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A study of pelvic radiography image quality in a Nigerian teaching hospital based on the Commission of European Communities (CEC) criteria

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Abstract

Purpose To assess subjectively the image quality (IQ) of pelvic radiographic examinations in a Nigerian university teaching hospital, using the Commission of European Communities (CEC) image criteria in order to establish base data for image optimization in pelvic radiography.

Materials and method A retrospective study was undertaken of 194 AP pelvis radiographs (period 2000 to 2008) that were housed in the radiographic film library of the University of Calabar teaching hospital. Eighty-six male and 108 female pelvis radiographs were subjectively evaluated by two experienced radiologists and two radiographers. They independently evaluated the radiographic technical parameters of optical density, beam collimation, patient position, correct use of gonad shields and use of anatomical markers. Ranked scoring from 1-4 was used for the study: 1 indicated low image quality (IQ) and 4 indicated high IQ. Radiographic technical parameters were assessed as good (G), fair (F) and poor/none. Coefficient of variability was used to check intra-reader consistency while agreement between the raters was determined by Cohen Kappa statistic.

Result Good image performance was 68% of the radiographs as all the criteria for good quality images were met. Evidence from the assessment of radiographic technical parameters showed that 43% of the sampled radiographs were flawed with respect to optical density measurements. All radiographs studied did not show evidence of the use of gonad shields and only 1% of all radiographs had adequate beam collimation.

Conclusion The results are indicative of the need for optimization of radiographic procedures, particularly radiographic technique, to address observed areas of deficiency. Implementation of a quality control process would facilitate this.

Keywords

Image criteria, optimization, quality control.

Introduction

The usefulness of a diagnostic radiograph depends on the quality of the produced image[1]. Image quality (IQ) refers to the accuracy with which the examined anatomic structures are reproduced on the image receptor. Regular quality assurance (QA) testing has been recommended for sustaining good practice in diagnostic imaging[2-4]. Quality control (QC) is important because it reduces practices that could adversely affect expected patient outcomes and therefore justify the process of patient irradiation[5].

To ensure adherence to desired standards of quality, image quality criteria recommended by the Commission of European Communities (CEC)[4] have been used for the assessment of images globally[6-8], and good radiography practice[9]. Although these criteria have been in use for more than a decade there are still locations where they have not been implemented. The adoption of, and compliance of diagnostic radiography practice to these image criteria, has been a major step towards ensuring satisfactory overall performance and standardization of procedures in radiographic examination of patients. Results from such studies using these criteria have been useful for the optimization of the imaging process in many clinical settings[5-8].

There are current efforts in diagnostic radiology to develop quality control programmes throughout Nigeria. However, such efforts are still at an embryonic stage largely because of the dearth of qualified personnel and available equipment. There are, therefore, a wide range of variations in adopted protocols and techniques even within the same hospital[10]. Studies elsewhere have shown that variation in issues, such as personnel training, equipment type, and age of equipment and technical factors, explain why image quality varies from one location to the other[6-7]. These differences and the lack of global standards have made it practically useful to compare studies from different locations.

Pelvic radiography, the subject of this study, is indicated in trauma cases and is a very common examination. The anteroposterior (AP) radiographic projection of the pelvis involves direct exposure to the reproductive organs. Optimization of the technique in pelvic radiography is therefore necessary in terms of ALARA (as low as reasonably achievable).

Apart from routine radiographic checks prior to using the film for diagnostic assessment, there is currently no QA programme in place at the facility. Since no previous study has been done means that there is a need for baseline data that could be used in prospective studies. This study is therefore a first step towards establishing a database for future pelvic image quality assessment studies in the hospital. It will contribute towards developing a data pool for pelvic radiography image quality in Nigeria. It is the first part of the pelvic radiography optimization process in the hospital. It is intended that subsequent studies will focus on the dose-image quality relationship using the current study as a baseline for the image

quality component (no dose data was available to establish baseline values for dose). It is hoped that the CEC criteria will be applied to improve radiographic practice even in the face of technical challenges encountered in the developing world.

