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Research Article

Clinical Evaluation of Image Quality for Intravenous Urography basis on the European commission guidelines on quality criteria in Sudan

O. Loaz [1, 2], Mohamed Yousef[1], A. Sulieman[1, 3]

[1]Sudan University for Sciences and Technology, College of Medical Radiologic Sciences, Al-Baladya Street. P. O. Box 1908, Postal code 11111, Khartoum, Sudan.

[2]Hail University, College of Medical Applied Sciences, Department of Diagnostic Radiology Science. Hail -KSA.

[3]Prince Sattab bin Abdulaziz University, College of Medical Applied Sciences, Radiology and Medical Imaging Department, Alkharj, KSA

***Corresponding author**
Omer lawz
Email: lawzomer@hotmail.com

Abstract: Assessment of image quality in radiography allows reduction of patient radiation doses without affecting the diagnostic findings. The aim of this study was to experiment the level of adherence to the European guidelines in certain Sudanese hospitals on the subject of the image quality of Intravenous Urography (IVU). Experience Clinicians made a subjective evaluation of 354 Images of special radiologic Intravenous Urography (IVU), 99 Patients images, drawn from the Radiology departments at seven major hospitals in the Sudanese capital- Khartoum. Images produced following routine examinations of the IVU being evaluated using anatomical parameters that were classified into technical and procedural criteria. The results of image quality assessment set on the European guidelines illustrate the IVU images scores ranged as Fully Acceptable; Probably Acceptable; Poor; all anatomical structures seen were in percentage of the maximum reachable scores illustrate the IVU images quality scores was 65.9. The corresponding mean Entrance Surface Air Kerma (ESAK) to the patient for specified IVU techniques was 1.1 mGy, 3.6 mGy, 2.1 mGy, 1.6 mGy, 1.6 mGy, 1.0 mGy and 2.4 mGy for Khartoum, Omdurman, Bahry, Souba, Ribat, Milltry Hospitals and S D C, respectively. The image criteria scores have been found valuable and their endorsement in the hospitals suggested, the radiation dose to the patient can be coupled to the required image quality and to the performance of the radiographic procedure or protocols, need to be used and read-through in a similar way.
Keywords: Image quality, image criteria, diagnostic radiology, IVU, European guidelines

INTRODUCTION

Intravenous Urography (IVU) is a radiographic examination of the urinary tract that uses intravenous (IV) iodinated contrast media in conjunction with plain radiographic. IVU has been first-choice technique for identifying urinary system diseases since it was first carried out in 1923 at Mayo Clinic [1, 2]. In recent years, however, other advanced imaging modalities including Ultrasonography (US), computed tomography (CT), and magnetic resonance (MR) imaging have been used with increasing frequency to recompense for the limitations of intravenous urography in the evaluation of urinary tract disease. Like Intravenous Urography, however, these examinations have their confines. IVU examination still has a leading role in imaging the urinary tract disorders especially in the low economics countries. However, during the procedure, patients are exposed to a significant radiation dose [3-5]. It is useful in the finding of renal and ureteral calculi. The indications for an Excretory Urography (EU) examination include, to evaluate the presence of suspected or known ureteral obstruction, assessment of the urinary tract following trauma or therapeutic interventions, the congenital anomaly and the lesions that may explain hematuria, infection or abnormalities, for possible renal parenchymal mass [6].

To guarantee adherence to pet standards of quality, image quality criteria recommended by the Commission of European Communities (CEC) have been used for good radiography practice and the assessment of images globally [7, 8, 9]. The compliance of diagnostic radiography practice to these image criteria has been suitable in general performance and standardization of dealings in radiographic examination of patients. Using of these criteria has been valuable for the optimization of the imaging process in many clinical settings [7, 9].

The determination of the optimum circumstances necessitates a measure of the radiation dose and image quality. The objective measures of image quality are an absolute descriptor of system performance; however, how they relate to the clinical setting has to be assessed using subjective analysis [10].

Radiological images for IVU investigation necessitate high quality to maximize diagnostic efficacy. Patients should be confident that the image produced is of optimal quality. A set of nearly objective guidelines for good radiographic techniques and the matching level of the image quality have been published by the European Union. The guidelines have proved to be a useful tool to unify the practices in Europe. In efforts to deal with the problem on dose reduction without affecting the patient care, the image criteria allow an immediate evaluation of the image quality of the respective radiograph, which appropriate for the most frequent requirements of special radiologic imaging investigations [9, 11, 12].

