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Research Article

Analysis of Image Quality for Hysterosalpingography Examinations

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Abstract: The study objective was to assess the image quality during Hysterosalpingography (HSG) according to the Commission of the European Communities (CEC) guidelines in certain hospitals in Sudan and to compare the findings with global standards. The image quality analysis was employed straightforward and easy method for clinical evaluating radiographic images via some common used exposure parameters in terms of image quality criteria scoring (IQCs). A subjective evaluation of patient images from nine hospitals (Public and Private) in three different provinces in Khartoum capital were considered in the current study has been made by expertise clinicians. A number of 347 HSG Images; 122 Patients exam demonstrated the European Guidelines on quality criteria for diagnostic radiographic images of assessment image quality. The maximum possible score of image criteria yielded 65.6, 67.9.71.1 and 81.7. Also, entrance surface air kerma (ESAK) quantified values of 2.1, 1.7, 2.5 and 2.4 mGy for TH, UH, MH and PH respectively. The overall image quality and ESAK were 71.6 and 2.1 mG, respectively. The analysis of image quality is critical for explanation of the radiographic process in any clinical setting. The above recent results have been shown that image quality is dependent on a wide variety of interactions including training of personnel, protocols, equipment age and type.
Keywords: Image quality, Hysterosalpingography, image criteria, European guidelines.

INTRODUCTION

Hysterosalpingogram (HSG) is an outstanding radiographic exam for assessing the anatomy and function of the female genital tract and the fallopian tubes and has been the most frequently used method in the evaluation of sterility using conventional X‑ray or fluoroscopy [1, 2]. It is usually performed as a definitive diagnostic tool to assess abnormal findings on Hysterosalpingogram [3-7]. HSG, which is achieved merely for diagnostic intent, can mend fertility due to the passageway of the contrast agent in pressure into the tubes through uterine cavity [8-10].

HSG include the imaging of cervical canal, uterine cavity, tubes of fallop and peritoneal cavity during injection of contrast media with fluoroscopic visualization. It should be done with the bare minimum radiation exposure required to provide adequate anatomic details for diagnosis of normal or anomalous findings. Compliance to the following practice parameters will get the most out of the diagnostic benefit of HSG. despite recent advances in various imaging modalities to assess the fallopian tubes such computed tomography (CT) and magnetic resonance imaging (MRI), still HSG remains the most appropriate test [11, 12].

The European Guidelines on Quality Criteria for Diagnostic Radiographic images (CEC) [13], set that the results of each X-ray examination must be ‘‘reproducible and have prognostic value, sufficient sensitivity, specificity and accuracy’’. All X-ray departments therefore should be consistently producing images that facilitate accurate diagnosis. These guidelines, allow direct evaluation of the image quality, in endeavors to point out the problem on dose reduction without affecting the patient health [14].

HSG engage an obligatory radiation dosage to the ovaries in patients of childbearing age, which addressed as an important issue that must be taken into consideration. However, the dose to the patient will be as low as reasonably achievable and compatible with the medical purpose when justified the practice and optimised the protection [15-17].

Image quality must always be correlated to the clinical queries presented. As these may discuss that image criteria [13], can describe features that distinguish good clinical images, possibly will be used to evaluate in general quality of the image [18].

In radiography, the assessment of air kerma or dose at the entrance surface of the patient is a familiar approach dosimetry. Entrance surface air kerma (ESAK) is the air kerma on the central X-ray beam axis at the point where the X-ray beam enters the patient or phantom, which includes the effects of backscatter. ESAK is recommended by the ICRU for dosimetry in medical imaging. The entrance surface dose (ESD) is defined as the absorbed dose to air at the point of intersection of the X-ray beam axis with the entrance surface of the patient, including backscattered radiation. The United Nations Scientific Committee on the Effect of Atomic Radiation (UNSCEAR) [19] report uses entrance surface dose for patient dosimetry [20].

An evaluation of radiologic protocols and image quality includes all those factors or variable that relate to precision with which the tissues being x-rayed 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 [21].

