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Evaluation of Diagnostic Quality of Chest Radiographs Seen in a Nigerian Teaching Hospital

M. C. Okeji[1*], K. K. Agwuna[2], U. Abubakar[3], I. Y. Izge[3], A. U. Aninworie[1] and I. O. Arogundade[1]

[1]Department of Medical Radiography and Radiological Sciences, Faculty of Health Sciences and Technology, University of Nigeria, Enugu Campus, Enugu State, Nigeria.
[2]Department of Radiation Medicine, College of Medicine, University of Nigeria, Enugu Campus, Enugu State, Nigeria.
[3]Department of Radiography, Faculty of Clinical Science, College of Health Sciences, Usmanu Danfodiyo University, Sokoto, Sokoto State, Nigeria.

Authors' contributions

This work was carried out in collaboration between all authors. Author MCO designed the study, performed the statistical analysis, wrote the protocol and wrote the first draft of the manuscript. Authors KKA, UA and IYI managed the analyses of the study. Authors AUA and IOA managed the literature searches. All authors read and approved the final manuscript.

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ABSTRACT

Chest radiograph is an invaluable tool to the physicians and surgeons for the assessment of the airways, lungs, mediastinum, heart, pleura and chest walls. Radiographs of poor diagnostic quality could lead to poor diagnosis and ultimately to poor management outcome. This study was aimed at assessing the diagnostic quality of chest radiographs in order to evaluate standards and establish causes of repeat. The study evaluated the anatomical details, physical and technical factors. A total of 800 chest radiographs, produced between January 2014 and February 2016, were retrieved from the records of the Radiology Department of University of Nigeria Teaching Hospital

**Corresponding author: E-mail: markokeji@yahoo.com, mark.okeji@unn.edu.ng;*

Ituku-Ozalla, Enugu State and evaluated. Of the 300 chest radiographs evaluated for year 2014, 16% met all the criteria for good diagnostic quality according to the European guidelines. In 2015, out of 400 chest radiographs evaluated, 14% of the radiographs met all the criteria for good diagnostic quality according to the European guidelines. In 2016, 32% of the radiographs met all the criteria for good diagnostic quality. Inadequate collimation, "scapula not out of lung field", darkroom processing faults, inadequate penetration and rotation were the major contributors to radiographs of poor diagnostic quality. Knowledge of diagnostic quality of radiographs is desirable for maintenance of standards, improvement in quality and reduction of wastages in our radiology departments.

Keywords: Chest radiograph; diagnostic quality; collimation; Nigeria.

1. INTRODUCTION

Chest radiography is an important diagnostic method for evaluation of the airways, pulmonary parenchyma and vessels, Mediastinum, heart, pleura and chest wall [1]. Chest radiographs are invaluable for solving a variety of clinical problems and also serve as the first-line diagnostic technique for determining further steps in the establishment of diagnosis, treatment and follow-up procedures [2]. Chest x-ray examination was reported to be one of the most frequently conducted diagnostic procedures in clinical practice and may be implemented in screening programs for large populations [3]. Chest radiography accounts for approximately 25% of all x-ray examinations performed [4], and therefore contributes to radiation exposure. Epidemiological studies had reported that exposure to ionizing radiation increases the risks of some cancers at organ dose range of approximately 50–100 mSv [5,6].

Radiographic images of poor diagnostic quality result in repeats and hence more radiation dose to the patients and economic loss to the hospital. The relationship between quality of radiographs and the dose to the patients depends on the performance characteristics of the x-ray machine, patients' shape and size, type of image receptor, radiographic technique, viewing condition as well as radiographers' experience [7]. Periodic audit of radiographs is an important step in patients' dose reduction, improvement in image quality and reduction in economic losses occasioned by rejected films. There is paucity of documented study on diagnostic quality of radiographs produced at the University of Nigeria Teaching Hospital (UNTH), Ituku-Ozalla, Enugu State at the time of this study. The study therefore aimed at evaluating the diagnostic quality of chest radiographs produced at UNTH, Ituku-Ozalla, Enugu State, Nigeria and to establish possible causes of rejects.