An evaluation of radiologic protocols and image quality includes all those factors or variables that relate to the precision or accuracy with which the structures and tissues being radiographed are reproduced on radiographic film or other image receptors. Some of these factors or variables relate more directly to radiographic positioning, which pursue an argument of the applied aspects of these factors [13].

The Image quality is significantly defined in the course of the utility of the images in achieving these tasks. The consensus for defining diagnostic image quality is maintained on such a task-based approach. This approach is at variance from subjective assessment by measuring the performance achieved and essentially setting a particular task for the image [14, 15].

The using of visual grading of the reproduction of important anatomical structures especially those pointed out in the European quality criteria for evaluating image quality in radiography has become an established method because the validity of such studies can be high since the quality criteria are based on the anatomical background and visual grading studies are relatively easy to conduct, especially in comparison with receiver operating characteristics (ROC) studies, the time consumption is moderate, at least for the observers, which means that it is realistic to believe that these methods can be implemented at almost any hospital [16].

Using ROC methodology, are generally accepted as the most dependable way of evaluating the diagnostic value the sensitivity and specificity of medical imaging techniques, the practical difficulties associated with such studies make balancing of evaluating image quality essential. Visual grading studies are an alternative solution, simple to carry out with clinically available images and not requiring any external ground truth. But in order for these studies to gain general acceptance, the data analysis methods must be appropriate [17]. The patient identification, the date of examination, positional markers and the name of the facility must be present and legible on the film. These annotations should not obscure the diagnostically relevant regions of the radiograph. An identification of the radiographers on the film would also be desirable.

MATERIALS AND METHODS

This study was carried out in seven major hospitals in the Sudanese capital- Khartoum. Seven x-ray units were included in the work. Radiographic Images were taken between 2012 and 2014 in the respective hospitals.

A subjective evaluation of 354 Images of special radiologic Intravenous Urography (IVU), 99 Patients images drawn from the Radiology departments of Two University Hospitals (UH), One Military Hospital (MH), Three Teaching Hospital (TH) and only one Private Clinic (PC). Include: Direct Digital Radiography (DR), Computed Radiography (CR) and Screen Film Radiography (SFR).

The current study focused on different techniques that affect image quality and radiation dose with relation to imaging protocols implemented in respected hospitals. Patient data (code number, gender, age and weight) and technical parameters (tube potential (kVp), tube current time product (mAs), film field size (cm) and the entrance surface air kerma ESAK (mGy)) were recorded for each examination (Tables 1 and 2). X ray machine characteristics were presented in Table 3.

Table 1: Number of IVU exams, number of radiographic and the mean values for patient demographics (age, height, BMI and weight

No. of Exams	No. of images	Patient age	Weight (kg)	Height (cm)	BMI (kg)
99	6-7	24-45	51-68	145-158	22.7-27.2

Table 2: Exposure parameters used in radiography for each Hospital

Exposure parameters	Khartoum	Omdurman	Bahry	Souba	Ribat	Military	SDC
Mean range ~kVp	68-78	60-80	72-78	68-86	68-83	65-75	65-75
Mean range ~mAs	14-32	20-50	16-22	10.-18	30-37	11.-16	25-40
AEC	Yes	No	No	Yes	Yes	Yes	No
FFD (cm)	100	100	100	100	109	100	100

Table 3: X- ray machine technical data

Hospital	Type	Filtration (mm Al)	Maximum tube potential (kVp)	Processing Type	Type
Omdurman	Shimadzu1/2P13DK installed 2006	1	150	Automatic processor	Conventional
Khartoum	Toshiba installed 2004	2	150	Laser Camera	CR
Bahry	Shimadzu1/2P13DK installed 2008	1.5	150	Automatic processor	Conventional
Ribat	Siemens installed 2004	3.5	125	Laser Camera	CR
Soba	Toshiba KXO-15E installed 2002	2	130	Automatic processor	Conventional
Milltry	Toshiba KOX-30 installed 2010	2	125	Laser Camera	CR
SDC	Siemens installed 2001	2	150	Automatic processor	Conventional

IVU Procedure

The standard procedure used for intravenous urography with optional images outlined as the preliminary kidney, ureter, and bladder (KUB) radiograph is an essential part of the series. This image should be obtained with appropriate technique (Optimal kVp, high milliamperage, short exposure time) to maximize inherent soft-tissue contrast and optimize visualization of lesions that are potentially of urinary tract origin [18].