The objective of the current study was to assess the image quality during Hysterosalpingography (HSG) according to the Commission of the European Communities (CEC) [13] guidelines in certain hospitals in Sudan and to compare the findings with global standards.

MATERIALS AND METHODS

The diagnostic imaging departments participated in this a three years work, integrated nine hospitals in Sudan capital where; Three Teaching Hospitals (TH) , One Military Hospitals (MH), Two University Hospital (UH), and Three Private Hospitals (PH). The investigations distribution was as follow; TH 28 cases (23%), UH 18 cases (14.7%), MH 16 cases (13.1%) and PC 60 cases (49.2%). All departments have been chosen achieved the required examinations frequently and all Patient's information were recorded for each examination as shown in Table 1 below.

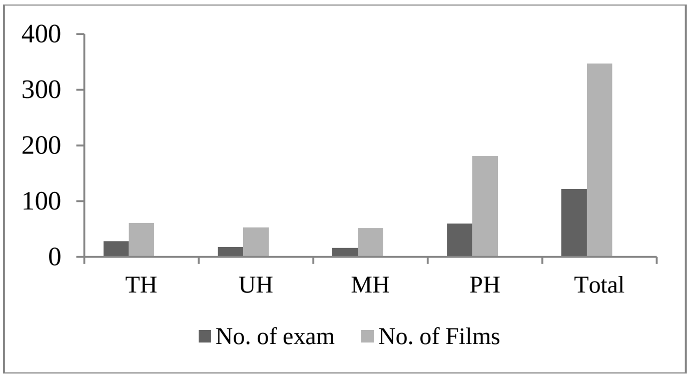

Figure1: the investigations distribution and Films accounts vs. Hospitals

Table 1: Mean values for patient demographics (age, height, BMI and weight).

Group	N	Patient age (ys)	Height (cm)	Weight (kg)	BMI (kg m^{-2})
TH	28	34.0 (27–41)	165.0 (156-174)	66.5 (51-82)	24.4 (21.0-27.1)
UH	18	31.0 (18–44)	166.5 (153-180)	68.5 (49-88)	24.7 (20.9-27.2)
MH	16	31.0 (22–40)	163.0 (154-172)	68.5 (56-81)	25.8 (23.6-27.4)
PH	60	31.5 (18–45)	165.8 (154-179)	68.5 (51-86)	24.9 (21.5-26.8)

Entrance surface air kerma (ESAK)

The ESAK is estimated using x-ray tube output parameters with a known focus to skin distance (FSD) and mAs per procedure for the accounts of patient measure. Calculation of the Entrance Air Surface Kerma ESAK completed for the patient who underwent the HSG depending on the following formula [22, 23].

$$ESAK = op \times \left\{\frac{Kv}{80}\right\}^2 \times mAs \times \left\{\frac{100}{FSD}\right\}^2 BSF.$$

Where, OP has to be the a tube output per mAs measured at a distance of 100 cm from the tube focal at 80 kVp, kVp is tube voltage peak, mAs is the tube Ampere-time product, FSD is the focal skin distance, and BSF to be the backscatter factor.

Table 2: Image quality criteria and scoring system adopted for Hysterosalpingography

Sl. No.	Criteria	Code
1	Production of the Uterus opacification or uterine outline.	C1
2	Density of the intrauterine cavity.	C2
3	Reproduction of the Fallopian Tubes.	C3
4	Visualization of Fimbrial rugae.	C4
5	Visualization sharp reproduction of the intraperitoneal spillage.	C5
	• Weakly visualised and not diagnostic.	Yes/No
	• Weakly visualised but diagnostic.	Yes/No
	• Good demonstration and diagnostic.	Yes/No
	• Outstanding visualisation	Yes/No

Image Criteria and evaluation panel

Subjective assessments of patient images were proposed following the European Guidelines on quality criteria for diagnostic radiographic images for the assessments of image quality [13] There were definite technical parameters (TP) provided for the evaluations of HSG images, these criterion regarded the Optical Density coded as TP1, Collimation of X-ray beam as TP 2, Patient identification as TP 3, Positioning of anatomical marker as TP4, Correct use of Gonad shields TP 5 and Assessment of Patient positioning and the degree of stability and/or entirety as TP 6.

