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Estimation of effective dose during hystrosalpingography procedures in certain hospitals in Sudan

K. Alzimami [a,*], A. Sulieman [b,c], E. Babikir [a], K. Alsafi [d], M. Alkhorayef [a], Hiba Omer [e]

[a] Radiological Sciences Department, College of Applied Medical Sciences, King Saud University, P. O. Box 10219, Riyadh 11433, Saudi Arabia
[b] Salman bin Abdulaziz University, College of Applied Medical Sciences, Radiology and Medical Imaging Department, P.O. Box 422, Alkharj, Saudi Arabia
[c] Basic Science Department, College of Medical Radiologic Sciences, Sudan University of Science and Technology, P.O. Box 1908, Khartoum, Sudan
[d] Radiology Department, School of Medicine, King Abdulaziz University, Saudi Arabia
[e] Faculty of Medicine, Dammam University, Dammam, Saudi Arabia

HIGHLIGHTS

- Radiation dose was made for females in child bearing age undergoing HSG procedure.
- Radiation doses were measured using calibrated TLD GR200A.
- The study revealed the urgent need for dose reduction techniques.
- Adoption of quality control measures may help to limit variations which are due to equipment related factors.

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ABSTRACT

The aims of this study were to measure the patients' entrance surface air kerma doses (ESAK), effective doses and to compare practices between different hospitals in Sudan. ESAK were measured for patient using calibrated thermo luminance dosimeters (TLDs, GR200A). Effective doses were estimated using National radiological Protection Board (NRPB) software. This study was conducted in five radiological departments: Two Teaching Hospitals (A and D), two private hospitals (B and C) and one University Hospital (E). The mean ESAK was 20.1 mGy, 28.9 mGy, 13.6 mGy, 17.5 mGy, 35.7 mGy for hospitals A, B, C, D, and E, respectively. The mean effective dose was 2.4 mSv, 3.5 mSv, 1.6 mSv, 2.1 mSv and 4.3 mSv in the same order. The study showed wide variations in the ESDs with three of the hospitals having values above the internationally reported values.

1. Introduction

Since its emergence in 1910, Hysterosalpingography (HSG) or uterosalpingography became the most frequently used diagnostic tool to evaluate the endometrial cavity and fallopian tube by using conventional X-ray or fluoroscopy (Chalazonitis et al., 2009). Radiological procedures constitute 4.5% of all fluoroscopic procedures in United States with mean effective dose of 1 mSv (NCRP, 2009). Despite the development of the imaging tools such as computed tomography (CT), magnetic resonance imaging (MRI), laparoscopy, hysteroscopy and ultrasound (US), HSG plays an extremely crucial role in the diagnostic assessment and treatment of infertility in female patients (Úbeda et al., 2001; Krysiewicz 1992). During the procedure, patients are subjected to fluoroscopic and radiographic exposures in genitourinary area; which is very sensitive to radiation, since it includes the ovaries and uterus. The partial exposure of patients result in a heterogeneous dose distribution; therefore the organ dose and effective dose values are more appropriate descriptors of patient dose and related risks. In the literature few studies were published regarding the radiation doses received by the patients (Sulieman et al., 2008; Phillips et al., 2010; Plećaš et al., 2010; Gyekye et al., 2012; Canevaro et al., 2008; Abdullah and Rassiah 2001; Gregan et al., 1998; Yousef et al., 2015; Okeji et al., 2011). These studies show broad differences in terms of dose, fluoroscopic time, number of radiographic images, equipment and inter-examiners variability. In addition, there is a need for continuous assessment of the patient's dose because some data were out-of-date due to improvement in X-ray systems and image receptor. In Sudan, still few data are available in the field of patient doses and its related risks. Therefore, quantification of radiation dose, organ dose and effective dose is important. The

* Corresponding author. Fax: +966 1 4693565.
E-mail address: kalzimami@ksu.edu.sa (K. Alzimami).

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aims of this study were to measure the patients' entrance surface air kerma (ESAKs), estimate the effective doses and to compare practices between different hospitals.

2. Materials and methods

2.1. Patient dose measurement

A total of 79 patients (aged 23–44 year) were examined for a period of 4 months in five radiological departments: (A) Omdurman Teaching Hospital (22 patients), (B) Alnilain Diagnostic Center (21 patients) (C) Asia Specialized Hospital (14 patients), (D) Khartoum Teaching Hospital (12 patients) and (E) The National Ribat University Hospital (10 patients).