The image coverage of the whole abdomen to include diaphragm to symphysis pubis to visualize the whole of the urinary tract (kidneys, ureters and bladder - KUB).Visualize sharp reproduction of the bones and the interface between air-filled bowel and surrounding soft tissues with no overlying artifacts [19].

Image Criteria evaluation

For the assessment of image quality, the image criteria refer to characteristic features of imaged anatomical structures with a specific degree of visibility as derived from the guidelines recommended by the European Commission [11].

The observers evaluated the image quality of all radiographs of each x-ray film. Images were judged depending on the routine practice of each radiology department. According to the European guidelines, the image criteria refer to characteristic features of x-rayed anatomic structures of each radiograph with a specific degree of visibility. The authors were divided the study into technical quality criteria (TQC) such as exposure factors, filtration, FFD etc, and procedural quality criteria (PQC) that were mainly caused by the radiographers' performance such as patient positioning. Images were evaluated using a subjective analysis which enclosed all the specified technical quality criteria and provided a good exhibition of the procedural quality criteria. The hard-copy image was displayed on a light box meeting the CEC guidelines for maximum luminance (2000-4000 cd/m^2) and uniformity (<30%).

Assessors Panel

In this study all images were evaluated independently by a minimum of two expert Radiographers. The evaluators had an average of 10 years working experience. For images displayed using soft-copy images, the evaluators were allowed to apply manipulation tools if required to at all extent needed to display the suitable criteria.

For all images, each member of the evaluation group was asked to score each criterion applicable to that image from 0 (Poor), 1 (probably acceptable), 2 (Fully acceptable).To measure the intra-observer variation, observers were asked to re-evaluate the same randomly selected image, using the same evaluating conditions.

Technical quality criteria (TQC)

Evaluation of some radiographic parameters or information on radiographic technique (Protocols) defined as follows: Patient Identification., Collimation of the X-ray beam to the area of interest, Automatic or manual exposure control, the anatomical marker position, correct positioning without hindrance with optical density of the film and diagnostic information, contrast and sharpness. This was evaluated by experienced radiographers. Use of gonad shield and correct positioning of the gonad shields were assessed.

Image criteria scores

Image quality assessment was as follows. Using the image quality criteria in Table 4, two assessors reviewed the films in terms of compliance with the CEC recommendations, using a reference image as guide to indicate that the evaluators considered four criteria. Image criteria are to be referred to sequences of films, AP projection taken before or at intervals after contrast administration, modified to patients individually, therefore every criterion counted up one by one coded 1 as yes if films fulfilling the criterion set before and zero if not (Table 4).

Table 4: Commission of European Communities criteria for pelvic image quality

No.	Criteria Description	Code
1	Production of the area of the whole urinary tract from the upper pole of the kidney to the base of the bladder.	IC_1
2	Reproduction of the kidney outlines.	IC2
3	Visualization of the renal pelvis and calyces (pyelographic effect) and the pelvi-ureteric junction.	IC_3
4	Visualization of the area normally traversed by the ureters and whole bladder area.	IC_4

The Absorbed Dose calculations

ESAK dose was calculated from x-ray tube output parameters. To calculate the ESAK the following x-ray tube exposure parameters were recorded for each patient who underwent the specified diagnostic procedure: peak tube voltage (kVp), exposure current-time product (mAs), the focus-to-film distance (FFD), patient sex and patient gender. The exposure to the skin of the patient during standard radiographic examination or fluoroscopy can be measured directly or estimated by a calculation to exposure factors used and the equipment specifications from formula below [20, 21]

$$ESAK = op_{\times} \left\{\frac{Kv}{80}\right\}^2 {}_{\times} mAs_{\times} \left\{\frac{100}{FSD}\right\}^2 BSF.$$

Where

OP is the tube output per mAs measured at a distance of 100 cm from the tube focus along the beam axis at 80 kVp, kV is peak tube voltage recorded for any given examination, mAs is the tube current-time product, FSD is the focus-to-skin distance, and BSF is the backscatter factor.