Image criteria are to be referred to sequences of radiographs, taken at intervals after contrast Injection, modified to patients individually. These criteria were; (a) Production of the Uterus opacification or uterine outline, this was coded 'C1', (b) Density of the intrauterine cavity, coded 'C2', (c) Reproduction of the Fallopian Tube, coded 'C3', (d) visually sharp reproduction of Fimbrial rugae coded 'C4' (e) Visualization of Intraperitoneal spillage coded 'C5'.

Images were evaluated in parallel by least of two clinicians, each with minimum 10 years experience in evaluating radiological images, two clinicians from each hospital whilst, one assessor was remains constant for all examinations across the hospitals investigated for entire measurement process. Every radiographers scored 1or 0 for the patient image as regards to performance of each criterion. No limitations were placed on observers with respect to time and distance from the viewing boxes. The observers evaluated the image quality of all radiographs of each x-ray film according to the basis indicated against all anatomical structures. According to the European guidelines, the image criteria refer to characteristic features of imagined anatomic structures of each radiograph with a specific degree of visibility. Images were evaluated using an individual analysis which enclosed all the specified technical quality criteria and provided a good demonstration of the procedural quality criteria.

Images were displayed on a light box relative to the ambient enlightenment of the interpretation room as well as the consistency and luminance (cd/m2). The whole image quality was calculated per radiograph as the Image Quality Score (IQS) defined by the total image criteria scores gained per film and the maximum score obtainable. The evaluators were allowed to manipulate tools to whatever extent required to display the appropriate criteria for Images exhibited using soft-copy techniques, all members of the assessment group were score each criterion related to that image from 0 (Weakly visualised and not diagnostic), 1 (Weakly visualised but diagnostic), 2 (Good demonstration and diagnostic) and 3 (Outstanding visualisation).

Machines

HSG procedures were completed through nine X-ray rooms. Five machines equipped with digital fluoroscopic machines and outlying controlled with a $90^0/90^0$ tilt table with three fluoroscopic modes (High, Normal and Low). The range of the tube voltage is 40–150 kVp with a total filtration of 3.8 mm Al. whilst the remaining hospitals relied on analogue techniques and range of the tube voltages is 40–125 kVp with a total filtration of 4.0 mm Al for other four machines, tube current ranges from 1 to 850 mA for all machines, and they were set with automatic brightness control (AEC). The exposure factors can be either selected by hand or semi- automatically by the machine for radiography and fluoroscopy. Focus to image receptor distance was fixed at 100/109cm.

Table 3: Sets of images acquired varying SID, automatic exposure control (AEC), manual mode, lesions, kVp and mAs.

Hospitals	Sets of images acquired		Processing Type	Parameters			
				SID	AEC/manual	KVp Range	MAs Range
TH	1 AEC	2 manual	1CR/2AP	100	Medium/manual	63-80	14-40
UH	2 AEC	0 manual	1DR/1AP	109/100	Medium/manual	64-85	10-38
MH	1 AEC	0 manual	1DR/0AP	109	Medium/manual	75-80	25-32
PH	2 AEC	1 manual	2DR/1AP	109/100	Medium/manual	70-80	18-40
AP= Automatic Processor, CR = Computer Radiography and DR= Digital Radiography.							

Procedure

Hysterosalpingography was achieved within the first ten days after the last menstrual period. Using accurate volume of contrast agent administered under fluoroscopic to demonstrate the anatomic structures of female genital system. Speculum is used to distend the vagina and an 8F Foley catheter is inserted into the uterine cavity. Hyperosmolar Diluted, water soluble iodinated contrast agent is then hand injected into the uterine cavity via the Foley catheter [23, 24].