2. MATERIALS AND METHODS

The study adopted the retrospective cross-sectional survey. A total of 800 chest radiographs, produced between January 2014 and February 2016, were retrieved from the records of the Radiology Department, UNTH Ituku-Ozalla, Enugu State and evaluated. All the chest radiographs were assessed for physical details, proper identifications, adequacy of collimation, display of entire anatomical details, full inspiration, presence of rotation, adequacy of penetration and throwing off the scapula. Also patient's number, date of examination, patient's age and patient's sex were recorded. Researcher-developed pro forma was the instrument for data collection. All adult and paediatrics chest radiographs in either postero-anterior or antero-posterior views were included in the study. All radiographs showing spinal deformity and history of diseases that will not allow them to adapt to the required conditions were excluded. All the radiographs were evaluated by an experienced radiographer and a radiologist. The European guidelines for image quality in chest radiographs [8] recommended that a good chest radiograph should show the lung apices, the costo-phrenic angles up to the 6^{th} anterior ribs above diaphragm and 9^{th} posterior ribs. The vertebra and medial ends of clavicles should be equidistant, showing no rotation. The lower intervertebral disc below 9^{th} thoracic spine should be defined, as indication of adequate penetration. The medial border of scapula should be out of lungs field. The patient's details and anatomical marker should be displayed on the film. No blurring should be seen in the film. Evidence of collimation should be visualised by the presence of silver lining at the four sides of the film, as indication of radiation protection. No fogs or artefacts should be seen on the films, indicating safe handling of the films. Evidence of good darkroom practices

should be observed by the films not turning yellow, or being under or over developed.

Data obtained were subjected to descriptive statistics and analyzed using analysis of variance.

3. RESULTS

A total of 800 radiographs were evaluated, 300 radiographs in 2014, 400 radiographs in 2015 and 100 radiographs in 2016.

Of the 300 chest radiographs evaluated for year 2014 (Table 1), 96% showed all the patient's details and had full inspiration. Anatomical marker was shown in 98% of the radiographs while 95% had good coverage of the anatomy. Artefacts were noticed in 10% of the radiographs while 64% had the scapula thrown out of the lungs field. Inadequate penetration was noted in 41% while 1% of the radiographs had fogged parts. Rotation was observed in 26% while 7% were blurred. Adequate collimation was seen in 16% while 21% had darkroom faults such as poor development, fixing or washing. In total only 16% met all the criteria for good diagnostic quality according to the European guidelines [8].

In 2015, out of 400 chest radiographs evaluated 95% showed the patient's details and 99% displayed anatomical marker (Table 2). There was deep inspiration and good coverage of anatomical areas in 97% of the films. A total of 61% of the radiographs had the scapula well thrown off the lungs field and 77% had adequate penetration. Artefacts were noticed in 8% of the radiographs, 3% had fogged parts and 1% showed blurring. Body rotation was observed in 28%, 14% had adequate collimation while 20% had darkroom processing faults such as poor development, poor fixing or inadequate washing. A total of 14% of the radiographs met all the criteria for good diagnostic quality according to the European guidelines [8].

Table 1. Diagnostic quality of chest radiographs produced in 2014

S/N	Criteria	Yes (%)	No (%)	Total (%)
1	Patient details	288(96%)	12(4%)	300(100%)
2	Anatomical marker	293(98%)	7(2%)	"
3	Anatomical coverage	285(95%)	15(5%)	"
4	Full Inspiration	287(96%)	13(4%)	"
5	Presence of artifact	30(10%)	270(90%)	"
6	Scapula out of lungs field	193(64%)	107(36%)	"
7	Adequate penetration	201(67%)	99(33%)	"
8	Fog	3(1%)	298(99%)	"
9	Rotation	78(26%)	222(74%)	"
10	Blurring	21(7%)	279(93%)	"
11	Adequate collimation	48(16%)	252(84%)	"
12	Darkroom processing faults	63(21%)	237(79%)	"

Table 2. Diagnostic quality of chest radiographs produced in 2015

S/N	Criteria	Yes	No	Total
1	Patient detail	380(95%)	20(5%)	400(100%)
2	Anatomical marker	395(99%)	5(1%)	"
3	Anatomical coverage	387(97%)	13(3%)	"
4	Full Inspiration	389(97%)	11(3%)	"
5	Presence of artefact	31(8%)	369(92%)	"
6	Scapula out of lungs field	244(61%)	156(39%)	"
7	Adequate penetration	306(77%)	94(23%)	"
8	Fog	12(3%)	388(97%)	"
9	Rotation	112(28%)	188(72%)	"
10	Blurring	3(1%)	397(99%)	"
11	Adequate collimation	56(14%)	344(86%)	"
12	Darkroom processing fault	80(20%)	320(80%)	"

In 2016, 98% of the radiographs showed all the patients 'details and 96% displayed the anatomical marker (Table 3). There was good coverage of anatomical areas in 95% of the films and 99% showed deep inspiration. A total of 9% of the radiographs had artefacts and 1% had fogged part. The scapulae were well thrown off the lung field in 63%, 69% had adequate penetration and 23% of the radiographs were rotated. All (100%) were done without any form of blurring, 32% showed evidence of adequate collimation and 29% had darkroom faults such as poor development, poor fixing or inadequate washing. In 2016, 32% of the radiographs met all the criteria for good diagnostic quality.

The greatest contributor to the poor quality of the radiographs was inadequate collimation which accounted for 83% of the faults (Table 4).

