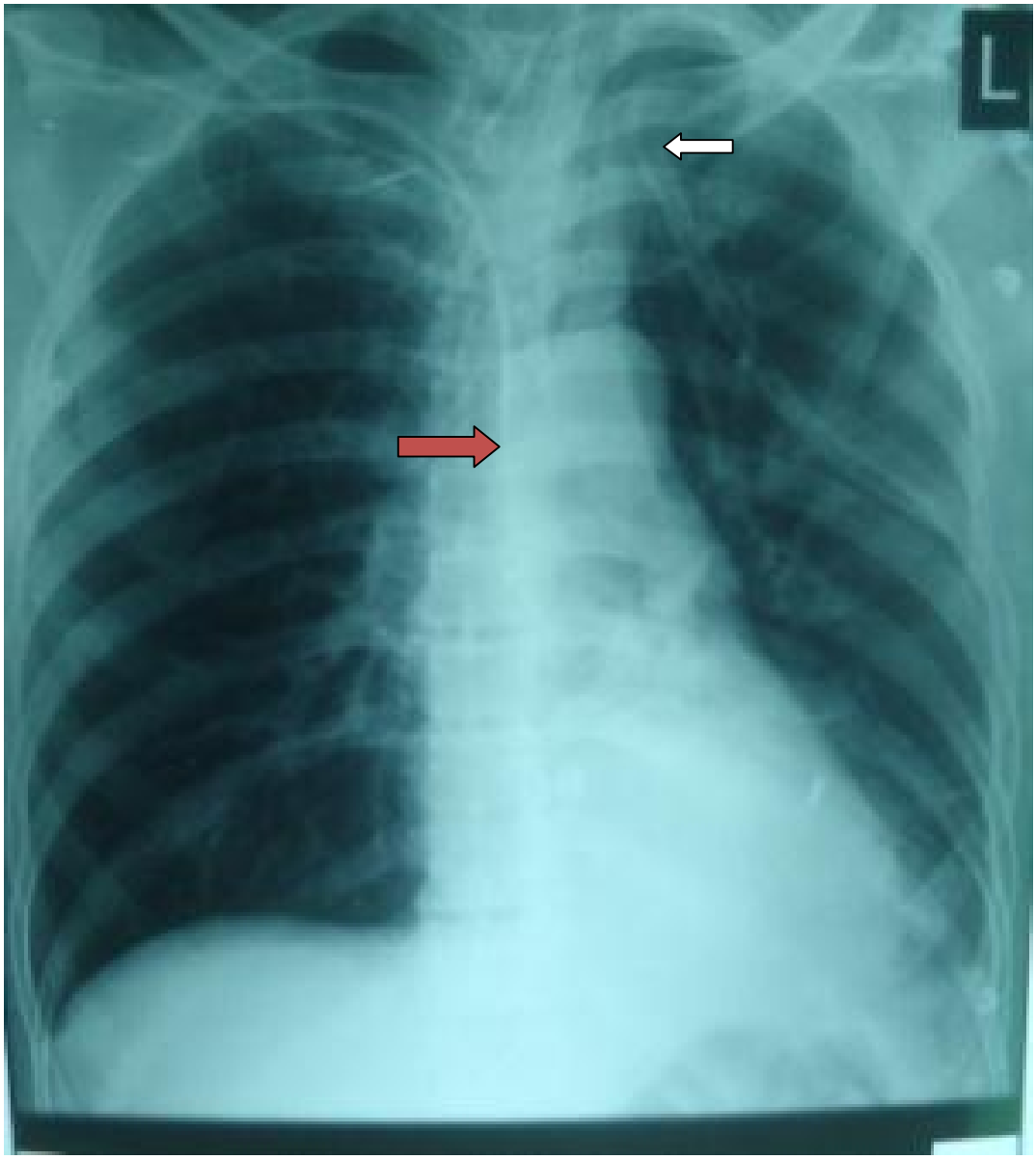


Figure 12: Shows AP film with correctly position of the central venous catheter: the tip is projected in the distal superior vena cava lumen (red arrow) and parallel to it just above the right atrium. Also note correctly placed left chest tube for draining a pneumothorax (white arrow).