Plain film of the pelvis is essential, so the feasible intrapelvic calcifications or lesions will not obscure reading of the images. A metallic marker is located over one side of the receptor to specify the right or left side of the patient. The films were taken intervals throughout the filling of the uterine cavity and filling of the fallopian tubes. At the end, after removal of the catheter ensure the presence of contrast agent in the peritoneal cavity and the reflux of the contrast agent [25].

RESULTS

The outcome data achieved from this survey regarding the HSG image quality analysis employed straightforward and easy method for clinical evaluating radiographic images via some common used parameters in terms of image quality criteria (IQC).

The Image quality criteria scoring (IQCs), which have been settled by the European guidelines [13] for special radiologic investigation was consequent from where scoring was relating to the degree of visibility of anatomic or pathologic structures.

The images acquired with mean values of kVp and mAs and had a SID of 100/109 cm, Manual/AEC, 85-63 kVp and 40-10 mAs. The images were scored using a three Likert point scale (much worse, slightly worse, slightly better, much better than) using prearranged criteria.

This work yielded over 347 measurements of routine HSG investigation from nine hospitals, five of them their machines acquired images using digital technology, whilst the remaining hospitals relied on analogue techniques. Table 4 shown total of 122 patients performed the HSG exam, distributed among hospitals go through analysis; were 28, 18, 16 and 60 for UH, MH and PH respectively.

Table 5 showed the maximum possible scores of image criteria rated 65.6, 67.9.71.1, 81.7 and ESAK was 2.1, 1.7, 2.5 and 2.4 mGy for TH, UH, MH and PH respectively. The overall image quality and ESAK were 71.6 and 2.1 mGy, respectively.

Patient demographic data (age, weight, height and BMI), screening time and number of radiographic and fluoroscopic images are presented in Table 1. The exposure factors for each group are also shown in Table 2.

Table 4: The measurement distribution and Film account vs. Hospitals

Hospital	No. of patients	No. of Measurements	Percentage
TH	28	61	23%
UH	18	53	14.7%
MH	16	52	13.1%
PH	60	181	49.2%
Total	122	347	100%

Table 5: The percentage values of quality criteria scores and ESAK average

Hospital Groups	Max Image Score	ESAK Average mG	No. of radiographic images
TH	65.6	2.1 (1.1-3)	3 (2–5)
UH	67.9	1.7 (1.6-1.8)	4.2 (3–6)
MH	71.1	2.5 (2.2-2.8)	4.5 (3–6)
PH	81.7	2.4 (2.1-2.8)	7.8 (2–22)
The percentage value represents the score awarded as a proportion of the maximum possible score of image criteria			

DISCUSSION

The Quality Criteria provided in this survey, offer a system for scoring compliance with the Image Criteria [13], and also include a system for scoring more general aspects of the image, such as blackening, contrast, sharpness and diagnostic acceptability, which the maximum obtainable image criteria score for this work was 71.6, higher than what have been reported by Abdullah *et al*. [26] who made a comparison between conventional and high voltage technique during HSG using conventional X-ray machine and their results showed that overall image quality scores 33 and 31 depending on the type of water soluble contrast was used. Mohd Nor and his colleges [27] emphasised the finding of this study when they reported that Radiographic imaging quality was considered good to excellent between three contrast agent used with regard to sharp reproduction of uterine outline, fallopian tube outline and free peritoneal spillage outline. However, the Superior Quality scores ranged between 62.8 and 100 for all HSG images criteria they approved for their study.

Digital radiographic acquisition has many advantages over film-screen radiography, including improved analytic quality especially in areas of high attenuation (intrauterine cavity, the Fallopian Tubes and the Fimbrial rugae), improve the maximum total of details, show an excellent quality of radiographic image logical contrast and density and least exposure dose as shown in Fig. 2.

