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ORIGINAL ARTICLE

A Comparison of Radiation Dose and Image Quality in Hysterosalpingography Using Conventional and High Kilovolt Techniques

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ABSTRACT

Objective: *To compare the dose area product, effective dose, and image quality of hysterosalpingography using conventional and high kilovolt techniques.*

Patients and Methods: *Image quality and patient dose were assessed for hysterosalpingography examinations performed on 30 patients at the University of Malaya Medical Centre. Dose-area product was measured and the effective dose estimated using conversion factors tabulated by the National Radiological Protection Board of the United Kingdom. Image quality was assessed by three radiologists based on an objective set of criteria.*

Results: *The results showed no significant decrease in patient dose with the use of high kilovolts, while screening times contributed substantially to the total patient dose received. The mean dose-area product for the conventional kilovolt technique was 4.95 Gycm^2 and 4.68 Gycm^2 for the high kilovolt technique. The effective dose yielded 1.36 mSv for conventional kilovolts and 1.33 mSv for high kilovolts. There was no significant difference in image quality with the use of high kilovolts, the average image quality score being 33 and 31 for conventional kilovolts and high kilovolts, respectively.*

Conclusion: *Hysterosalpingography using the high kilovolt technique is comparable to the conventional technique in terms of both patient dose and image quality.*

Key Words: *Dose-area product, Effective dose, Hysterosalpingography, Image quality, Technique factors*

INTRODUCTION

Despite the use of ionising radiation, hysterosalpingography (HSG) remains an excellent radiological technique and is often the only procedure performed routinely for the investigation of infertility.[1] HSG clearly demonstrates the morphology of the uterine cavity and the presence of any obstruction. Ultrasound, including echo-enhancing contrast medium (hysterocontrast sonography), offers a possible alternative,[2] although lack of expertise and high cost may be a limitation.

As HSG is performed primarily on women of child-bearing age, good radiological practice is important to keep the radiation dose to the minimum. However, there is little information in the literature on HSG reference doses.[3] One estimate of ovarian dose derived from entrance surface dose, using thermoluminescent dosimetry (TLD) data, was 2.8 mGy for a 24 x 30 cm film screen radiography.[4]

The use of the high kilovolt (kV) HSG technique has not been evaluated. This technique can reduce the amount of scatter radiation deposited within the body, and thus the mean effective dose to the ovaries. The objective of the current study was to compare the dose-area product (DAP), the effective dose, and the image quality of HSG using conventional and high kV techniques.

PATIENTS AND METHODS

The HSG examinations were performed on 30 patients randomly selected from those presenting for investigation of infertility at the University of Malaya Medical Centre (UMMC). All patients gave informed

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consent for the investigative procedures. 16 patients were evaluated by the high kV technique, while 14 patients were assessed using the conventional kV technique. The ethnic distribution was eight Chinese, 10 Indians, and 12 Malays. Patient's ages ranged from 23 to 41 years (mean, 32 years), weight ranged from 42 to 71 kg (mean, 57 kg), and body mass index ranged from 19 to 29 kg/m^2 (mean, 24 kg/m^2). Dose measurements were recorded using a dose area product meter (Diamentor M, Physikalisch-Technische Werkstatten, Freiburg, Germany) during HSG examinations undertaken with an under-couch fluoroscopy unit (Toshiba DC-1050F, Tokyo, Japan). All exposures were made on 24 x 30 cm cassettes, with 400 being the nominal relative speed of the screen-film combination (Kodak X-Omat film and Kodak Lanex regular screen, Rochester, USA).

Dose-area product (DAP) readings (Gycm^2) were corrected against a secondary standard dosimeter referenced to a primary standard. The DAP meter was calibrated over the range of 60 to 120 kV.[5] Other data noted during the procedure included the degree of difficulty of the examination, the applied potential range during fluoroscopy, the screening time and the number of radiographs taken.

Examination Procedure

The usual sequence of the HSG examination was as follows. A 24 cm x 30 cm, 'split two', radiograph was taken as a control followed by a subsequent radiograph on the same film once the uterine cavity was filled with contrast medium (Lopamiro, Bracco, Italy). When the fallopian tubes were sufficiently filled to demonstrate the peritoneal spill, two further radiographs were taken on another 24 cm x 30 cm film.

