# Radiation dose measurements during hysterosalpingography

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**Abstract**

**Objectives:** Hysterosalpingography (HSG) is an effective method to evaluate abnormalities of the uterus and fallopian tube using conventional X-ray or fluoroscopy. The aim of this study was to determine and evaluate the radiation dose for females undergoing HSG during the reproductive period. **Materials and Methods:** This study conducted in three radiology departments: Omdurman Teaching Hospital, Alneelain Diagnostic Center and Asia Specialized Hospital. A total of 50 patients was studied from three hospitals, 20 patients from Neelain Diagnostic Center in range of (25-40) years, 20 patients from Omdurman teaching Hospital in age range from (24 to 43) years. The study duration was carried out for a period of 3 months, from March 2011 to June 2011. Patient dose measurements were performed using unfors dosimeter. Organ dose and effective doses were estimated using National Radiological Protection Board software. **Results:** The mean patient dose was 20.1 and 28.9 and 13. 6 Omdurman Teaching Hospital, Neelain Diagnostic Center and Asia Specialized Hospital, respectively. Ovaries and uterus have the highest dose compared to other organs. **Conclusion:** The results of this study are higher compared with previous studies.

**Key words:** Dose measurements, hystrosalpingography, ovaries, radiation, uterus

## INTRODUCTION

Hysterosalpingography (HSG) is an important diagnostic method for the evaluation of the female reproductive tract that involves the exposure of patients to ionizing radiation. It is a relatively frequent radiogynecological procedure, generally used to assess the uterine cavity and patency of Fallopian tubes.

The common indication for the use of HSG is primary and secondary infertility.[1-4] HSG is merely an initial step in gynecoradiological procedures. Depending on the findings, one may proceed with selective salpingography, tubal catheterization, or a similar therapeutic procedure.[5] In all radiological procedures in gynecology, their radiation of ovaries is unavoidable and one should, thus, consider both the radiation exposure of the patient and the radiological risks associated with it for the fetus and born child during the period of growth.

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| Quick Response Code: | Website: www.sudanmedicalmonitor.org |
| | DOI: 10.4103/1858-5000.144652 |

Concerns over radiation doses received by patients and the associated radiation risks have become a major issue in recent years.[6,7] The contribution of HSG to the collective dose is not significant;[8,9] however, good radiation protection is of utmost importance at the individual level, as the said examination involves the irradiation of females of reproductive capacity and of the gonadal region of relatively young patients, with a possibility for repeated examinations.

There are several studies on dose levels from HSG, mainly from screen-film radiological units. Assessed dose levels are commonly reported in terms of an easily measured entrance surface dose (ESD) or dose-area product.[10,11] However, it is just as important to estimate organ and effective doses

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as quantities directly related to the radiological risk. In the available literature, reported entrance surface air kerma for the HSG procedure is in the range of 9.7-30 mGy while reported kerma-area product values range from 4 to 7 Gycm$^2$.[1,4,8,9,12,13] A typical effective dose to the patient undergoing HSG as a part of infertility work-up is 1.2 mSv to 3.1 mSv, with the ovarian dose in the range of 2.7-9.0 mGy. However, higher values of the effective dose (8 mSv) and corresponding ovarian dose (9-11 mG) were also reported.[1,2,13] Furthermore, the ovarian dose can be as high as 45 mGy,[1] which certainly requires careful analysis and application of dose reduction strategies.

The aim of this study was to determine and evaluate the radiation dose for females during the reproductive period undergoing HSG.

## MATERIALS AND METHODS

A total of 50 patients was examined from three hospitals, 20 patient from Alneelain Diagnostic Center in range (25-40) years, 20 patient from Omdorman teaching Hospital in range from (24 to 43) years.

### Materials

#### *X-ray machines [Table 1]*

Lead aprons for technologist, with 0.5 mm thickness which is made in Japan.

#### *Hysterosalpingography procedure*

Patient lies supine on the table in lithotomic position bends her knees and places her feet at the end of the table. A vaginal speculum inserted into the vagina, the vaginal walls and cervix are cleaned with antiseptic solution. A cannula inserted into the cervical canal, which attached with syringe fill with contrast media (CM), inject CM into the uterine cavity. If the uterine tubes are patent, CM will flow from distal end of the tubes to peritoneal cavity there are four images recorded during conventional radiography using 10 × 12 inch films with vertical center rays 5 cm superior to symphysis pubis (anteroposterior [AP] plain radiograph, AP film with CM to show the uterus. AP film with CM to show the uterine tubes. AP film with CM to show spill of CM in the peritoneal cavity).