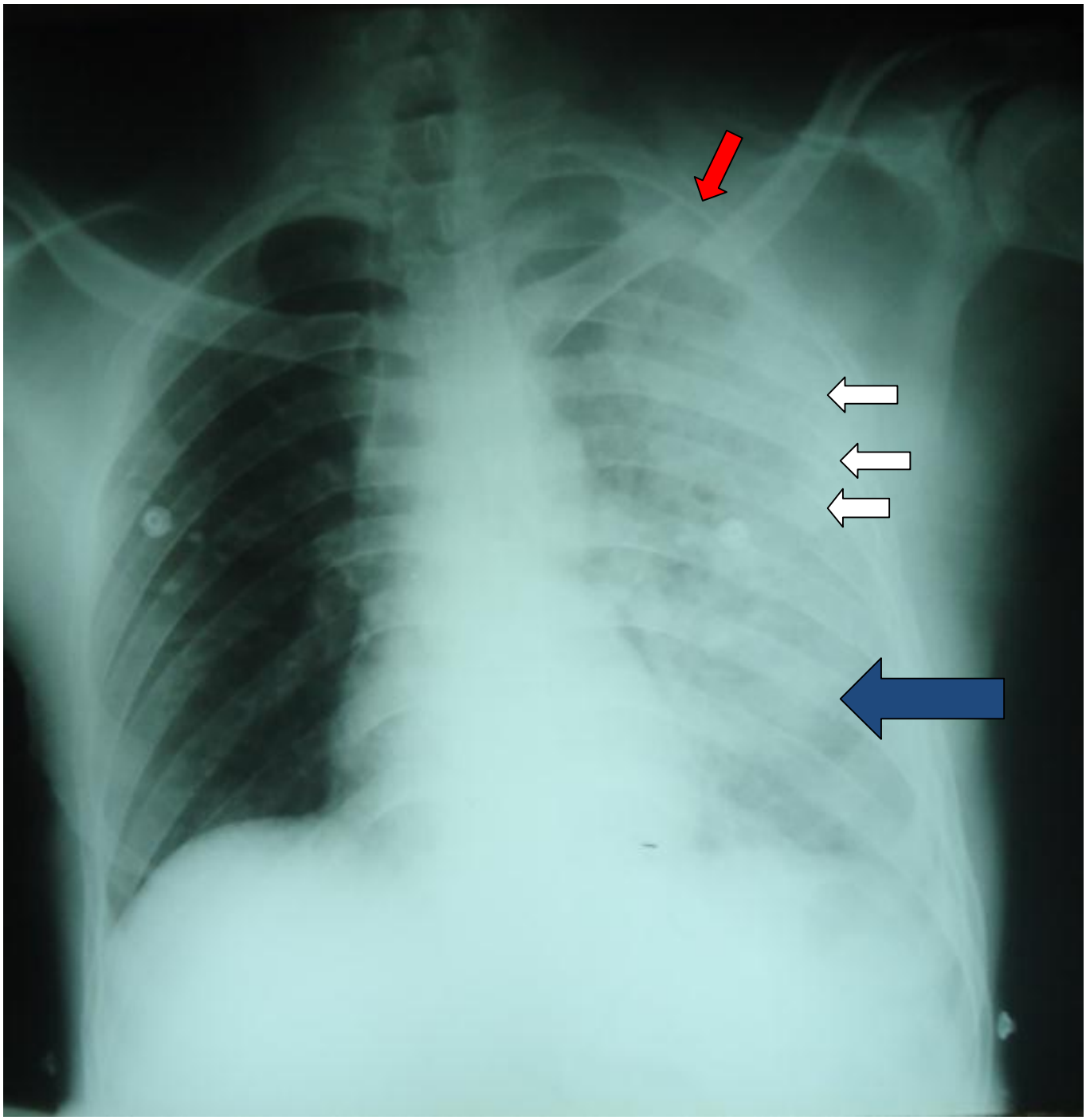


Figure 13; AP chest film showing fracture left mid clavicle(red arrow) and multiple left sided rib fractures(white arrows) in patient who was involved in road traffic accident. There is also left lung contusion (blue arrow).