For both the conventional and high kV techniques, fluoroscopy was undertaken at 70 to 98 kV, depending on the patient's size. Radiographs were taken at 115 kV or 120 kV for the high kV technique whereas 68 to 98 kV was used for the conventional kV technique. As UMMC is a teaching hospital, all HSG examinations were performed by trainee radiologists under the supervision of a certified radiologist. The radiographic images obtained were assessed according to a set of image quality criteria and scored independently by three experienced radiologists (Table 1). Any difference in scoring was resolved by consensus discussion.

Table 1. Image quality criteria and scoring system for hysterosalpingography

1	Demonstration of the uterine outline	
2	Density of the intrauterine cavity	
3	Demonstration of the cornua on either side	
4	Demonstration of the isthmus on either side	
5	Demonstration of the fimbria on either side	
6	Demonstration of the peritoneal spill on either side	
7	Demonstration of the cortex of the pelvis	
8	Demonstration of the trabeculae of the pelvic bones	
•	Poorly visualised and not diagnostic	0
•	Poorly visualised but diagnostic	1
•	Good demonstration and diagnostic	2
•	Excellent visualisation	3
•	Visualisation obscured by pathology	Pathology

Estimation of Effective Dose

Total DAP is the measurable dose quantity recommended for complete examinations in the UK National Protocol – Dosimetry Working Party, National Radiological Protection Board (NRPB).[5] DAP is not directly related to effective dose and so cannot be used for comparing risks to patients under different exposure conditions. For instance, increasing tube potential will reduce entrance surface dose and DAP without a corresponding reduction in depth dose.[6] However, the NRPB tables[7] contain conversion factors for a variety of exposure conditions and different projections which were used to estimate the effective dose for patients. The effective dose from the fluoroscopy and radiographic exposure were considered separately because of the different exposure factors and projections used.

RESULTS

The findings of the study are presented in summary form in Table 2 and Table 3. The mean DAP for conventional kV was 4.95 (2.20 to 13.0) Gycm^2 while for

Table 2. Comparison of normal kV and high kV technique

	Conventional kV technique	High kV technique
Mean DAP / Gycm^2 (minimum to maximum)	4.95 (2.20-13.0)	4.68 (2.63-8.55)
Median DAP/ Gycm^2	3.34	4.11
Image quality score	33	31
Mean number of radiographs	2	2
Mean screening time (seconds) [minimum to maximum]	119 (44-285)	112 (48-304)
Mean effective dose for whole examination (mSv)	1.36 (0.60-3.48)	1.33 (0.6-2.40)

Abbreviations: kV = kilovolt; DAP = dose-area product.

Table 3. Contribution of radiography and fluoroscopy to effective dose (mSv)

	Conventional kV technique		High kV technique	
	Radiography	Fluoroscopy	Radiography	Fluoroscopy
Minimum	0.28	0.23	0.08	0.51
Mean	0.36	1.00	0.16	1.16
Median	0.37	0.54	0.17	1.03
Maximum	0.42	3.14	0.27	2.21

Abbreviation: kV = kilovolt.

high kV it was 4.68 (2.28 to 8.55) $Gycm^2$. The difference in the total DAP noted between the conventional and high kV techniques was not statistically significant (t-test, $p>0.05$). This finding is illustrated in Figure 1 which shows the total DAP distribution for both techniques. The large variation in the total DAP distribution for both the normal kV and high kV techniques reflects differing kV selection during screening, according to patient size and radiologists' preference. In addition, screening time depended on the complexity of the examination and the experience of the trainee radiologist performing the investigation.

The screening times and applied potentials used during fluoroscopy were comparable for both techniques. The mean screening times were 119 seconds and 112 seconds for the conventional kV and high kV techniques, respectively. As the mean screening time and applied potential during screening for both techniques were similar, it is reasonable to assume that the DAP contributed by fluoroscopy was also similar.

The image quality scores for both techniques were comparable. Images obscured by pathological conditions (not by exposure techniques) were not included in the calculation of the mean image quality score.

Radiographs contributed 10% of the total DAP in the high kV technique, whereas radiographs contributed 27% of the total DAP with the conventional kV method. Fluoroscopy accounted for 70% to 90% of the total dose for both the conventional and high kV techniques, masking the differences seen between the techniques with respect to radiograph dose. These were almost three times higher with the conventional kV technique than for the high kV technique (Table 2). This leads to the assumption that the total radiation dose could be significantly reduced without deterioration in image quality with the use of high kV, if the screening time is lowered. However, a lower mean screening time may not be achievable in a teaching institution such as the UMMC where investigations are frequently completed by trainee radiologists.