Materials and methods

A total of 194 adult antero-posterior (AP) pelvic radiographs of both male (n=86) and female (n=108) patients were retrieved from the x-ray film archive of the University Teaching Hospital. The radiographs were from examinations conducted between the years 2000-2008. Inclusion criteria were non-trauma films with no demonstrated pathologies, or storage defects like discoloration/stains and scratches that obscured landmarks used for image quality assessment.

The radiographs were first assessed for radiographic technical quality following Egbe et al[11], by two experienced radiographers. Technical parameters studied with their identification codes are shown in Table 1. Radiographs were graded as: good (met all assessed parameters); fair (met 3-5 parameters); and poor/none (0-2 parameters fulfilled). Optical density (OD) measurements within the useful 0.5-2.5 range were accepted as optimal quality diagnostic images[12]. OD measurements were made with a Sakura PDA-81 digital densitometer (Konica Corporation, Japan), which had variation less than 5% and reproducibility of ±0.02. The average density was obtained four random positions on each radiograph.

Image quality assessment was as follows. Using the image quality criteria in Table 2, two radiologists reviewed the radiographs in terms of compliance with the CEC recommendations, using a reference image (I_{ref}) as guide to indicate that the assessors considered seven criteria. The assessors had an average of 10 years working experience. They rated the radiographs independently using the same optimized viewing conditions[4,13]. Quality assessment charts, with a scoring pattern of 1 (bad), 2 (fair), 3 (good) and 4 (very good) were used in the study. The retrieved archived radiographs were rated according the CEC image quality criteria using Iref since they had been used to aid in management of patients. A 'bad' film did not imply the radiograph did not contribute to management of a patient but in terms of this study it means that if a robust quality control protocol were in place then such a film might have been rejected.

Both assessors were briefed on the methodology and trial sessions were done to ensure they understood the procedure. A score of ≤2 was taken as failure to satisfy a criterion. A good film (passed film) was rated as satisfying four or more of the criteria in the reference image. Assessors' review sessions were repeated after a period of between two and three weeks to evaluate consistency. Intra-reader consistency was studied by coefficient of variability percent (COV %). Using the rater score for each radiograph, between reader agreements was computed with the Cohen Kappa statistic (κ). Values of Kappa were interpreted as:
<0 - less than chance agreement; 0.01-0.20 slight agreement; 0.21-0.40 fair agreement; 0.41-0.60 moderate agreement; 0.61-0.80 substantial agreement; 0.81-0.99 almost perfect agreement[14].

Overall image quality was computed per radiograph as the image quality score (IQS) defined by the ratio of the

Table 1: Assessment of radiographic technical (RT) parameters.

Parameter	Code
Optical density	RT1
Collimation of X-ray beam	RT2
Patient identification	RT3
Positioning of anatomical marker	RT4
Correct use of Gonad shields	RT5
Assessment of Patient positioning	RT6

Table 2: Commission of European Communities criteria for pelvic image quality.

Criteria Description	Code
Symmetrical reproduction of the pelvis as judged by the imposition of the symphysis pubis over the midline of the sacrum.	IC1
Visually sharp reproduction of the sacrum and its intervertebral foramina.	IC2
Visually sharp reproduction of the pubic and ischial rami.	IC3
Visually sharp reproduction of the sacroiliac joints.	IC4
Visually sharp reproduction of the neck of femora which should not be distorted by foreshortening or rotation.	IC5
Visually sharp reproduction of the spongiosa and corticalis.	IC6
Visually sharp reproduction of the Trochanters.	IC7

Table 3: Results of assessed radiographic technical parameters.

