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Investigation of the image quality of plain abdominal radiographs in three Nigerian hospitals

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ABSTRACT

Purpose: A retrospective study of image quality of abdominal radiographs to establish a baseline for the development of quality control programmes in Nigerian hospitals.

Materials and Method: Subjective evaluation of 210 plain abdominal radiographs produced between 2002 and 2004, and drawn from the film libraries of the hospitals, a teaching hospital (TH), a specialist hospital (SH) and a private clinic (PC) was carried out by four radiographers and three radiologists, using basic radiographic criteria such as collimation, optical film density, positioning, use of and correct placement of gonad shields, as well as criteria for image quality defined by the Commission for European Communities. Films were assessed as adequate, not adequate and poor for the radiographic/technical parameters, and scored 1 to 4 in an ascending order of performance for image quality. They were then ranked in order of overall quality. Pooled results were studied by method of analysis of means.

Results: Results generally showed good radiographic image performance for pooled data. Respective hospital performance was best for TH for most of the data assessed. Based on individual parameters, the study found 6.61% of the total number of films 'rejectable'. Of the 210 radiographs studied, 107 satisfied all the criteria for good quality images.

Conclusion: Findings underscore the need for implementing quality control programmes using the results of this study as a baseline.

Keywords: Plain abdominal radiographs, image quality, quality control, films, Calabar

INTRODUCTION

Maximising the benefits of the radiological process is the objective of efforts at optimisation of technique, reduction of patient doses, equipment design and research. This has also led to the publication of guidelines for good radiography practice by the Commission for European Communities (CEC) [1] and the International Atomic Energy Agency (IAEA) [2], which list conditions for acceptance of radiographs and recommend appropriate techniques for obtaining them.

Plain abdominal radiographs commonly form a part of medical assessments. Although the examination is not ordered or performed routinely, it forms a significant fraction of radiographic examinations requested in many

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X-ray diagnostic centers, particularly in accident and emergency (A/E) departments. Plain abdominal radiographs have been used in assessing levels of patient preparation for contrast-based examinations involving the gastro-intestinal tract (GIT) as well as the urogenital system. Kidney stones and other forms of calcification are readily demonstrated in plain films of the abdomen. Some pathology is sometimes demonstrated depending on age [3].

Image quality is usually defined for specific tasks [4] and could be studied physically or subjectively [4, 5, 6]. The aim of quality control (QC) is to define levels of acceptability of radiographs in order to satisfy set clinical targets [2]. This underscores its importance in defining safe radiation dose levels for radiologic procedures.

Radiographic practice in most developing countries has received a boost in recent years with conscious attention to the development of quality assurance and control programmes. The practice had been lacking in standardised procedures of technique, image quality and dosimetry. To date, the level of implementation of the UNSCEAR's [7] directive for optimisation of procedures in many developing countries, particularly in sub-Saharan Africa, is still at the gestational stage. The situation is not different in Nigeria. Most diagnostic X-ray centers still operate the manual film processing method, even though many of these record very high levels of patient through-put.

Following recent establishment of the Nigerian Nuclear Regulatory Authority (NNRA) to oversee and regulate the use of ionising radiation in the country, efforts at running quality assessment and control programmes are being intensified across the country. This has created the need to define a basis for comparison of results of quality assessment studies. This work aims at providing information on the radiographic/technical and image quality of abdominal radiographs obtained in Nigeria. It will serve as a baseline, as there is no study reported to date, on image quality of abdominal radiographs or indeed, any other type of radiographic images. The best effort has been the reports of Ogundare *et al* [8, 9]. Both reports focus on radiographic technique and radiation dose to patients, with comparison of doses to Commission for European Communities (CEC) criteria. This position applies to countries in the same health care level as Nigeria. It is, therefore, the aim of this study to provide first time information on the area of study specifically, and add to the reservoir of information available globally with respect to studies on image quality. It is hoped that this will serve as a reference base for future work.