DISCUSSION

Despite HSG being the most widely used technique in the assessment of infertility, there has been little research completed on HSG radiation doses. Fernandez et al reported a median DAP with HSG assessment of 713 $cGycm^2$ (range, 247 $cGycm^2$ to 1623 $cGycm^2$).[3] The current study however, showed that the DAP was 495 $cGycm^2$ (range, 220 $cGycm^2$ to 1300 $cGycm^2$) for

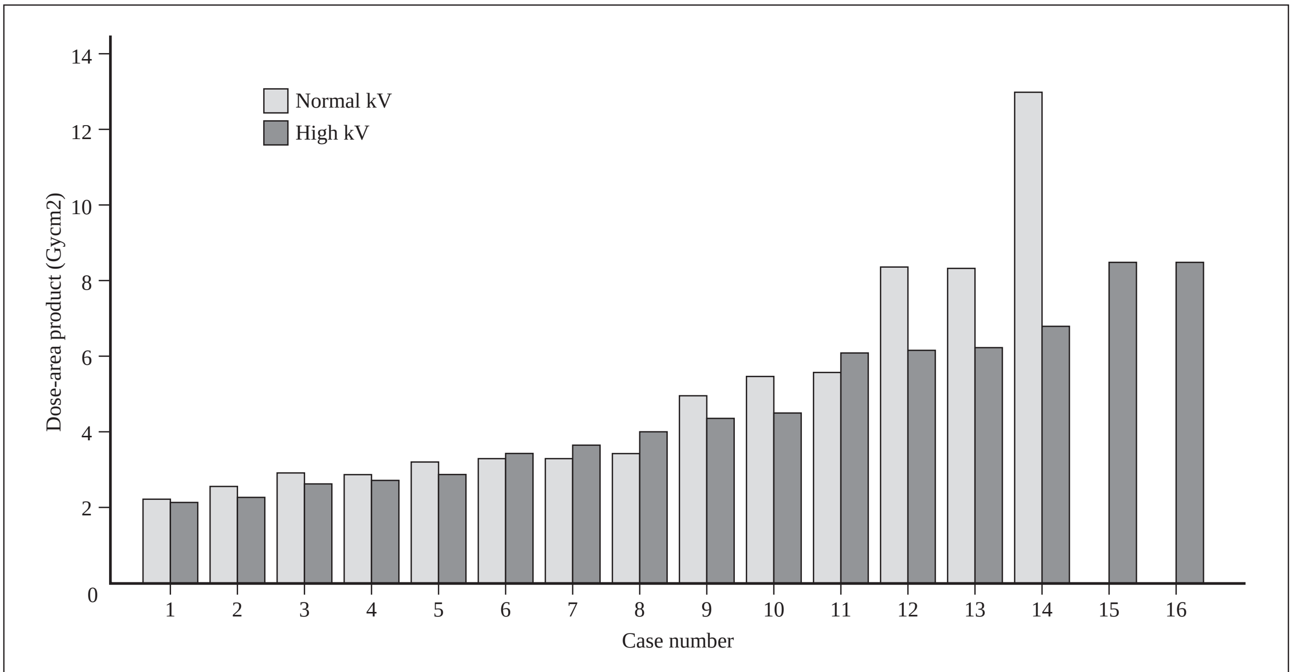

Figure 1. Distribution of total dose-area product for normal and high kilovolts.

the conventional kV technique while the high kV technique showed a mean DAP of 468 $cGycm^2$ (range, 228 $cGycm^2$ to 848 $cGycm^2$). The difference in the doses between these two studies probably relates to the fact that the Fernandez et al study used seven exposures for each study examination while the UMMC study used only four exposures. Greater screening times were used in the current study — from 44 to 304 seconds compared with 6 to 60 seconds reported by Fernandez et al. This marked increase in screening time was due to the fact that most of the studies at UMMC were performed by trainee radiologists under supervision. The impact of screening times on DAP is highlighted by the fact that 70% to 90% of the DAP in this study was due to fluoroscopy, compared with only 26.8% in the Fernandez et al study.[3]

The current study indicates that the DAP using high kV technique radiographs was almost three times lower than that using the low kV conventional technique without any deterioration in image quality. Following the recommendations of the NRPB (reference values of DAP per examination based on the third quartile values), the reference value obtained from this study was 6 $Gycm^2$. This value was derived by combining both the techniques since the difference in total DAP between the two techniques was insignificant. Overall, the study demonstrated that in the setting of a teaching hospital, HSG using the high kV technique, appears comparable with the conventional HSG technique, both in terms of patient dose and image quality.

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