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

P. G. NYAGAH, C. K. ONYAMBU, N. M. KIMANI, M. WAMBUGU and A. A. AYWAK

ABSTRACT

Background: **The chest radiograph is the most commonly requested and performed radiographic examination in the Intensive Care Unit (ICU). It allows rapid detection of pathology that could be easily 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: **to determine the utility of routine chest radiographs in clinical decision making in the intensive care unit at Kenyatta National Hospital (KNH).**
Study Design: **A prospective cross-sectional study**
Setting: **KNH ICU ward.**
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 98were 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: **In conclusion the findings presented in this study show that routine chest radiographs play a vital role in clinical decision making in the intensive care unit. The specific contribution included evaluation of medical device placement and development of complications.**

INTRODUCTION

Physicians often order routine daily antero-posterior chest radiographs(CXR) for patients in intensive care unit(ICU) to assess cardiopulmonary illness and impact of medical interventions [1]

as well as 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. Routine CXR are also done to all patients every Monday morning before the doctors round.

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.

MATERIALS AND METHODS

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) the written radiological request form for the chest radiographic examination contained appropriate clinical history and the reason for the examination and these request forms were completed by the referring physician.

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 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.

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.

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 admission are presented in this chapter.

PATIENT CHARACTERISTICS

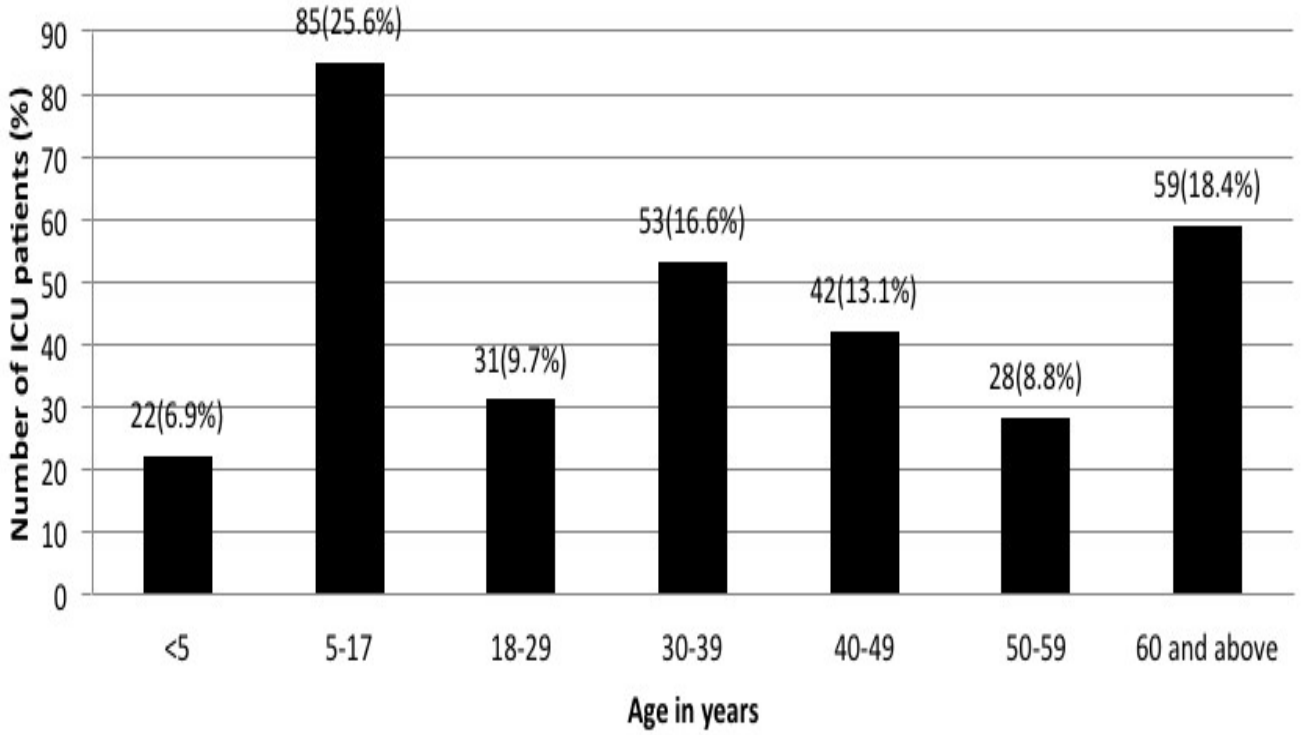
There were 396 films seen, 218 films (55.1%) from male patients while 178 films (44.9%) were for females (Male-to-female ratio 1: 1.2).