MATERIALS AND METHODS

A subjective evaluation of 210 plain abdominal radiographs of adult patients, drawn from the film libraries of three hospitals, a teaching hospital (TH), a specialist hospital (SH) and a private clinic (PC), located within Calabar Municipality in Southeastern Nigeria, was carried out. The selected hospitals, though within the same geographical area, present a fair representation of the spectrum of health care institutions (Federal, State Government and privately owned) across the country. The radiographs (150 for TH, 38 for SH and 22 for PC) were taken between 2002 and 2004 in the respective hospitals. The difference in the number of films from each institution reflects the level of patronage received. In addition, SH was out of operation for nearly a year (see footnote). All the centres operated single units for general purpose radiography over the period* of operation being studied. There was no record of any QA programmes in operation at any of the institutions including any information on the reject film analysis. All films used in the study were taken with the patient in the supine position. Exposure factors could not be ascertained as there were no records available. Current trend in exposures is the subject of another study.

Study Plan for radiographic technical criteria

The study was divided into two parts with the first involving the study of some radiographic parameters defined as follows:

1. Collimation of the X-ray beam to the area of interest (this assesses radiation protection)
2. Optical density of the film. This was studied with a Sakura PDA – 81 portable densitometer (Konica Corporation, Japan) with a measuring accuracy of ± 0.02 and reproducibility of 0.002. Measurement of density was done on four arbitrarily selected portions, averaged for each radiograph. Optical densities between 0.5 and 2.0 were taken as adequate [5]. The same film viewing boxes, which had been previously tested for uniform light output, as well as controlled conditions of glare and ambient light levels, were used for assessment of all films [10].
3. Patient Identification: Correct positioning and printing of identification was assessed.
4. Position of the anatomical marker, correct positioning without interference with diagnostic information.
5. Use of gonad shield: The use of and correct positioning of the gonad shields were assessed. This also gave indication of attitude to radiation protection of the patient.
6. Assessment of patient positioning for the abdominal radiograph. Patient rotation was used to check for this.

Radiographs were scored 'adequate' or 3 if they satisfied all the six criteria listed, as well as being free of the characteristics listed under poor or none. A score of 'not adequate' or 2 was given to films with three or more, but less than the six listed criteria, while 'Poor/None' or a score of 1, was given for films with less than three listed criteria, as well as evidence of any, or all of artifacts, wrong use of grids, motion blur, poor film screen contact, fog, and geometric faults. These affect the overall image quality and therefore the decision

making process. It was the opinion of the assessors that films in this later category would normally have been rejected if there was a QA programme in place. The films were studied by four experienced radiographers working independently.

Criteria for image quality

For the assessment of image quality, criteria from the guidelines recommended by the European Commission (EC) [1] were adopted for the study. These were:

1. Production of the area of the whole urinary tract from the upper pole of the kidney to the base of the bladder. This was coded 'A'.
2. Reproduction of the kidney outlines, coded 'B'.
3. Visualisation of the Psoas muscle outlines, coded 'C', and
4. Visually sharp reproduction of bones, coded 'D'.

Three consultant radiologists scored the films from 1 to 4, with each criterion scoring 0 or 1. Thus, a film with all four criteria scored 4, and those with three, two and one criteria present scored 3, 2 and 1, respectively. Each assessor worked independent of the others and had no access to the views of the other assessors. The data from the assessors were pooled and treated with the method of analysis of means, to reduce the effects of subjectivity in the results. The coefficient of variation was determined for both sets of readers to quantify inter-reader differences.

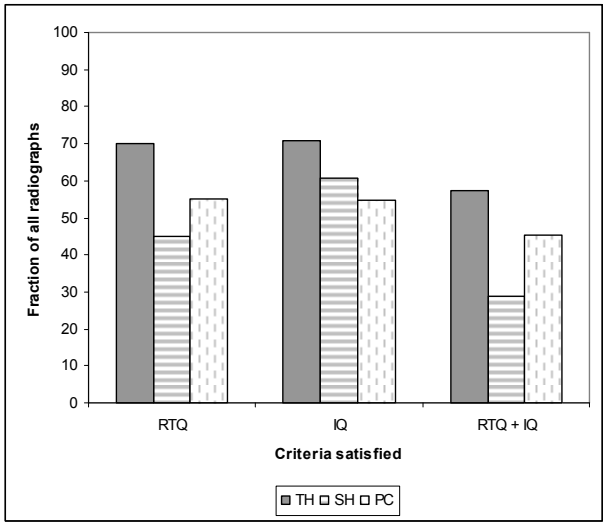

Figure 1 Summary of fraction of total number of abdominal radiographs satisffying quality criteria in respective hospitals. TH (Teaching hospital), SH (specialist hospital) and PC (Private clinic).