Technical parameter code	% of films and rating		
	Good	Fair	Poor/None
RT1	57.4	42.6	-
RT2	1.1	-	98.9
RT3	93	4.1	2.9
RT4	93.6	6.4	-
RT5	-	-	100
RT6	52.3	42.8	4.9

Table 4: Inter-observer agreement determined by Cohen Kappa (κ)

Image criteria code	Kappa value	Agreement
IC1	0.36	Fair
IC2	0.75	Substantial
IC3	0.49	Moderate
IC4	0.71	Substantial
IC5	0.74	Substantial
IC6	0.76	Substantial
IC7	0.40	Fair

total image criteria score obtained per film and the maximum score available. The mean IQS for all assessed films was determined and is given as the pelvic image score for the hospital.

Results

From the assessment of the radiographic technical parameters, it was observed that only 111 (57%) of the assessed radiographs had optical density (OD) values within the acceptable range of 0.5-2.0. Mean OD was 1.6 ± 0.6. Other results obtained are presented in Table 3. Beam collimation to the areas of interest (RT2), indicated by the presence of clear margins bordering the images, was the least fulfilled technical parameter with only 1.1% of the studied radiographs recording adequate beam collimation. Poor collimation and the fact that not a single film in the entire sample had any evidence of the use of gonad shields (RT5 in Table 4), may have serious implications for patient radiation protection.

Patient identification on radiographs was correct in 93% of the films studied. However, 4% were poorly identified or had patient identification scratched onto the emulsion while there was no evidence of patient identification in 3% of the sample (n=108). Anatomical marking was evident on 93.6% of the radiographs. Adequacy of patient positioning (RT6) showed that 101 (52%) of the assessed radiographs had no evidence of patient rotation; 43% (n=83) were labeled 'fair' while 10 (5%) of the images showed evidence of poor patient positioning.

In terms of reader consistency for two readings sessions assessed by COV% was found to be 0.3 and 0.5%, respectively, for both assessors. This showed good consistency in individual reader scores over the two reading sessions. Mean Kappa (κ) value indicating inter-reader agreement in the assessment of pelvic radiography image quality with the CEC criteria was 0.60 (0.36-0.76). Kappa values indicated fair agreement between raters for IC1 and IC7, moderate agreement for IC3 and substantial agreement for the other image criteria studied (Table 4). The raters recorded Kappa values above 0.7 for IC2, IC4 and IC5 and IC6, indicating better agreement for these criteria.

All image quality criteria assessed obtained scores above 50% (Figure 1). However, IC2 (visually sharp reproduction of the sacrum and its inter-vertebral foramina), IC4 (visually sharp reproduction of the sacroiliac joints) and IC5 (visually sharp reproduction of the neck of femora without distortion by foreshortening and rotation) appeared to be areas of comparatively reduced quality. This may largely be due to the large number of radiographs with poor patient positioning. Overall image quality score (IQS) for pelvic radiography in the hospital was found to be 68 ± 0.04%, indicating that there was still a significant shortfall in the level of image quality compliance with the CEC criteria even though sampled radiographs had been previously used in management of patients. In other words since this was a retrospective study it should be borne in mind that the IQS applies to the radiographs that had been previously used for diagnosis.