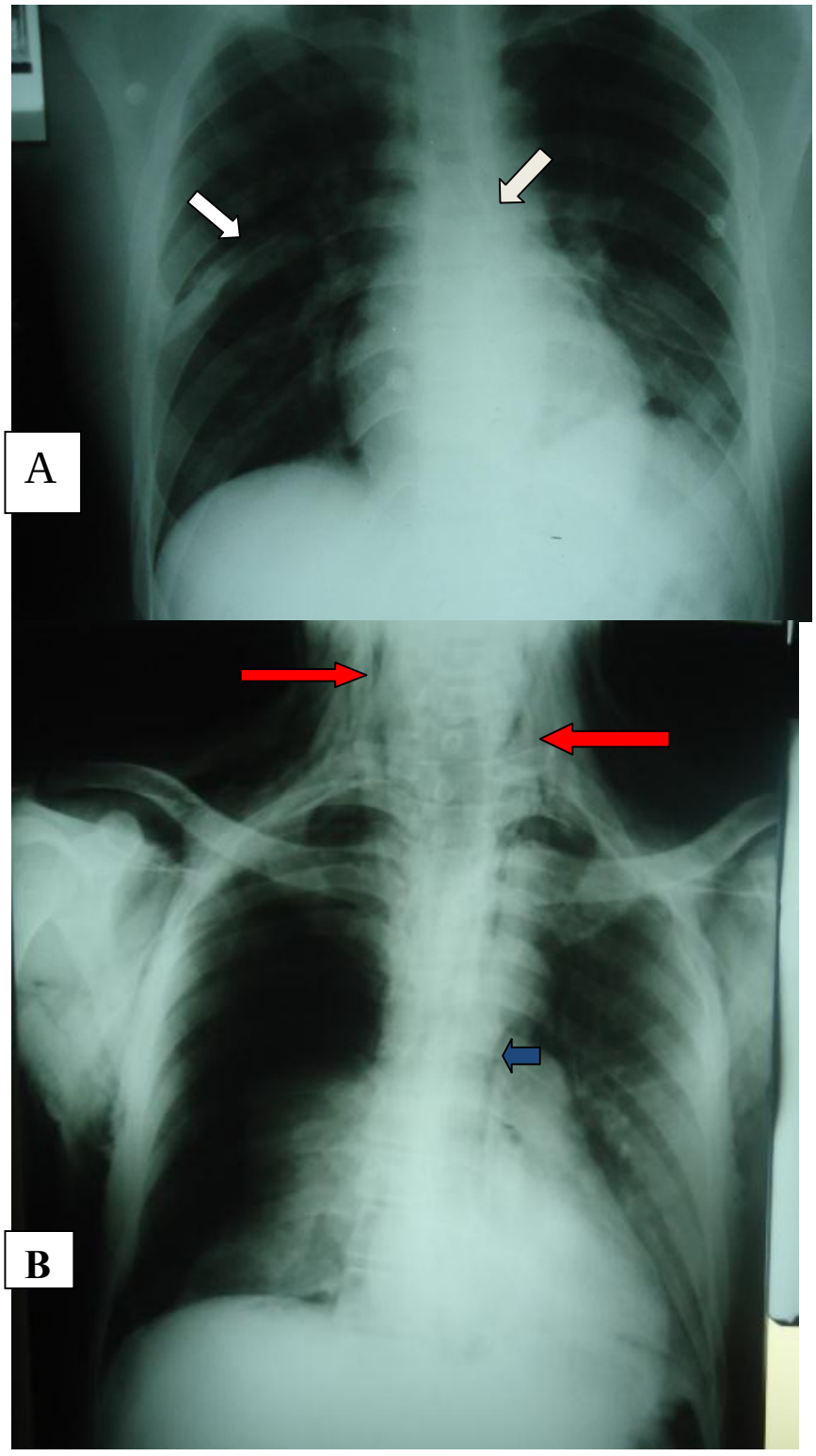


Figure 14: Two AP chest films **A** and **B** from the same patient. Film **A** shows bilateral chest tubes in situ(white arrows).The left chest tube is wrongly inserted into the mediastinum and film **B** with pneumomediastinum(blue arrow) and soft tissue emphysema (red arrows). Patient died few days later.