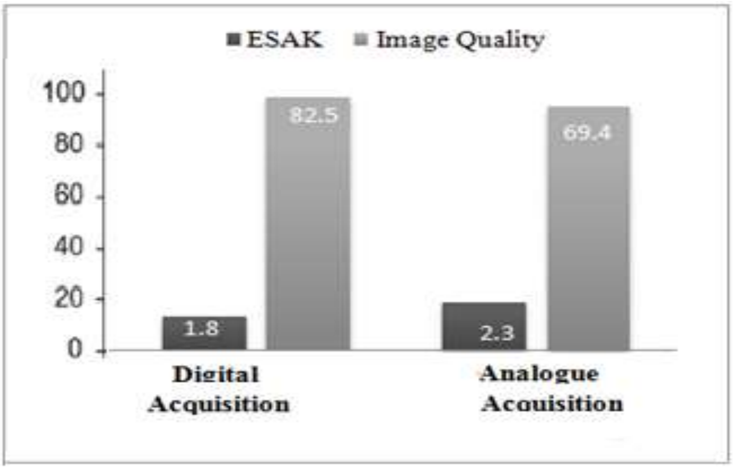

Fig. 2: A summary of the max. image criteria scores for analogue and digital acquisition

In this work, test of the methods employed, exact SID, tube voltages (kVp), AEC usage and selection of film screen speed combination in the departments under consideration showed varying levels of fulfillment with the CEC [13] guidelines showed in Table 3.

The mean ESAK yielded 2.1 mGy per image in present study. These mean ESAKs calculated for HSG is close to and within range of the reviewed literature recommended reference values. They are however similarity results with Kushner *et al*. [28] who obtained a mean ESD (2.2) mGy per image as they studied the radiation dose reduction using low-mode scanning beam digital imaging system also they found ranged between 4 and 10 images, whilst the number of images for this study was 5 (2-13) per procedure. It was observed that the number of films per procedure were within the reviewed studies level except in Two Private hospital where a higher number of films raised up to 22 images in some procedures was recorded in this survey, which indicated that these specific HSG examinations were carried out by trainee radiologists under supervision or gynecologists who are not fully trained in radiation protection.

Comparing this result with the previous data (Table 6 and figure 3), it is clear that, this study reports the observable reduction of the radiation ESAK dose values consequently, decreased risk of hereditary radiation effects. In same approach Sulieman *et al*. [17], refer to when they study radiation dose optimisation and risk estimation to patients and staff during Hysterosalpingography; radiation protection dosimetry, they obtained an ESD of 3.6 mGy and Kushner [28] assessed the ESD during HSG. Though, it seems to be comparable with the previous studies. The ESD during HSG was also estimated by Khoury *et al*. [29], Gregan *et al*. [30] and Alzimami *et al*. [31], at 12.6 mGy, 14.6 mGy and 23.16 mGy, in that order, which were observed to be elevated in the dose values than the current study.

The present work did have some limitations. The HSG examination was not done by the same investigator, which appears to be that the radiologic technologists at some hospitals were unenthusiastic or not appreciated the experience. In addition, the mathematical technique, even if well liable to errors, but could be engaged until dose monitoring tools become more accessible.

Table 6: **The mean patient parameters, number of radiographic images, ESAK mG dose in various studies**

Author	No. pts	Age Yrs	No. of Film mean	ESAK mG
Present study	122	31.5 (18-45)	5 (2-13)	2.1 (1.7-2.8)
Yousef *et al*. [2].	50	NA	NA	9.5-42.5
Alzimami K *et al*. [31]	79	NA	4.5 (1–12)	23.16(9.3–48.4)
A. Sulieman *et al*. [17]	37	34.0 (20–43)	0.2 (0–1)	3.60 (0.7–8.17)
Gregan *et al*. [30]	21	31.6 (24–39)	2 (2–4)	14.6 (1.4–45.7)