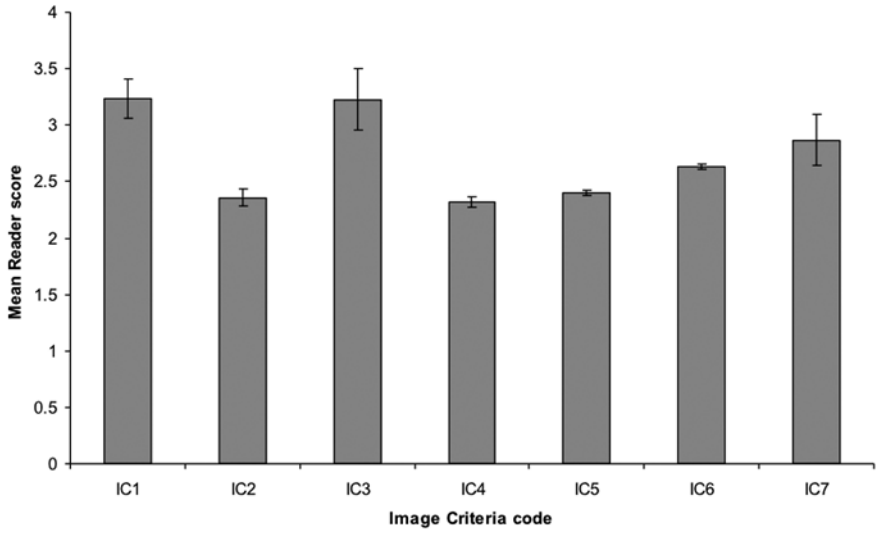

Figure 1: Observers' average rating of image criteria. The error bars are standard error of the mean from both observer viewing sessions.

Discussion

This first assessment of the image quality of pelvic radiographs in a Nigerian teaching hospital shows that within limits of the unavoidable discrepancies in the subjective visual grading analysis, the image quality of the 108 AP pelvis radiographs was found to be 68 ± 0.04% compliance with CEC image quality criteria. As this was a retrospective study of archived radiographs the expected higher image score was perhaps lowered because technically inferior radiographs could obviously not be repeated. The results obtained are however indicative of the need for quality control protocols to be implemented for pelvic radiography in the area of study. No such QA facility has been reported in the center up to the time of this study thus there is a wide variations in radiographic imaging procedures.

The degree of compliance of pelvic radiographs to the CEC image quality criteria with respect to IC2 and IC4 could be improved by careful selection of exposure factors, while IC5 reveals the need for better personnel performance in patient positioning. This suggests that improvement in individual radiographer technique will assuage the areas of low image performance. It is recommended that the department set up a procedure for maintaining standards in practice and encourage strict adherence to such standards.

Although patient dose measurement was not included in this study inferences drawn from assessment of radiographic technical parameters, such as beam collimation and use of gonad shields, reveal evidence of poor adherence to radiation protection principles in the center. There was no dose data available to assess the risk accruing to patients from these exposures. Dose records were not kept over the period studied thus this needs to be rectified to improve radiology service delivery. Adoption of beam collimation and use of gonad shields will go a long way towards reducing patient dose as well as the potential harmful effects of ionizing radiation. Beam collimation also adds to improved IQ since the effects of scatter on the film are reduced thus radiographic contrast is improved. The authors intend continuing in their efforts at optimization of the radiographic procedure by conducting a prospective follow-up study to include assessment of patient doses with corresponding image quality. The

relationship between gender and image quality/dose would also be considered.

This findings of this study are similar to earlier reports on dose and image quality studies from elsewhere in Nigeria[10-11]. Similar conclusions were arrived at in these studies in terms of factors that attributed to low or above average image quality. These include poor radiographic technique and a lack of standardized radiographic technique protocol in the country, for example. One hopes that the Nigerian Nuclear Regulatory Authority, which has the mandate to regulate radiation usage in the country, will raise the pace and tempo of its current efforts to drive home the need for implementation of quality control protocols. Frequent monitoring of facilities should include local efforts towards improved practice. It is recommended that local regulations to standardize practice should be set up. Radiographic staff should also frequently and regularly attend continuous professional development (CPD) programmes and improve record keeping.

Conclusion

This retrospective study revealed that pelvic radiography images in the hospital had a 68% compliance rate in terms of the CEC criteria for image quality. Cognizance should be taken that 32% of the sample did not fully comply with the said criteria. It could be argued that in the presence of QA and QC programmes similar quality images would probably be rejected and the examination repeated to improve image quality. The results revealed that 43% of the radiographs had technical faults. If there was a quality control programme operating, then such radiographs would have been considered as possible rejects. The results indicate the need for the improvement of procedures and the introduction of quality control programmes to enhance image performance in the hospital. It is envisaged that this study will serve as a basis for a prospective study to include patient dose assessment.

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