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 1

Age distribution (in years) of icu patients at knh undergoing chest radiography



Patient's positioning

Approximately three-quarters (72.2%) of all patients were examined in the supine position and the remaining patients were examined in semi-recumbent position.

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

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

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 2). 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 2

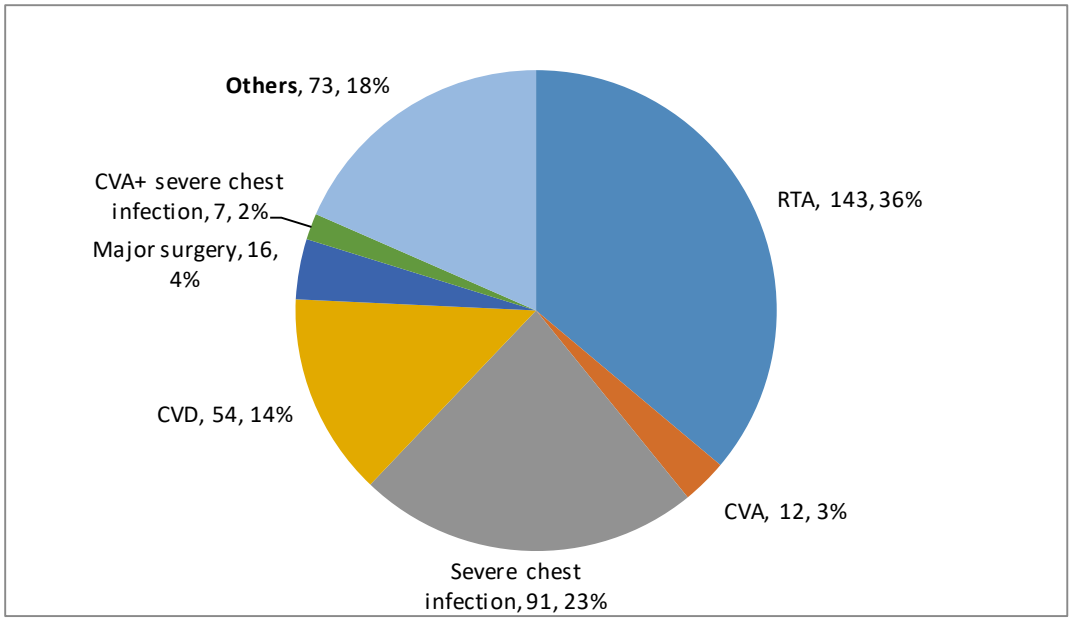
Diagnostic quality of films in ICU patients at KNH

	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 2: Shows the presenting complaints on admission to KNH ICU. The leading causes of admission were road traffic accidents 143 (36%), severe chest infection 91 (23%)and cardiovascular disease 54 (14%).

Figure 2

Presenting complaints on admission to KNH ICU.



The leading causes of admission were road traffic accidents 143 (36%), severe chest infection 91 (23%) and cardiovascular disease 54 (14%).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 3)

Table 3

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 4. 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 4

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 opacification	146	36.9
Other findings	110	27.8
Total	396	100.0

Of the 146 chest X rays showing lung contusions and 50 (34.3%) were atypical parenchyma opacifications, 52 (35.6%) were lung pneumonias (Table 5)