RESULTS

The result attained from this study presents an uncomplicated and easy method for clinical evaluating radiographic images via few parameters in terms of image quality criteria (IQC); the IVU images quality yields an average score of 65.9% (Table 5). In diagnostic radiology the images pattern engages an interaction of many factors and the perfect balance is to obtain an image, which is adequate for the clinical purpose with the minimum radiation dose received by the patient, so that the appropriate options can be selected. The corresponding mean ESAK per IVU procedure was 1.1 mGy, 3.6 mGy, 2.1 mGy, 1.6 mGy, 1.6 mGy, 1.0 mGy and 2.4 mGy in Khartoum, Omdurman, Bahry, Souba, Ribat, Milltry Hospitals and S D C, respectively(Table 6). The values of ESAK were wide-ranging with X-ray tube potential, focal to image receptor distance, patient size, filtration applied and automatic exposure control (AEC) (Table 7). Table 4 shows selecting dose given to the patients with independent of the X-ray tube potential, age, and patient size. Almost all IVU examinations recorded large focal spot values of more than or equal to 1.5. In all investigation 26.8% of examinations employed manual selection of the exposure whereas 73.2% utilized AEC.

Table 5: show the total study of 354 radiologic investigations distributed as 99 IVU investigations.

Hospitals	Khartoum	Omdurman	Bahry	Souba	Milltry	Ribat	SDC	Total
No. of exam	7	11	6	9	41	20	7	99
Images per exam	7.1	5	5.3	5.1	5.5	10.7	4.1	6.4
No. of Images	27	41	13	41	134	66	32	354

Table-6: Show ESAK Mean values mGy for IVU exams between Hospitals.

Hospitals	Khartoum	Omdurman	Bahry	Souba	Ribat	Milltry	SDC
Mean ESAK in mGy	1.1	3.6	2.1	1.6	1.6	1	2.4

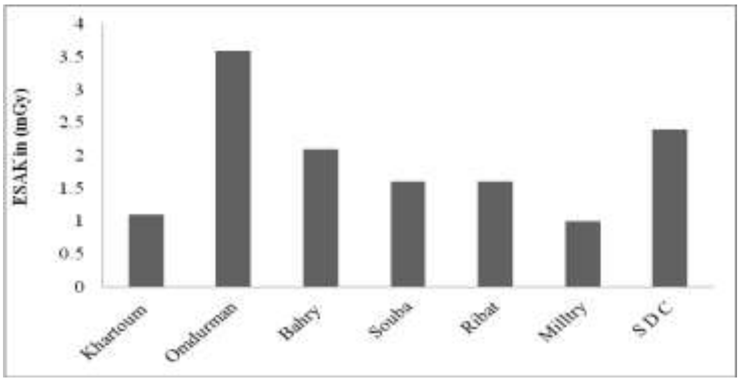

Fig. 1: Patient ESAK dose (mGy) per hospital.

Table 7: ESAK values for manual and automatic exposure control

Mode Exposure	No. of Images	ESAK mGy
AEC	227	1.3
Manual	127	2.5

The observers were achieved a subjective opinion on image quality, which was defined as fully acceptable (Minimal or no defects), probably acceptable (Major deficiencies with satisfactory clinical information), Poor (Inadequate clinical information). Since the number of criteria used to assess images and thus total image score was outcrop exact, the results are presented as percentages of the maximum reachable scores showed in Table 5 below, illustrate the IVU images quality scores was 65.9%.

Table 8: Fulfillment with Guidelines set up by the European Commission (CEC) for 354 images of IVU examinations

Image criteria	Images score per count category		
	1	2	3
Production of the area of the whole urinary tract from the upper pole of the kidney to the base of the bladder.	34 (9.6%)	45 (12.7%)	275 (77.7%)
Reproduction of the kidney outlines.	49 (13.8%)	229 (64.7%)	76 (21.5%)
Visualization of the renal pelvis and calyces (Pyelographic effect) and the pelvi-ureteric junction.	61 (17.2%)	1 (0.3%)	292 (82.5%)
Visualization sharp of the area normally traversed by the ureters and whole bladder area.	65 (18.3%)	0 (0%)	289 (81.7%

Results from the ratings of image quality, 1 = *Poor*, 2= *Probably Acceptable* Quality and 3= *Fully Acceptable* Quality.