11.0 DISCUSSION

The current study conducted in the ICU at Kenyatta National Referral Hospital aimed to determine the utility of routine chest radiographs in clinical decision making during intensive care. The patients admitted to ICU for whom chest radiographs were reviewed had a median age of 32 years (range 1.5-83), and males accounted for 55.1% of the reviewed chest films.
The male to female ratio was 1.2: 1. Previous studies conducted within ICUs in Nairobi including KNH ICU, reported similar male predominance in chest radiographs of patients admitted to ICU [1]. Considered together, age and gender distributions revealed that admissions to ICU were predominantly young males thus agreeing with existing study from Kenyan ICUs [1]. Further, RTA was the leading cause of ICU admission. The demographic findings in this study are therefore possibly explained by the higher involvement of males, especially young adults in the economically productive age group in RTAs.
Equally important was the observation that chest infections (23%) and cardiovascular disease (14%) were significant contributors to ICU admission. In a study done by Chahine-Malus et al on utility of routine chest radiographs in a medical-surgical intensive care unit, out of 97 medical patients admitted in ICU, 45 had severe respiratory diseases while 15 had cardiovascular diseases [2]. This shows almost a similar distribution.

Approximately 60% of chest radiographs in this study were conducted by either trainee radiographers (40.4%) or radiographers with less than three years experience (21.5%). The exposure factors including tube output (mean = 55.8) and mAs (mean = 2.9) were within the acceptable ranges, and indeed the mean tube output was comparable to output reported in hospitals where only qualified radiographers administer radiation. In addition most of the films were interpretable reflecting either acceptable diagnostic quality or above average diagnostic quality. Only 8 (2%) films were not of diagnostic quality. In the context of resource constrains within the Kenyan health system, these findings are quite informative with regards to the potential role of task shifting in radiography. These data however, need to be interpreted with caution and could form the basis for future investigation within this area of role to substitution among radiographers and radiographers in training but its noteworthy that it is a requirement that the trainees must work under close supervision of qualified radiographers.
The common indications for requesting chest radiographs in ICU patients were post device placement evaluation (59.1%) and routine examination (17.7%) or evaluation of clinically

suspected lesions (17.7%). In contrast, routine CXRs account for between 72% and 91% of indications for chest radiography within medical and surgical ICUs in developed countries [2]. Within the same studies and for non-routine CXR, the most common indication is to verify position of medical device and exclude complications. These findings confirm the importance of CXR in post device placement assessment within intensive care in both developed and developing countries [2, 40].

Most of the catheters were correctly placed on visualization using chest radiographs. However, one-third (33.4%) of all visualized devices were incorrectly placed. The range of devices placed incorrectly was 16.3% for ETT, 27.9% for CVC and 34.7% for chest tubes. Overall, higher rates of misplacement of catheters in ICU patients ranging from 19.5% (ETT), 28.1% (chest tubes) and 58.5% (CVC) were previously reported by Omwenga (MMED dissertation 2000) [1].

Other existing literature also suggests that the frequency of tube malposition after endotracheal intubation justifies the routine chest radiographs after such procedures. Schwartz et al [38] reported an overall incidence of 42(15.5%) out of 271 malposition, with 10 mainstem intubations. Brunel et al [39] reported that 30(13.7%) out of 219 intubations required repositioning, including 10 mainstem intubations. In a broader evaluation of post procedural CXR in the ICU, Gray et al [32] reported an incidence of endotracheal tube malposition of 28(25%) out of 112, although the number predicted by physical examination was only six (5%) out of 112. They recommended that very few malpositioned tubes are detected by physical examination and chest radiographs immediately post intubations are indicated to ensure proper positioning. The rate of endotracheal tube malposition in KNH ICU demonstrated 23(16.3%) out of 141 is consistent with the data previously reported. However, the generally high tube/catheter misplacement rate in KNH compared to other studies could be explained by unguided techniques in devices insertion by the ICU physicians. This could be improved by incorporating radiologists while undertaking the procedures.

Eight studies were reviewed regarding CVP catheters insertion [6, 24, 30, 31, 36, 39, and 40]. The majority came to the same conclusion that approximately 10% of the chest radiographs demonstrated malpositioned catheters. Pneumothoraces were present in only a small percentage [6%] of films. They recommended that chest radiographs after insertion of a CVP catheter should be obtained to demonstrate proper placement and detect any complications and follow-up

chest radiographs are suggested only when complications are suspected clinically. In this study, 208 (52.5%) films had CVC lines demonstrated and 58 CVC lines (27.9%) were malpositioned. In comparison with these studies, the current study done in developing country showed a larger percentage of CVC malposition. However, of all the inserted CVC lines, and just like studies done in the developed countries, only a small percentage [7%] was associated with pneumothoraces.