RTQ = Radiographic technical quality, IQ = Image quality, and RTQ + IQ inclusive of both RTQ and IQ.

RESULTS

Inter-reader differences determined by the coefficient of variation (COV), was marginal (<1%, averaged for all the readers). COV ranged from 0.5-0.9% (mean 0.7%) for assessors of RTQ, while COV for the IQ assessors was 0.6-1.1% (mean 0.9%). Means of the pooled data were analysed and the percentages determined for the different criteria studied. These are presented under the respective headings.

Radiographic technical quality (RTQ)

Information on equipment and other operating criteria in the centres at the time of production of the radiographs is shown in Table 1. Radiographs were ranked according to the criteria satisfied. There was remarkable variation in the distribution of the parameters studied among the centres. Pooled data from the assessment of the performance of radiographs for radiographic technical quality are shown in Table 2. The range of densities measured was 0.14 to 2.62, with an error of ±2%. This was within acceptable recommendations by the International Standards Organization (ISO) [11]. The TH films were most consistent in optical density with 76% of them being adequate and only 24% not being adequate, or having densities above or below accepted range. Similar results were obtained for the patient identification (81.3% adequate and 6.7% not adequate). However, 12% of the films were identified after processing by either 'scratching' the identification unto the wet film or using a marker pen to write on the dry film. The anatomical marker was positioned correctly in 86% of TH films. However, 10% of them were not adequately marked while 4% either had no anatomical marker at all or had something other than the "L" and "R" marker used for marking. Figure 1 (RTQ) presents the picture of films that would be acceptable purely on radiographic parameters.

Radiographic positioning of the patient was adequately done in 69.3% of TH films, while 22% were not adequate and 8.7% were poorly positioned. For radiation protection, a very weak effort in the use of gonad shields was noticed in TH (14.7%), while none of the other hospitals recorded any abdominal radiographs with gonad shield protection (Table 2). Collimation fared better but was still sufficiently low as to negatively affect overall performance of radiographic RTQ. Radiation protection parameters were therefore omitted in computing the total RTQ.

Image quality (IQ)

The assessment of image quality with EC [1] recommended criteria showed that TH had over 80% of radiographs with a score of 3 and above, while 62% of SH radiographs and 74.1% of PC radiographs obtained similar scores, respectively.

The performance of abdominal radiographs with respect to image quality assessment using the CEC defined criteria is presented in Figure 1 (IQ). Again TH films performed well above those from the other centres. The number of radiographs satisfying both radiographic technical and image quality criteria are shown in Figure 1 (RTQ + IQ). Films in this category were considered to be of the appropriate image quality. The percentage of each hospital's radiographs in this category is higher for TH, PC and SH in that order.

DISCUSSION

The quality of a radiograph is primed on its utility for the intended diagnostic purpose [4, 12]. The benefits of carrying out quality control studies in radiodiagnostic departments are well documented [2]. This practice is however in very short supply among hospitals in the study area. There is as yet no documentation of any attempt at carrying out this exercise.

Abdominal radiographs studied rate high on individual study criteria for both technical and image quality parameters. However, since no radiograph is accepted on the basis of individual parameters, the assessment of optimum image quality is based on the sum of all the factors under consideration. In this study, this yields an average score of 50.9% (107 of the 210 films studied). At least 14 radiographs or 6.61% of the total would most probably have been rejected or repeated, were there a functioning quality control programme in the hospitals studied. These were those that failed both the RTQ and IQ tests.