DISCUSSION

This trial evaluation of the image quality of IVU radiographs in Sudan hospitals shows that the image quality of the 354 IVU films was found to be 65.9% compliance with CEC image quality criteria. The greatest amount of details and optimal density, display a good quality of radiographic image reasonable contrast and least distortion [22]. The subjective obtained results from this study suggested that the image criteria system is that of choice, also these results indicates that quality criteria can be expressed into a scoring method defers reproducible data in nearly all rates, in agreement with Offiah and Hall [8]. The CEC criteria were able to detect differences in quality of film–screen and digital images. Even an argument raised by Tingberg *et al.* [23] and Håkansson *et al.* [24] about the validity of using VGAS and the CEC image criteria as a measure of clinical image quality. The values attained in this work are in good agreement between each other and with data reported in the literature.

The comparison of the FFD, kV, film-screen combination speed, total filtration and automatic exposure control (AEC) revealed that Sudanese hospital under evaluation in this study perform in conformity with the European recommendation in regards to IVU examinations (Table 8).

Sudanese hospitals involved in this survey, in a certain circumstances it may be difficult to adhere to all the CEC recommendations due to equipment restrictions and the radiographic staff themselves not in awareness to the image quality conception, which seem to be other limitation, Thus there are an indication of the necessitate for the development of continuous education programmes for employees in diagnostic centers.

The mean ESAK per IVU procedure was 1.1 mGy, 3.6 mGy, 2.1 mGy, 1.6 mGy, 1.6 mGy, 1.0 mGy and 2.4 mGy in Khartoum, Omdurman, Bahry, Souba, Ribat, Milltry Hospitals and SDC, respectively. Even the CEC guidelines recommends 10 mGy as reference dose for IVU procedure, radiation doses measured in this work are well within the established international reference doses (Fig. 1). These variation could be explained by the rather few number of IVU image in the present study mean about 6.4. or could be because reference doses were recognized 18 years ago and that advances in imaging technology contributed to the improvement of the equipment performance. This might specify the need for established new reference dose levels acting as compliance in each hospital or in whole country for the current practice, in agree with Halato *et al*. [25].

The ESAK was within the same range of recent study which was performed on adult patients conducted by Halato *et al*. [25]. The dose value in this study was less than the dose value for adult patients reported by Sulieman *et al*. [26] and Suliman *et al*. [27] (Table 9).

Table 9: Show the previous studies results during IVU procedure

Author	No. of exam	Country	ESAK mGy
Present Study	99	Sudan	1.0-3.6
Halato *et al*. [25]	42	Sudan	1.6-3.2
Sulieman *et al*. [26]	141	Sudan	12.4 $\pm$ 8.7
Suliman I. *et al*. [27]	72	Sudan	6.6 - 15.3

CONCLUSION

The study results concluded that the image criteria scores have been found valuable and endorsement in daily practice in the hospitals suggested, the radiation dose to the patient can be coupled to the required image quality and to the performance of the radiographic procedure or protocols, need to be used and read-through in a similar way. The need to provide relevant education and training to staff in the radiology departments is of utmost importance.