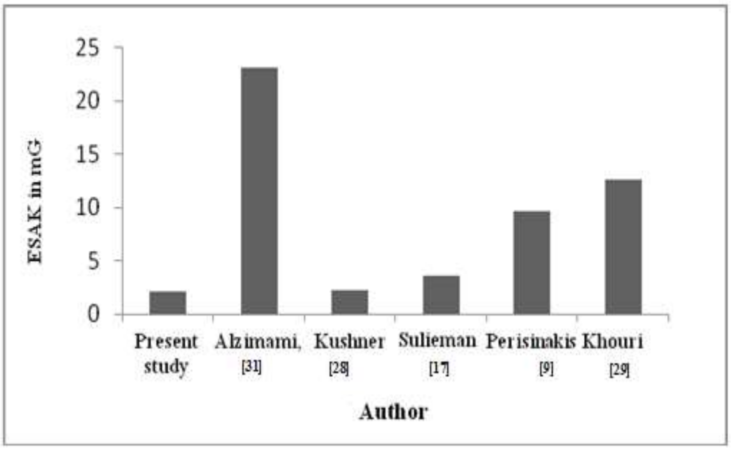

Fig-3: Comparison of ESAK values for HSG for previously published studies

CONCLUSION

Analysis of image quality is critical for explanation of the radiographic process in any clinical setting. The above recent results have been shown that image quality is dependent on a wide variety of interactions including training of personnel, protocols, equipment age and type. Because of these variations, and a lack of a global standard, make possible correlation of both image quality and dose parameters from hospital to hospital, to pass up the increasing danger of hereditary radiation effects in patients undergo the HSG exam.

REFERENCES

1. Pundir J, El Toukhy T; Uterine cavity assessment prior to IVF. Womens Health (Lond. Engl.), 2010; 6: 841-847.
2. Yousef M, Tambul JY, Sulieman A; Radiation dose measurement during HSG. Sudan Medical Monitor, 2014; 9(1): 15-18.
3. Ayida G, Chamberlain P, Barlow D, Kennedy S; Uterine cavity assessment prior to in vitro fertilization: comparison of transvaginal scanning, saline contrast hysterosonography and hysteroscopy. Ultrasound Obstet. Gynecol., 1997; 10: 59-62.
4. Brown SE, Coddington CC, Schnorr J, Toner JP, Gibbons W, Oehninger S; Evaluation of outpatient hysteroscopy, saline infusion hysterosonography, and hysterosalpingography in infertile women: a prospective, randomized study. Fertil Steril., 2000; 74: 1029-1034.
5. Loverro G, Nappi L, Vicino M, Carriero C, Vimercati A, Selvaggi L; Uterine cavity assessment in infertile women: comparison of transvaginal sonography and hysteroscopy. Eur J Obstet Gynecol Reprod Biol., 2001; 100: 67-71.
6. Narayan R, Goswamy RK; Transvaginal sonography of the uterine cavity with hysteroscopic correlation in the investigation of infertility. Ultrasound Obstet Gynecol., 1993; 3:129-133.
7. Roma DA, Ubeda B, Ubeda A, Monzón M, Rotger R, Ramos R *et al.*; Diagnostic value of hysterosalpingography in the detection of intrauterine abnormalities: a comparison with hysteroscopy. AJR Am J Roentgenol., 2004; 183:1405-1409.
8. Maubon AJ, De Graef M, Boncoeur-Martel MP, Rouanet JP; Interventional radiology in female infertility: technique and role. Eur Radiol., 2011; 11: 771–778.
9. Perisinakis K., Damilakis J, Grammatikakis J, Theocharopoulos N, Gourtsoyiannis N; Radiogenic risks from hysterosalpingography. Eur Radiol., 2003; 13: 1522–1528.
10. De Placido G, Clarizia R, Cadente C, Castaldo G, Romano C, Mollo A *et al.*; Compliance and diagnostic efficacy of mini-hysteroscopy versus traditional hysteroscopy in infertility investigation. Eur J Obstet Gynecol. Reprod Biol., 2007; 135:83-87.
11. Unterweger M, De Geyter C, Frohlich JM, Bongartz G, Wiesner W; Three-dimensional dynamic MR-hysterosalpingography; a new, low invasive, radiation-free and less painful radiological approach to female infertility. Hum Reprod., 2002; 17(12): 3138-41.
12. ACR Practice Parameter for the Performance of Hysterosalpingography Res. 50 – 2011. Amended 2014 (Res. 39).
13. CEC, European guidelines on quality criteria for diagnostic radiographic images, Report EUR 16260 EN. Luxembourg: Office for official publications of the European Communities, 1996.
14. Jessen KA; Balancing image quality and dose in diagnostic radiology. Eur Radiol Syllabus, 2004; 14: 9–18.
15. European Union; Council Directive 97/43 Euratom, on health protection of individuals against the dangers of ionizing radiation in relation to medical exposure. Official Journal of the European Communities No. L 180, 9th July, 22–27, 1997.