#### *Absorbed dose calculations*

Entrance surface doses in this study were calculated using DoseCalc software [developer: BawDuction Software, 2014] developed by the radiological protection center of Saint George' Hospital, London, this software is extensively used to calculate patient dose in diagnostic radiology. For dose measurement using the software, the relationship between X-ray unit current time product (mAs) and the air kerma free in air was established at a reference point of 100 cm from tube focus for the range of tube potentials encountered in clinical practice, the X-ray tube output was measured in (mGy/mAs) using Unfors Xi Dosimeter (Unfors Inc., Billdal, Sweden) with accuracy better than 5%. ESD was calculated according to the following formula:

$$ESD = OPx\left(\frac{kV}{80}\right)^2 xmAsx\left(\frac{100}{FSD}\right)^2 xBSF$$

Where (OP) is the output in mGy/(mA s) of the X-ray tube at 80 kV at a focus distance of 1 m normalized to 10 mA s, (kV) the tube potential, (mA s) the product of the tube current (in mA) and the exposure time (in s), the focus-to-skin distance (FSD) (in cm), and the backscatter factor (BSF). The normalization at 80 kV and 10 mA s was used as the potentials across the X-ray tube and the tube current are highly stabilized at this point. BSF is calculated automatically by the DosCal software after all input data are entered manually in the software. The tube output, the patient anthropometrical data, and the radiographic parameters (kVp, mA s, FSD and filtration) are initially inserted in the software. The kinds of examination and projection are selected afterward.

The study of Davies *et al.* shows that ESDs calculated using DosCal software are within 20% compared with ESDs measured using thermo luminescence dosimeters (TLDs). Another reason for using DosCal software is that the working procedures in crowded emergency department and non-co-operative patient to wear TLDs envelope is somewhat difficult.

#### *Estimation three of absorbed organ doses and effective doses*

Entrance surface doses were used to estimate the organ equivalent dose (*H*) using software provided by the National Radiological Protection Board (SR262).[3]

Organ doses were obtained from pelvis conversion factors for the organ equivalent dose (*mSv*) is given by:

$$H_T = \sum_R W_R . D_{T,R}$$

Where $D_{T,R}$ is the mean absorbed dose to tissue (T) from radiation (R) and $w_R$ is the radiation-weighting factor.

Effective dose (*E, mSv*) is a quantity that has been introduced to give an indication of risk from partial or nonuniform exposure in terms of the equivalent whole body exposure which gives the same risk:

$$E = \sum_T W_T H_T$$

Where $H_T$ is the equivalent dose to tissue *T*.

**Table 1: X-ray machines**

| Hospitals | Type | Model | Filtration | kV-mA max | Date of installation |
|---|---|---|---|---|---|
| A | Shimadzu | 1/2P13DK-85 | 1.5 mm Al at 70 kV | 150 kV-700 mA | November-2007 |
| B | Shimadzu | R-20 J | 1.5 mm Al at 70 kV | 150 kV-500 mA | July-2004 |
| C | Toshiba | LTN-25 m | 1.5 mm Al at 70 kV | 125 kV-500 mA | June-2003 |

**Table 2: Patient body characteristics (age, height, BMI, and weight), screening time and number of radiographic images (mean and range in parentheses)**

| Hospital | Number of patients | Patient age (year) | Weight (kg) | Height (m) | BMI (kg/m²) |
|---|---|---|---|---|---|
| Alneelian diagnostic center | 20 | 32.56±5.1 (25-40) | 73.3±13.0 (60-105) | 1.67±0.15 (1.45-2.2) | 26.21±6.61 (14.46-41.01) |
| Asia hospital | 10 | 34.4±5.25 (27-43) | 74.3±13.9 (52-97) | 1.63±0.1 (1.54-1.69) | 28±4.4 (20.31-34.03) |
| Omdurman teaching hospital | 20 | 32.75±6.21 (24-43) | 72.9±13.0 (50-95) | 1.63±0.05 (1.51-1.7) | 27.6±5.2 (18.65-35.08) |

BMI = Body mass index

## RESULTS

The blockage of tubes is the most common indication in this study which was 24% of total number of patients (in Al neelain diagnostic center which 25%, 10% in Asia hospital and 30% in Omdurman teaching hospital), and recurrent abortion 12% in total number of patients (15% in Alneelain diagnostic center, 30% in Asia hospital) [Table 2 and 3].