Studies performed to evaluate the efficacy of the initial chest radiograph after the insertion of a chest tubes shows that about 10% of tubes are malpositioned [6, 24, 30, 36]. They found that many of the radiographic abnormalities detected are minor and do not result in changes of tube positions and recommended that after insertion of a chest tube, a chest radiograph is needed to show the position of the tube, any success in drainage, and possible complications from insertion. Beyond this point, evaluation of tube position and function is warranted based on management of the pleural space and clinical indications. Out of the 49 films that demonstrated chest tubes, 17 (34.7%) films were incorrectly placed making the occurrence more than three times higher than in developed countries.

In cases where tube misplacement was noted, corrective action was taken within six hours for half of malpositioned ETT and chest tubes. Of significance was the variation in practice related to intervention when incorrect catheter placement was noted in CVC lines with 30% of misplaced CVC lines being repositioned or reinserted over 12 hours later and no documented intervention in 12% of incorrectly placed CVC lines. A comprehensive literature review conducted during the current study on timing of intervention post identification of device misplacement did not yield comparable data on time to intervention. However, clinical guidelines for critical care recommend that corrective intervention be implemented immediately since interventions that were implemented within six hours showed marked improvement compared to cases where intervention was delayed.

Post device placement complications occurred in 17.7% of films and most commonly included aspiration pneumonia or atelectasis. It is also noteworthy that there was no significant increase in occurrence of complications with the insertion of multiple devices.

Lung parenchyma opacifications was observed in one-third of films making it the most common condition seen on CXR in ICU patient. Atypical pneumonia and lung contusions accounted for

approximately 70% of the Lung parenchyma opacifications. Apart from opacifications, other common findings were pneumothorax (12.4%) and cardiomegaly (9.3%). ICU studies from different settings indicate variable findings for common conditions seen on CXR possibly reflecting differences in settings and patient populations [2, 4, 5, and 23].

There was strong evidence of correlation between clinical diagnosis and radiologic findings. The findings that showed clear correlations were: RTA and pneumothoraces, RTA and lung contusions, severe chest infections and lung parenchyma opacifications, and cardiovascular disease with cardiomegaly or pulmonary edema. These associations confirm that commonly used clinical algorithms for making diagnoses correspond to radiologic findings.

Conclusion

In conclusion, there is a significantly high rate of tube and catheter misplacement in KNH ICU and routine CXR has a role in identifying the malpositioned devices, associated complications and providing feedback for implementing quality assurance.

12.0 RECOMMENDATIONS

Several recommendations are made based on the findings of the present study including suggestions on organization of radiology care in the KNH ICU, and studies to address gaps identified in the analysis reported here.

The films from ICU were developed in the main hospital dark room located in the radiology department resulting in significant delays in patient management decision making. The distance between KNH ICU and radiological department is approximately two to three hundred meters apart and it takes about thirty to fifty minutes for radiographers to have the entire examination done (film exposure and processing). A dark room for film processing should be situated within the ICU or within close proximity of the unit.

The delayed intervention following visualization of misplaced devices in ICU can be partly attributed to the shortcoming in organization of care noted above. In addition to the change suggested above the study recommends that specific guidelines should be established to outline the course of action once chest radiographs have been reported by the radiologist.

This study has demonstrated that a significant proportion of catheters and devices inserted are associated with complications and misplacement. This could be attributed to the procedures being performed by the doctors on training and it is suggested that all procedures must be done under qualified medical supervision.

There is an urgent need to review existing protocols with the aim of improving accuracy of catheter/tube placement in KNH ICU. In previous studies the role of CXRs in checking placement of a medical device has been evaluated. Palesty et al concluded that CXRs are not necessary following the placement of a central line over a guide wire, as they observed no complications in 380 cases [33]. There remains a need for future studies designed to specifically evaluate the role of such techniques including imaging guided placement of medical devices in ICU patients in our settings.

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APPENDIX A

QU ESTIONNAIRE

PART A: TO BE FILLED BY THE RADIOGRAPHER

1. **Patient's biodata**

Study ID number.....

Date.....

Time.....

IP/OP No.....

CXR number.....