The performance of the images from each hospital (Figure 1) seems to be a follow up from the caliber and training of the personnel operating therein. TH has graduate radiographers, SH several technical (X-ray) assistants and one graduate radiographer, while PC employs a part time graduate radiographer with a full time technician to cover other hours. The results are a strong indication of the need for proper pre-employment training and the development of continuous education programmes for employees in diagnostic centres. Current efforts by the Radiographers Registration Board of Nigeria (RRBN) are set to address the need for continuous professional development programmes.

This study did not intend to assess the correctness of diagnosis or to review technical competence, but to review the performance of the abdominal radiograph within the study area, and confirm areas where the current efforts at standardisation of technique and quality control could be improved. It is clear from these results that the lack of QA programmes in the area has negatively impacted on the quality of radiographs passed. Films are passed for reasons other than quality. This is in tandem with the report of Bassey *et al* [13] who have attributed this development to economic and practical reasons. This would explain why "rejectable" films are found in good numbers in the film library. This situation may also be the case in Ghana, where a report has attributed the poor quality of radiographic images to poor techniques and lack of prescribed national standards [14].

The dearth of information on image quality of abdominal, and indeed other types of radiographs, in developing countries makes comparison difficult and underscores the importance of this study as a baseline for further investigations, especially of current practices that would lead to standardisation of technique and procedure, and develop a reservoir of data for planning and implementation of international regulations guiding image quality and patients' radiation doses.

CONCLUSION

While it is clear that image quality is ultimately 'task specific', standardisation of major criteria in diagnostic radiology is essential good practice. It has been shown that abdominal radiographs from three hospitals in Calabar, Nigeria, reveal generally good individual criteria image performance, but possess an average or marginal overall quality. A lot of improvement is needed in the area of study and this will largely be achieved by the implementation of QA programmes that have been legislated [15]. The results of this study provide a good starting point.

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Table 1 Summary of departmental operating criteria for centres at time of production of radiographs.

	Centre details		
Parameter	**TH**	**SH**	**PC**
Generator type	GEC MX4 Mobile * GEC R501 ceiling	Siemens Polymobile 3	GEC MX4mobile
Age	> 20 years	~11years	> 10 years
Filtration	2.6mm Al eq * 3.0 mm Al eq	n.a.	2.6mm Al eq
Focal spot	1.0/0.5 mm	n.a.	1.0/0.5 mm
Film type	AGFA, KONICA	AGFA, KONICA	AGFA, KONICA
Screens/speed	Rare earth/ 200	Rare earth/ 200	Rare earth/ 200
Grid	10:1 / 12:1	12:1	12:1
Processing method	Manual	Manual	Manual
QA programme	None	None	None
Staff:			
Radiologists	3	-	1
Radiographers	3	1	1 (P/T)
Technicians	-	6	1

* Unit used until October 2002. No longer in use
n.a.: not available. Unit had been removed prior to study. Details of the unit information were not available to the authors. A new unit was being installed during the study.
The information presented above is based on reports by radiographers employed in the respective departments within the period of production of films used in the study.

Table 2 Pooled results of technical assessment of abdominal radiographs for respective hospitals indicating fraction of total films found in each category.

	Average assessment results per hospital (%)								
	Teaching Hospital			**Specialist Hospital**			**Private Hospital**		
Parameter	**Ad**	**Nad**	**P/N**	**Ad**	**Nad**	**P/N**	**Ad**	**Nad**	**P/N**
Collimation	42.7	29.3	28	55.3	26.3	18.4	45.5	45.5	9.0
Film density	76	24	-	44.7	47.4	7.9	72.7	18.2	9.1
Pt. ID	81.3	6.7	12	73.7	15.8	10.5	68.2	18.2	13.6
Anat. Marker	86	10	4	52.6	26.3	21.1	54.5	27.3	18.2
Gonad shield	14.7	4	81.3	-	-	100	-	-	100
Pt. positioning	69.3	22	8.7	50	26.3	23.7	59.1	18.2	22.7

Ad = adequate; Nad = Not adequate; P/N = Poor/None
Pt. ID = patient identification
Anatomic Marker = Anatomical marker