2.2. Radiation dose measurement

Radiation dose measurements were made for patients during HSG procedure using TL dosimeters GR-200A TLDs (LiF: Mg, Cu, P (FIMEL, France)). All TLD dosimeters shared the same thermal history. TLD calibration was according to international protocols for the range of energies used in the study in order to determine their response and their individual calibration factor (Martin et al., 1998; Sulieman et al., 2007). The TLD signal was read using PCL3 TLD automatic reader (FIMEL, France) which allows fast readings of a large number of TLD samples with a reproducibility of $0.3 \pm 0.5\%$. The irradiated chips were read out at a 55 °C preheat temperature and the signal was acquired from 55 °C to 260 °C with heating rate of 11 °C/s. All TLDs were annealed in annealing oven (TLDO, PTW: Freiburg, Germany) at 240 °C for 10 min. A total of 40 calibrated TLDs were used in this study. TLDs were packed on a transparent plastic envelope to shield the TLDs from dirt and dust. Each envelope contained 4 TLDs and each of them was identified by its position in the array. The mean ESAK was measured using 2 envelopes (8 TLDs) placed at the center of the radiation field and were kept in position with medical adhesive tape.

2.3. Effective dose estimation

ESAK was used to estimate the organ equivalent dose (H) using software provided by the National Radiological Protection Board (NRPB-SR262,1996) (Hart et al., 1998). NRPB-SR262 is computer software provides estimation of organ doses and effective doses to adult patients undergoing diagnostic X-ray exposures. It contains the results of Monte Carlo calculations modelling the conditions of exposure relevant to 68 common radiographic views on a mathematical phantom representing an average adult patient (with a mass of 70.9 kg and a height of 174 cm and body mass index (BMI (weight/height^2)) of 23.12 kg/m^2, which included the female breasts, ovaries, uterus and testes). Each Monte Carlo run tracked the pattern of energy deposition in the anthropomorphic phantom from primary and scattered photons for total 4,000,000 photons used with each X-ray projection. For each radiographic view, normalized doses are presented for 26 organs or tissues and 3 regions of the body (head, trunk and legs), along with the effective dose as defined by ICRP 103. The data are provided for 40 X-ray spectra ranging from 50 kV to 120 kV peak applied potential and from 2 mm A1 to 5 mm A1 total beam filtration. The doses are normalized to both unit ESD(mGy) and unit DAP(Gy cm^2). Organs doses from HSG were obtained from the average value of conversion factors for anteroposterior pelvis view.

2.4. HSG imaging technique

The HSG procedure is usually carried out directly after the end of the menstrual cycle. At the beginning of the procedure, patient is placed on the table in lithotomic position bends her knees and places her feet at the end of the table. Catheterization of the cervix is performed after insertion of a vaginal speculum using 6 Fr Foley catheter with balloon inflation. Afterwards, the contrast medium is gently injected into the uterus and fallopian tubes. Radiographic and fluoroscopic images were obtained to evaluate the size and shape of the uterus and the fallopian tubes. The technologists perform the investigations as their daily practice. Demographic data: (age, height, weight and BMI) and exposure factors: (kVp and tube current–time product (mAs)) are obtained for all patients.

Table 1
X-ray machine technical data.

Hospitals	Type	Filtration (mm Al)	Maximum tube voltage (kVp)	Date of installation
A	Shimadzu	1.5	150	2007
B	Shimadzu	1.5	150	2004
C	Toshiba	1.5	125	2003
D	Toshiba	3.5	150	2005
E	Siemens	3.5	150	2004

2.5. Radiographic equipment

Five X-ray machines used in this study are from different manufacturers and have different tube characteristics as illustrated in Table 1. All departments used over couch X ray tube and X-ray film/screen with speed of 400.

3. Results

Patients' body characteristics are presented in Table 2. Minor variations were observed among patient populations in terms of weight and BMI. The mean exposure factors used during image acquisition for all groups are shown in Table 3. The patient characteristics and exposure factors are comparable for both groups. The ESAK, effective dose values and number of films for all patients groups are presented in the same table. The results show asymmetry in the dose distribution. This can be attributed to different factors: patient pathology, X-ray machine characteristics and inter-operator differences.

4. Discussion

This study investigated the patient doses during HSG in five hospitals in Khartoum state. Patient doses were evaluated in different hospital to evaluate the current practice and imaging protocol. The mean ESAK for all HSG procedures was ranged between 13.6 ± 4.1 mGy per procedure in hospital C and 35.7 ± 7.8 mGy in

Table 2
Patient characteristic, mean and SD, range in the parenthesis.

Hospital	No.	Patient age (year)	Weight (kg)	BMI (kg/m^2)
A	22	33.8 ± 7.3 (22.0–43.0)	73.4 ± 12.3 (53.0–97.0)	28.1 ± 6.1 (18.8–36.2)
B	21	31.7 ± 5.5 (23–42)	74.2 ± 12.0 (58.0-107.0)	25.6 ± 5.4 (15.5–40.3)
C	14	32.1 ± 4.3 (26–44)	75.1 ± 12.2 (51.0–102.5)	28 ± 4.4 (20.31–34.03)
D	12	31.3 ± 7.1 (22.0–40.0)	75.5 ± 12.8 (54.0–91.0)	25.6 ± 2.5 (20.7–29.0)
E	10	31.1 ± 5.5 (24.0–39.0)	74 ± 7.27 (62.0–85.0)	25.61 ± 3 (20.0–29.6)