In all a total of 17% of the 800 chest radiographs studied met all the criteria according to the European guidelines [8]. Of the 17% that met all the criteria, 5% were done in antero-posterior view while 95% were in postero-anterior views. Paediatrics chest radiographs accounted for 8% while 85% were adults of up to middle age and 7% were geriatrics. Also 53% were males and 47% were females. Digitally processed radiographs accounted for 57% while 43% were manually processed radiographs.

4. DISCUSSION

Poor collimation (82%) was the major fault observed from our study. Our value of 82% was higher than 52% and 47.7% reported in earlier studies in Nigeria [9] and Nepal [10] respectively. The purpose of collimation is to protect the patient from unnecessary radiation by limiting the beam field to the anatomy of interest thereby reducing the volume of tissue irradiated [11]. The major contributors to the inappropriate collimation were the manual processing and paediatric chest radiographs. However physical observation during the period of our study showed that radiographers pay less attention to radiation protection while using phosphor cassettes (computed radiography) and while conducting paediatric chest examination. Due to the post processing application in computed radiography it was easy to mask the poor radiation protection application. Some of the reasons adduced by radiographers for poor radiation protection during paediatrics radiography were absence of dedicated paediatric chest stand and the children being 'uncooperative' during the examination. Radiation protection should be a primary consideration in the adherence to radiographs of good diagnostic quality as recommended in the European guidelines. Poor collimation increases the radiation dose to the patients evoking possibility of stochastic effects of radiation. Some studies had reported that cancer risk and other genetic (hereditary) defects increase linearly with increasing radiation dose, with no threshold [12,13].

The poor application of collimation during chest radiography meant that other body parts outside the chest region, such as the radiosensitive thyroid gland, may have been irradiated in most of the patients. There is need for stricter supervision and audit in chest imaging to obviate future occurrences and radiographers must be sanctioned in cases of improper collimation. Beam alignment and collimation test should be conducted periodically to ensure that there is congruency of the light to the radiation field and hence radiation will not fall outside the area of interest after collimation by the radiographer (optimization) [14].

Table 3. Diagnostic quality of chest radiographs studied in 2016

S/N	Criteria	Yes	No	Total
1	Patient detail	98(98%)	2(2%)	100(100%)
2	Anatomical marker	96(96%)	4(4%)	"
3	Anatomical coverage	96(96%)	4(4%)	"
4	Full Inspiration	99(99%)	1(1%)	"
5	Presence of artefact	9(9%)	91(91%)	"
6	Scapula out of lungs field	63(63%)	37(37%)	"
7	Adequate penetration	79(79%)	21(21%)	"
8	Fog	1(1%)	99(99%)	"
9	Rotation	23(23%)	77(77%)	"
10	Blurring	0(0%)	100(100%)	"
11	Adequate collimation	32(32%)	68(68%)	"
12	Darkroom processing fault	29(29%)	71(71%)	"

Table 4. Major causes of poor quality radiographs within the three years

Causes of poor quality	2014	2015	2016	Total (%)
Inadequate collimation	252	344	68	664(83%)
Scapula not out of lung field	107	156	37	300(37.5%)
Darkroom processing faults	63	180	29	272(34%)
Inadequate penetration	99	94	31	224(28%)
Rotation	78	112	23	213(26.6%)

The 'scapula not out of the lung field' (37.5%) and presence of 'rotation' (26.6%) in the radiographs studied were mostly from geriatric and paediatric patients. The radiographers reported difficulties in rotating the shoulders during paediatrics chest examinations and in the sick elderly patients.

The darkroom processing faults and inadequate penetration were observed more when manual processing was in use.

There was significant difference ($p < 0.05$) in the diagnostic quality of radiographs produced in 2016 when compared to that of 2014 and 2015. There was however no significant difference ($p > 0.05$) between the diagnostic quality of radiographs produced in 2014 when compared to 2015. The improved diagnostic quality of radiographs may have been occasioned by supervisory functions introduced in the department.

The limitations of the study; The prolonged down time of the computed radiography (CR) reader in 2015 did not allow comparison of the diagnostic quality of radiographs in the three years under study.

5. CONCLUSION

Our study showed that the production of chest radiographs of good diagnostic quality and correct application of radiation protection largely depends on the skills, experience and disposition of the radiographer. It is also dependent on the availability and correct application of the equipment. Often due to economic considerations chest radiographs of poor diagnostic quality were accepted in the department. There should be conscious efforts by radiographers to adhere to international standards as outlined in the European guidelines. This will avail the physicians of chest radiographs of good diagnostic quality, save cost to the department and prevent unnecessary radiation to the patients.

CONSENT

It is not applicable.

ETHICAL APPROVAL

It is not applicable.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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