Sex.....

Age.....

2. **Patient's positioning**
   i. Supine
   ii. Semi-recumbent
   iii. Others(specify)

3. **X-ray projections**
   i. Anteroposterior
   ii. Others (specify)

4. **Exposure factors**
   i. Film tube distance
   ii. Kilovoltage
   iii. mAs

5. **Experience of the radiographer in terms of years of service.**
    i. Kenya Medical Teaching College student.
    ii. Below 3 years
    iii. Above 3 years

6. **Diagnostic quality of the film:-**
    i. Not of diagnostic quality
    ii. Poor, barely adequate diagnostic quality
    iii. Fair, acceptable diagnostic quality
    iv. Good, above average diagnostic quality
    v. Excellent diagnostic quality

PART B: TO BE FILLED BY THE PRINCIPAL INVESTIGATOR

7. **Presenting complaints during admission to ICU.**
    i. Trauma due to Road traffic accident
    ii. Cerebro-vascular event
    iii. cough and difficulty in breathing
    iv. Cardiovascular disease
    v. Major surgery
    vi. Others (specify)
8. **Reason for ordering CXR examination.**
    i. Routine for admission
    ii. Evaluation of clinically suspected lesion
    iii. Post procedure evaluation
    iv. Due to change of patient clinical state
    v. Routine follow-up
    vi. Others (specify)

9. **What was the initial CXR radiological diagnosis?**
    i. Pleural effusion
    ii. Pneumothorax
    iii. Lung collapse
    iv. Pulmonary edema
    v. Cardiomegaly
    vi. Lung parenchyma opacifications (specify)
    vii. Other findings

10. Positions of tip of catheters and tubes (tick, specifying location if incorrect).

i.	Endotracheal tube	correct.....	incorrect.....
ii.	CVP line	correct.....	incorrect.....
iii.	Dialysis catheter	correct.....	incorrect.....
iv.	Chest tube	correct.....	incorrect.....
v.	NG tube	correct.....	incorrect.....
vi.	Swan- Ganz catheter	correct.....	incorrect.....

11. Complications noted post-device placement:

i. Pneumothorax
ii. Atelectasis
iii. Pneumomediastinum
iv. Aspiration pneumonia
v. Esophageal perforation
vi. Others (specify)

12. If the devices in 10 above was malpositioned? How long did it take to intervene?

i. Immediately(less than one hour)
ii. One to six hours
iii. Six to twelve hours
iv. More than twelve hours
v. No intervention

13. Follow up CXR findings.

i. Worsening
ii. Improving
iii. Normally placed tube(s)
iv. Malpositioned tube(s)
v. Newer findings

14. Any other interventions in patients' management after CXR findings?

i. Yes
ii. No

15. If yes, what is the therapeutic response?

i. Change in medications
ii. Changes in respiratory response
iii. Changes in ventilation settings
iv. Placement of extra medical devices (specify)
v. Others

APPENDIX B:

ESTIMATED BUDGET

ALLOCATION	BREAKDOWN	AMOUNT IN KENYA SHILLINGS.
Stationary	4 reams printing papers @ 500/-	2,000
	Biro pens (1 box) @ 1,000/-	1,000
	10 Folders @ 200	2,000
Ethics board	Ethics Fee	2,000
Secretarial services	Typist fees	5,000
	Photocopy	3,000
Computer and printer	Laptop Computer	60,000
	Computer softwareôs	6,000
	Printer and cartridges	8,000
	SSPS software	2,000
	Flash disk	1,000
Internet hours	50 hours @ 60	3,000
Data collection and analysis	Statistician services	20,000
	Data collection assistant	10,000
Selected images	Scanning of images	5000
Printing and binding	Proposal	4,000
	Final report	12,000
Contingencies	Contingencies	10,000
Total		**159,000**

The above expenses will be met by the researcher.

APPENDIX C

PATIENT CONSENT FORM

My name is Dr. Paul Gichirah Nyagah, a master of medicine student in the department of Diagnostic imaging and Radiation Medicine at the University of Nairobi.

I am carrying out a study to determine the utility of routine chest radiographs in clinical decision making in patients admitted in the intensive care unit.

I would like to recruit your patient in this study. Information obtained will be treated with confidentiality. Only the hospital number will be used. Results of the study will be used to improve on clinical management of ICU patients.