16. International Commission of Radiological Protection; Recommendations of the International Commission of Radiological Protection. ICRP 60, Oxford: Pergamon Press, 1991.
17. Sulieman A, Theodorou K, Vlychou M, Topaltzikis T, Roundas C, Fezoulidis I *et al*.; Radiation dose optimisation and risk estimation to patients and staff during hysterosalpingography. Radiation Protection Dosimetry, 2008; 128(2): 217–226.
18. Ullman G, Sandborg M, Tingberg A, Dance DR, Hunt R, Carlsson GA; Comparison of clinical and physical measures of image quality in chest PA and pelvis AP views at varying tube voltages, Report / LIU-RAD-R-098-2004.
19. United Nations Scientific Committee on the Effects of Atomic Radiation UNSCEAR; Report to the General Assembly, with scientific annexes Volume I: Report to the General Assembly, Scientific Annexes A and B, 2008.
20. Jabbari N, Zeinali A, Rahmatnezhad L; Patient dose from radiographic rejects/repeats in radiology centers of Urmia University of Medical Sciences, Iran , Health 4, 2012: 94-100
21. Statkiewicz Sherer MA, Visconti PJ; Ritenour ER: Radiation protecuon in medical radiography. 3rd edition, Mosby, SI Louis, 1998.
22. International Commission on Radiation Units and Measurements; Patient dosimetry for X-rays used in medical imaging. J ICRU, 2005; 5(2): Report 74.
23. Gyekye PK, Emi-Reynolds G, Boadu M, Darko EO, Yeboah J, Inkoom S *et al*.; Cancer incidence risks to patients due to hysterosalpingography. J Med Phys., 2012; 37: 112-116.
24. Eng CW, Tang PH, Ong CL; Hysterosalpingography: current applications, Singapore Med J., 2007; 48 (4): 368 –374.
25. Athanasios C, Ioanna T, Fotios L, Petros P, Nikos P, Georgios T; Hysterosalpingography: Technique and Applications. Curr Probl Diagn Radiol., 2009; 38: 199-205.
26. Abdullah BJJ, Ng KH, Rassiah P; A comparison of radiation dose and image quality in hysterosalpingography using conventional and high kilovolt techniques. J H K.Coll Radiol., 2001; 4: 133–136.
27. Mohd Nor H, Jayapragasam KJ, Abdullah BJJ; Diagnostic image quality of hysterosalpingography: ionic versus non ionic water soluble iodinated contrast media. Biomed Imaging Inter J., 2009; 5(3): e29.
28. Kushner DC, Yoder IC, Cleveland RH, Herman TE, Goodsitt MM; Radiation dose reduction during hysterosalpingography: an application of scanning-beam digital radiography. Radiology, 1986; 16: 31–33.
29. Khoury HJ, Maia A, Oliveira M, Kramer R, Drexler G; Patient dosimetry in hysterosalpingography. In Proceedings of the International Conference on Radiological Protection of Patients in Diagnostic, Interventional Radiology, Nuclear Medicine and Radiotherapy. 26–30 March, 2001.
30. Gregan ACM, Peach D, Mc Hugo JM; Patient dosimetry in hysterosalpingography: a comparative study. Br J Radiol., 1998; 71: 1058–1061.
31. Alzimami K., Sulieman A, Babikir E, Alsafi K, Alkhorayef M, Omer H; Estimation of effective dose during hystrosalpingography procedures in certain hospitals in Sudan. Appl Radiat Isotopes, 2015; 2: 100.