Table 5

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

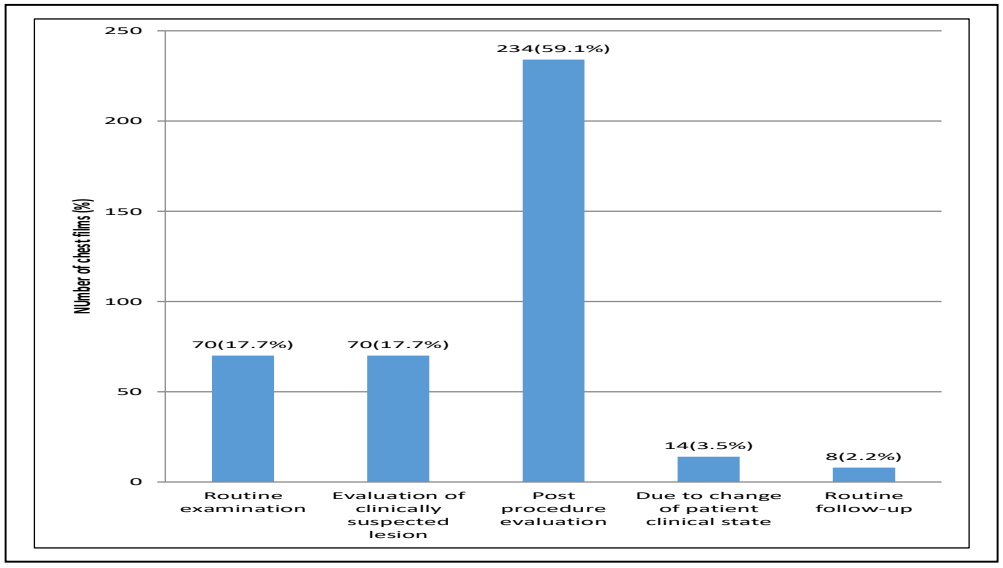
There were 110 (27.8%) films with other radiologic findings. Multiple rib fractures accounted for 14 (12.7%) cases among the other findings and COPD accounted for 7(6.4%) films. The remaining films were normal.

Figure 3

Reasons for chest radiograph requests in ICU patients at KNH

Reasons for requesting chest radiograph in ICU

Chest radiographs were commonly requested 234 (59.1%) as part of post intervention evaluation (Figure 3). Routine examination and evaluation of clinically suspected lesions each accounted for 17.7% of the chest radiograph requests

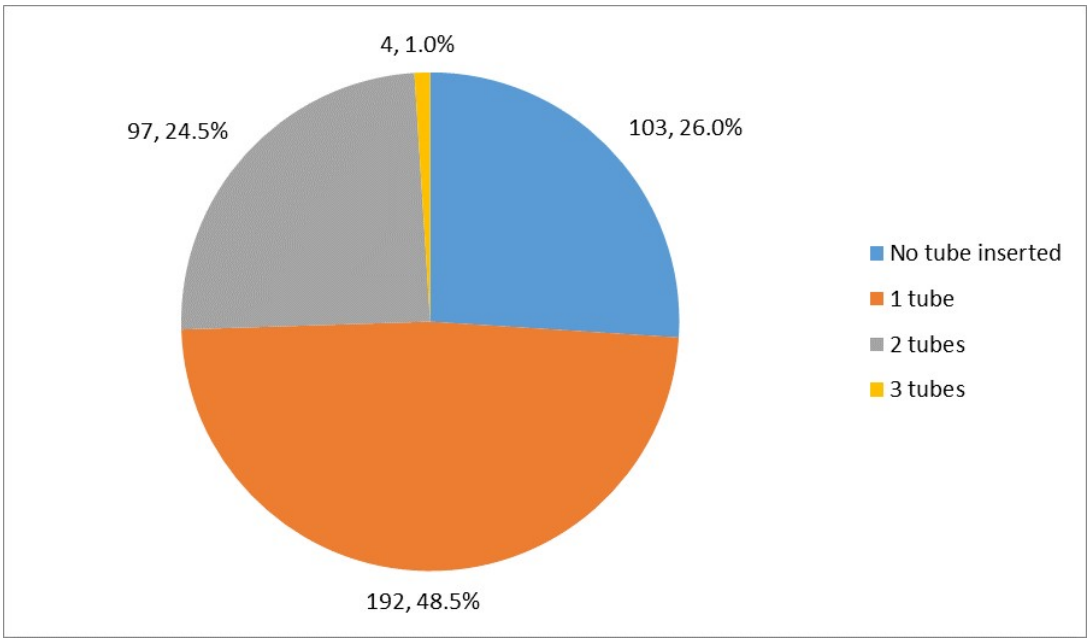


Catheter and tube placement

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 4).