REFERENCES

1. Elhag B, Omer H, Sulieman A; Estimation of pediatric radiation doses in intravenous urography. Asian J Med Clin Sci., 2012; 1(1): 4–8.
2. Osborn ED, Sutherland CG, Scholl AJ, Rowntree L; Roentgenography of urinary tract during excretion of sodium iodide. JAMA, 1930; 95(19): 1403-1409.
3. Bontrager, Kenneth L; Textbook of radiographic positioning and related anatomy. 8th edition, Mosby.
4. Masarani M, Dinneen M; Ureteric colic: new trends in diagnosis and treatment. Postgrad Med., 2007; 83(981): 469-472.
5. Dyer RB, Chen MYM, Zagoria RJ; Intravenous Urography: Technique and Interpretation RadioGraphics, 2001; 21(4): 799–824,
6. American College of Radiology, ACR; Practice Guideline for the Performance of Excretory Urography. 2009. Available from: http://acr.org/secondarymainmenucategories/quality_safety/ contrast manual.aspx.
7. Brennan PC, Johnston D; Irish X-ray departments demonstrate varying levels of adherence to European guidelines on good radiographic technique. Br J Radiol., 2002; 75(891): 243-248.
8. Offiah AC, Hall CM; Evaluation of the Commission of the European Communities quality criteria for the pediatric lateral spine. Br J Radiol., 2003; 76: 885–890.
9. Rainford LA, Al-Qattan E, McFadden S, Brennan PC; CEC analysis of radiological images produced in Europe and Asia. Radiography, 2007; 13(3): 202- 209.
10. Launders JH, Cowen AR, Bury RF, Hawkridge P; A case study into the effect of radiographic factors on image quality and dose for a selenium based digital chest radiography system. Radiat Prot Dosim., 1998; 80(1-3): 279-282.
11. European guidelines on quality criteria for diagnostic radiographic images; CEC Report EUR 16260 EN, Office for official publications of the European Communities, Luxembourg, 1996.
12. Jessen KA; Balancing image quality and dose in diagnostic radiology. Eur Radiol Syllabus, 2004; 14(1): 9–18.
13. Sherer MAS, Visconti PJ, Ritenour ER; Radiation protection in medical radiography, 3rd edition, Mosby, St Louis, 1998.
14. Barrett HH, Myers K; Foundations of Image Science, John Wiley and Sons, 2004.
15. Tapiovaara M; Relationships between physical measurements and user evaluation of image quality in medical radiology – a Review. STUK-A219, 2006. Available from http://www.stuk.fi/julkaisut/stuk-a/stuk-a219.pdf
16. Bath M, Mansson LG; Visual grading characteristics (VGC) analysis: a non-parametric rank-invariant statistical method for image quality evaluation. Br J Radiol., 2007; 80: 169–176.
17. Smedby O, Fredrikson M; Visual grading regression: analysing data from visual grading experiments with regression models. Br J Radiol, 2010; 83(993): 767–775.
18. Dunnick NR, Sandler CM, Newhouse JH, Amis ES Jr.; Textbook of uroradiology. 3rd edition, Lippincott Williams & Wilkins, Philadelphia, 2001.
19. Whitley AS, Sloane C, Hoadley G, Moore AD, Alsop CW; Clark's positioning in radiography. 12th edition, New York, 2005.
20. International Commission on Radiological Protection; Recommendations of the International Commission on Radiological Protection. Annals of ICRP, 1990; 21(1-3).
21. Toivonen M; Patient dosimetry protocols in digital and interventional radiology. Radia Prot Dosim., 2001; 94(1-2):105-108.
22. Pontual ML, Veloso HHP, Pontual AA, Silveira MMF; Errores en, radiografias intrabucales realizadas en la Facultad de Odontología de Pernambuco-Brasil. Acta Odontol Venez, 2005; 43(1):19-24.
23. Tingberg A, Båth M, Håkansson M, Medin J, Besjakov J, Sandborg M *et al*.; Evaluation of image quality of lumbar spine images: a

comparison between FFE and VGA. Radiat Prot Dosim., 2005; 114(1-3): 53-61.

24. Håkansson M, Båth M, Börjesson S, Kheddache S, Grahn A, Ruschin M *et al*.; Nodule detection in digital chest radiography: summary of the RADIUS chest trial. Radiat Prot Dosim., 2005; 114(1-3): 114-120.
25. Halato MA, Badawi AA, Suliman I, Sulieman AA, Gassom GA, Barsham MA *et al*.; Radiation doses in intravenous urography and potentials for optimization. Tenth Radiation Physics & Protection ConferenceNasr City - Cairo, Egypt, , 27-30 November 2010.
26. Sulieman A, Theodorou K, Vlychou M, TopaltzikisT, Kanavou D, Fezoulidis I *et al*.; Radiation dose measurement and risk estimation for paediatric patients undergoing Micturating cystourethrography. Br J Radiol., 2007; 80: 731–737.
27. Suliman II, Al-Jabria AJ, Badawi AA, Halatob MA, Alzimami K, Sulieman A; Radiation dose and cancer risk in patients undergoing multiple radiographs in intravenous urography X-ray examinations. Radiat Phys Chem., 2014; 104: 272–275.