The researcher will only review radiographs ordered by the attending clinicians and any procedure arising from such review will be for the benefit of the patient and not the researcher.

Please note that the participation is voluntary and you have a right to decline or withdraw from the study.

Guardian Signature _____

Date _____

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

Dr Paul Gichirah Nyagah

Signature _____

Date _____

APPENDIX D

KIBALI CHA MGONJWA

Jina langu ni Daktari Paul Gichirah Nyagah, mwanafunzi wa masomo ya upigaji picha za mwili katika chuo kikuu cha Nairobi. Nafanya uchunguzi kuhusu wagonjwa waliolazwa kwenye chumba cha wagonjwa mahututi. Naomba ruhusa kwako ili nitumie majibu ya mgojwa wako kwa uchunguzi ninaofanya.Majibu yatashugulikiwa kisiri. Nitatumia nambari ya hospitali tu ili kukutambulisha. Mwishowe maoni ya uchunguzi wangu yatasaidia kwenye utibabu.

Nitakagua zile picha zimeagizwa na daktari anayekutibu tu,na ikiwa kuna haja ya matibabu ya siada itakuwa kwa manufaa ya mgonjwa na sio ya mkaguzi.

Hauwajibiki kukubali hila hakuna uchunguzi mwingine utakaotekekelezwa juu ya mgonjwa wako isipokuwa ile imehidhinishwa na daktari wako.

Mchunguzi hafaidiki kwa fedha ama rasilimali zozote

Kama umekubali, tafadhali weka sahihi hapa chini.

Sahihi _____

Tarehe _____

Nadhibitisha kwamba nimemueleza msaidizi wa mgonjwa juu ya uchunguzi na amenipatia kibali.

Daktari Paul Gichirah Nyagah

Sahihi _____

Tarehe _____

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KENYATTA NATIONAL HOSPITAL
APPROVED
02 DEC 2013
ETHICS & RESEARCH COMMITTEE

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Ref: KNH-ERC/A/385 **Link:www.uonbi.ac.ke/activities/KNHUoN** 2nd December 2013

Dr. Paul Gichirah Nyagah
Dept.of Diagnostic Imaging and Radiation Medicine
School of Medicine
University f Nairobi

Dear Dr. Nyagah

RESEARCH PROPOSAL: UTILITY OF CHEST RADIOGRAPHS IN MANAGEMENT ON PATIENTS IN INTENSIVE CARE UNIT AT KENYATTA N.HOSPITAL (P371/07/2013)

This is to inform you that the KNH/UoN-Ethics & Research Committee (KNH/UoN-ERC) has reviewed and **approved** your above proposal. The approval periods are 2nd December 2013 to 1st December 2014.

This approval is subject to compliance with the following requirements:

a) Only approved documents (informed consents, study instruments, advertising materials etc) will be used.
b) All changes (amendments, deviations, violations etc) are submitted for review and approval by KNH/UoN ERC before implementation.
c) Death and life threatening problems and severe adverse events (SAEs) or unexpected adverse events whether related or unrelated to the study must be reported to the KNH/UoN ERC within 72 hours of notification.
d) Any changes, anticipated or otherwise that may increase the risks or affect safety or welfare of study participants and others or affect the integrity of the research must be reported to KNH/UoN ERC within 72 hours.
e) Submission of a request for renewal of approval at least 60 days prior to expiry of the approval period. (*Attach a comprehensive progress report to support the renewal*).
f) Clearance for export of biological specimens must be obtained from KNH/UoN-Ethics & Research Committee for each batch of shipment.
g) Submission of an *executive summary* report within 90 days upon completion of the study
This information will form part of the data base that will be consulted in future when processing related research studies so as to minimize chances of study duplication and/or plagiarism.

For more details consult the KNH/UoN ERC website **www.uonbi.ac.ke/activities/KNHUoN.**

"Protect to Discover"

Yours sincerely

PROF. M. L. CHINDIA
SECRETARY, KNH/UON-ERC

c.c. Prof. A.N.Guantai, Chairperson, KNH/UoN-ERC
The Deputy Director CS, KNH
The Principal, College of Health Sciences, UoN
The Dean, School of Medicine, UoN
The Chairman, Dept.of Diagnostic Imaging & Radiation Medicine, UoN
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