Figure 4

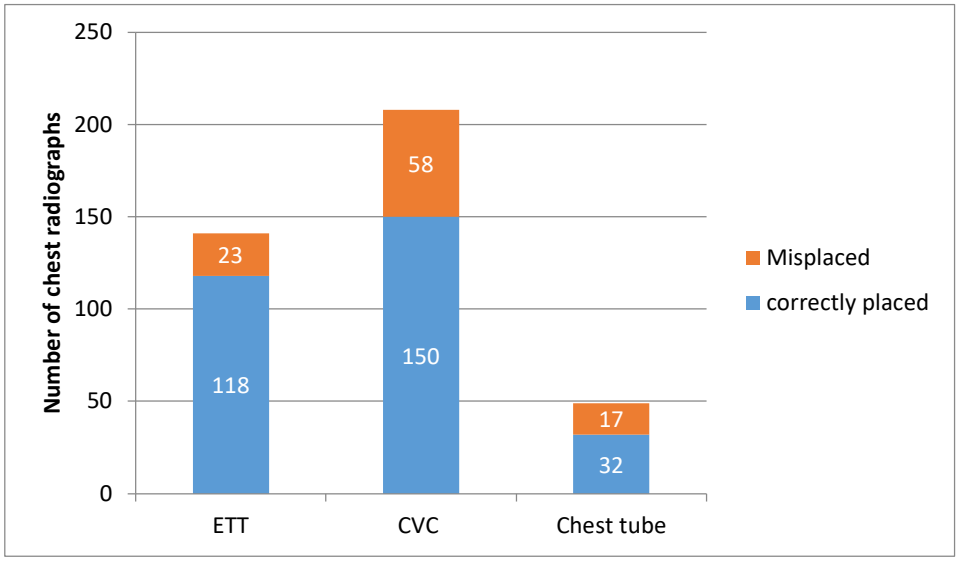
Catheter or tube insertion in ICU patients at KNH and visualization of devices on chest radiography



Three types of devices were inserted in ICU patients: 208 (52.5%) patients had CVC lines inserted, 141 (35.6%) had ETT and 49 (12.4%) chest tubes. Figure 5 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 ETT 23 (16.3%) and CVC 58 (27.9%) misplacements.

Figure 5

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 6 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 6

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 7). 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 7

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 8

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%) films visualized in ICU patients (Table 9). Most commonly the intervention involved either medication change 101 (37.3%) or placement/ repositioning of medical devices.

Table 9

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 X-ray visualization of misplacement. As presented in Table 10, 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 10

Device placement / repositioning following chest radiograph

	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 11 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 11

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**

ILLUSTRATIONS

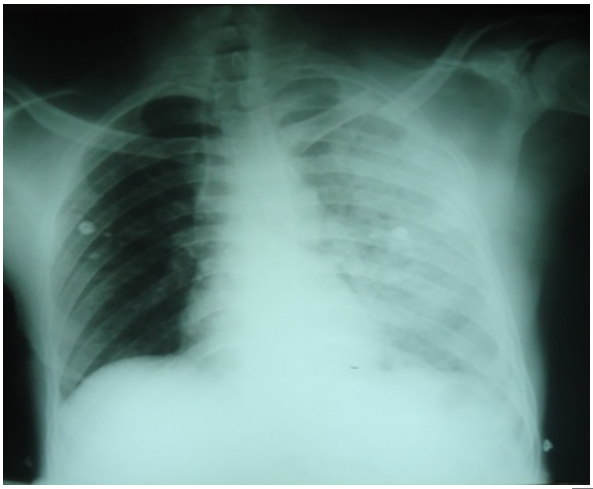


Figure 6 AP chest film showing fracture left mid clavicle and multiple left sided rib fractures in patient who was involved in road traffic accident. There is also left lung contusion.