The HSG indications are initial diagnosis for blockage of tubes, inversus uterus, salpingitis, blind external os, recurrent abortion, and bicornuate uterus.

## DISCUSSION

This study intended to provide a detailed evaluation of radiation dose during HSG and to analyze factors that might affect the radiation dose for patients. Patient body characteristics data (age, height, weight, and body mass index [BMI]) [Table 2] in this study, the patient age ranged (25-40) years in alneelain diagnostic center, (24-43) years in Omdurman teaching hospital and (27-43) years in Asia. The mean height, weight, and BMI in alneelian medical center were 1.7 m, 73.2 kg, 26.2 kg/m², in Omdurman teaching hospital were 1.6 m, 72.9 kg, 27.6 kg/m² and in Asia hospital were 1.6 m, 74.3 kg, 28 kg/m², respectively. The number of films depend on the pathologic conditions. The exposure factors (kVp, mAs) for all patients were comparable in three hospitals. In general, high kVp increase the scatter radiation thus also the patient's dose, while decreasing the contrast of the image. The quality of the radiation depends on the tube voltage and the total filtration of the X-ray beam. Radiographic exposure factors used in this study ranged 69-88 kVp and 12.6-30 mAs (the highest kVp used in Alneelain diagnostic center which is 88 kVp and the lowest kVp used in Omdurman teaching hospital which is 66 kVp, the highest mAs used in Asia which is30 mAs and the lowest mAs used in Omdurman teaching hospital which is12.6 mAs) [Table 3].

**Table 3: Describes mean and SD of (kV, mAs and number of films)**

| Hospital | kV | mAs |
|---|---|---|
| Alneelian diagnostic center | 77.9±4.72 (70-88) | 24.05±2.54 (20-28) |
| Asia hospital | 75.6±4.50 (69-81) | 23.4±4.62 (20-30) |
| Omdorman teaching hospital | 71.9±3.22 (66-77) | 18.93±3.08 (12.6-24) |

SD = Standard deviation

The mean ESD and E resulting from HSG procedure has been estimated to be 20.9 mGy and 1.94 mSv, respectively, for the total patient population table. The mean ESD result for all patients is higher than the previous study [Table 5]. This result indicates that a low degree of patient dose achieved in the previous studies. The effective dose in this study estimated to be 1.94 mSv higher than Sulieman *et al*. 0.43 mSv.[2] As HSG involves direct irradiations of some of the internal and radiosensitive organs, effective doses for specific organs were estimated are illustrated in Table 4. Ovaries, uterus, and bladder dose which receives radiation was estimated as 4.9, 6.7, 12.2 mGy in Alneelian diagnostic center, 2.3, 3.14, 5.7 mGy in Asia hospital and 3.4, 4.6, 8.5 mGy, respectively, in Omdurman teaching hospital. The equivalent dose for the breast is very low value because the breast too far away field of view "pelvis region." The bladder doses is the highest one.

## CONCLUSIONS

This study measured the patient doses during HSG in three hospitals in Khartoum state. The mean ESD result for all patients is higher than the previous studies. The dose values showed wide variation in the three hospitals. This can be attributed to the machine characteristics, technique, and operator experiences. Optimization

**Table 4: Organ dose**

| Organ | Alneelian diagnostic center | Asia hospital | Omdorman teaching hospital |
|---|---|---|---|
| Uterus | 6.7 | 3.14 | 4.6 |
| Ovaries | 4.9 | 2.3 | 3.4 |
| Breast | 0.002 | 0.008 | 0.012 |
| Bladder | 12.2 | 5.7 | 8.5 |
| Small intestine | 6.01 | 2.82 | 4.18 |
| Spleen | 0.17 | 0.08 | 0.12 |
| Pancreas | 0.17 | 0.08 | 0.12 |

**Table 5: Patient dose in three centers**

| Hospital | Mean | SD | Range |
|---|---|---|---|
| Alneeleen | 28.9 | 6.3 | 21.5-42.5 |
| Asia | 13.6 | 4.1 | 9.5-19.7 |
| Omdurman | 20.1 | 4.6 | 11.8-27.4 |
| Total | 20.9 | 5 | 9.5-42.5 |

SD = Standard deviation

technique is important in order to reduce patient doses to the international levels.

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**How to cite this article:** Yousef M, Tambul JY, Sulieman A. Radiation dose measurements during hysterosalpingography. Sudan Med Monit 2014;9:15-8.

**Source of Support:** Nil. **Conflict of Interest:** None declared.