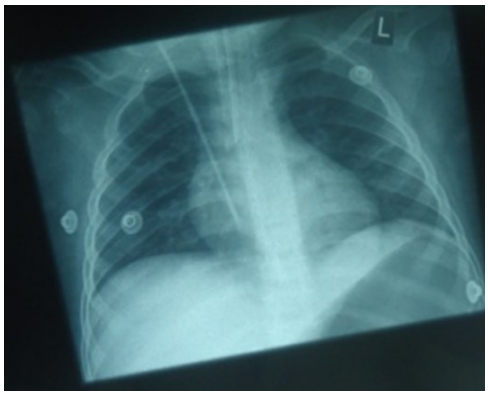


Figure 7: Shows an AP chest film showing the tip of endotracheal tube at the carina and central line catheter in right atrium.

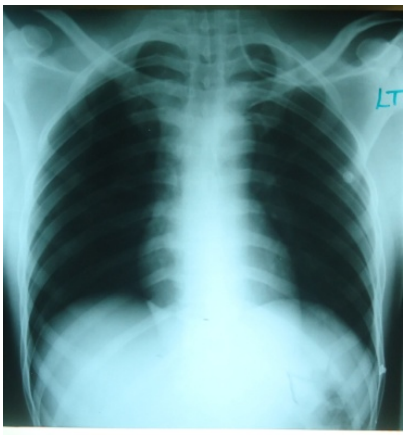


Figure 1: Supine chest film showing misplaced central line catheter. Catheter was introduced from left internal jugular vein but landed into left subclavian vein

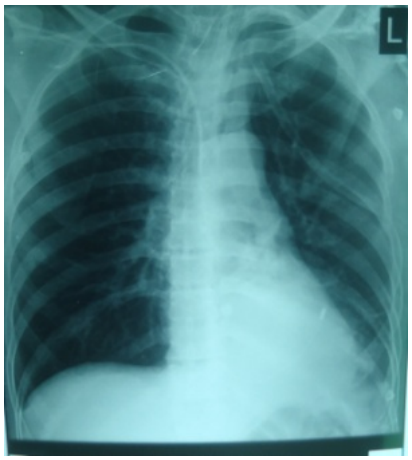


Figure 9: Shows AP film with correctly placed central line catheter that is within superior vena cava lumen and parallel to it. Also note correctly placed left chest tube for draining a pneumothorax

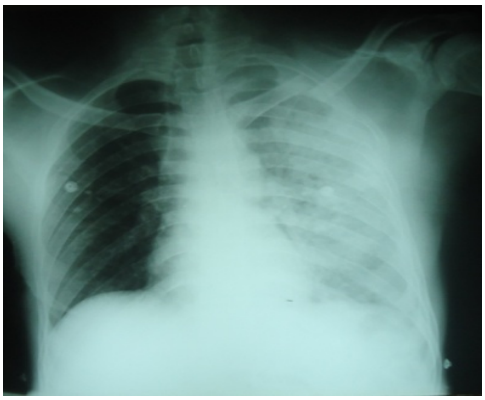


Figure 10; AP chest film showing fracture left mid clavicle and multiple left sided rib fractures in patient who was involved in road traffic accident. There is also left lung contusion.

DISCUSSION

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 studies 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 N, Stewart T, and Lapinsky SE 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 radiographer (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 radiographersThe 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].

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.

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.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.

RECOMMENDATIONS

First, regarding organization of care in KNH ICU it was noted that there was no radiologist within ICU department and commonly radiographs were interpreted by critical care clinicians. 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. To improve radiology care in the intensive unit the study recommends that the ICU should have a resident radiologist.

The unit should consider converting to digital radiography and acquire a digital machine to improve efficiency. Digitization of film processing will improve quality and output. This study has demonstrated that a significant proportion of catheters and devices inserted are associated with complications and misplacement. There remains a need for future larger studies designed to specifically evaluate the role of such techniques including imaging guided placement of medical devices in ICU patients in our settings.

CONCLUSION

In conclusion the findings presented in this study show that routine chest radiographs have a role in clinical decision making in the intensive care unit. The specific area of interest included evaluation of medical device placement and development of any complications

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