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Original Article

Entrance Surface Dose in Intravenous Pyelography Patients at Songklanagarin Hospital

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Abstract

The purposes of the study are to determine of entrance surface dose and the dose reference level from Intravenous Pyelography patients during April-July 2008 at Songklanagarind Hospital. The doses were calculated at the patient skin from 121 patients in 7 radiographic routine projections: scout IVP AP view, 5 min after contrast media injection, 10 min prone, 10 min supine, 30 min, full bladder and post voiding. The results showed the mean /third quartile entrance skin doses, using as the dose reference level at this center, for the 7 projections of 1.90/2.10, 2.93/3.47, 1.72/2.00, 2.22/2.68, 2.39/2.76, 2.99/3.44 and 2.25/2.70 mGy respectively. Most of the dose levels were generally within normal range of the diagnostic reference levels specified by European Commission as the European Guidelines for KUB studies of 10 mGy for entrance surface dose of a standard sized patient. However, there was one record with over normal range value caused by improper radiographic exposure technique.

Key Word: entrance surface dose, intravenous pyelography, radiographic projection

Introduction

The optimal use of ionizing radiation involves the interplay of three important aspects of the imaging process:

1. The diagnostic quality of the radiographic image,
2. The radiation dose to the patient,
3. The choice of radiographic technique.

In order to meet the optimization in patient, the European Commission[1] (EC) had set up The European Guidelines on Quality Criteria for Diagnostic Radiographic Images. This contains the Quality Criteria for six conventional examinations: Chest, Skull, Pelvis, Lumbar Spine, Urinary Tract and Breast. It defines diagnostic requirement for a normal, basic radiograph, specifying anatomical image criteria and important image details; it indicates criteria for the radiation dose to European Guidelines on Quality Criteria for diagnostic radiographic images.

As the routine intravenous pyelography (IVP) radiographic examination consists of seven projections of

1. Scout IVP
2. Five minutes after contrast media injection
3. Ten minutes after injection, supine projection
4. Ten minutes after injection, prone projection
5. Thirty minutes after injection
6. Full Urinary Bladder
7. Urinary Bladder Post voiding

Special care is taken during x-ray examinations to use the lowest radiation dose possible while producing the best images for evaluation. National and international radiology protection councils continually review and update the technique standards used by radiology professionals.

Quality Criteria for Diagnostic Radiographic Images[2] - KUB

1. Diagnostic requirements - Image criteria

1.1 Reproduction of the area of the whole urinary tract from the upper pole of the kidney to the base of the bladder

1.2 Reproduction of the kidney outlines

1.3 Visualization of the psoas outlines

1.4 Visually sharp reproduction of the bones

2. Important image details:

calcifications of 1.0 mm

3. Good Radiographic Technique

3.1 Radiographic device: grid table

3.2 Nominal focal spot value: 1.3 mm

3.3 Total filtration: 1.3 mm Al equivalent

3.4 Anti-scatter grid: r = 10; 40/cm

3.5 Screen film system: nominal speed class 400

3.6 FFD: 115 (100-150) cm

3.7 Radiographic voltage: 75-90 kV

3.8 Automatic exposure control: chamber selected - central or lateral

3.9 Exposure time: < 200 ms

3.10 Protective shielding: where appropriate, gonad shields should be employed for male and female patients.

- AP Projection

Either as plain film or before or after administration of contrast medium

Remarks: Compression is usually indicated. Satisfactory reduction of overlying bowel gas and faeces is essential for adequate urinary tract reproduction.

4. Diagnostic requirements- function criteria

Image criteria are to be referred to a series of radiographs, taken at intervals after contrast administration, tailored to the individual patient.

4.1. Increase in parenchymal density (nephrographic effect)

4.2. Visually sharp reproduction of the renal pelvis and calyces (pyelographic effect)

4.3. Reproduction of the pelvic-ureteric junction

4.4. Visualization of the area normally traversed by the ureter

4.5. Reproduction of the whole bladder area

5. Important image details

5.1. Calyceal detail: 0.3 mm

5.2. Calcifications: 1.0 mm

Criteria for Radiation dose to the Patient

Entrance surface dose for a standard-sized patient is 10 mGy per radiograph

1. Dose Monitoring

Prior to patient dose assessment, the information on x-ray exposure parameters (kVp, mAs) and geometrical parameters- X-ray tube focus film distance (FFD), X-ray tube focus-to-skin distance (FSD), field size in X-ray examinations of adult patients of average body mass for selected X-ray projections were collected. The X-ray exposure parameters were used later to estimate patient doses through a four step protocols: X-ray tube output measurement, incident air-kerma measurements, the entrance skin air-kerma (ESAK) calculations and entrance skin dose (ESD) determinations.

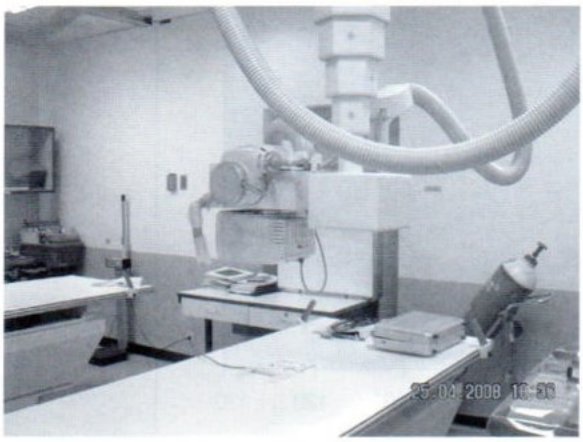
Materials

1. X-ray system. Manufacturer Quantum Model VZW2930 RC 2-82 (Fig 1A)
2. Solid state detector manufacturer UNFORS Model Xi (Fig 1B)
3. Special ruler for patient thickness measurement

Methods

1. Perform the quality control of the radiographic system using AAPM protocols for kVp accuracy and mGy/mAs test.

2. Patient data collection:



(A)

Fig.1A Radiographic system for IVP procedure.

(B)

Fig.1B Solid state dosemeter for air kerma measurements

2.1 H.N.

2.2 Age, weight, height, body thickness, gender

2.3 Patient dose determination

2.3.1 Record the following parameters: kVp, mA, FDD, FFD, exposure times.

2.3.2 Calculate the patient entrance skin dose, ESD

$$ESD = Y(kVp,\ FDD) \cdot mAs \cdot \left[\frac{FDD}{FDD\text{-}t_p} \right]^2 \cdot BSF$$

Y(kVp, FDD) is tube output for actual *kVp* used during examination (taken from output chart), *mAs* is actual tube current-time product used during examination and *FFD* is focus-to-film distance, while *FDD* is focus-detector distance and t_p is the patient thickness. BSF is the backscatter factor that depends on kVp and total filtration of X rays.

Results

1. The kVp accuracy and the relationship with mGy/mAs determination. The set kVp and measured kVp are accepted as they were within 10 percent. The relationship between the set kVp and mGy/mAs is displayed in fig. 2 as the output in air, air kerma, at the particular distance. The solid state detector is placed in air as the geometry in fig. 3 showing the distance of FFD and FDD.

2. Patient characteristics. Number of patients is 121 as information in table 1.

Discussion

The 121 patients underwent IVP in the year 2008 at Department of Radiology, Songklanagarind Hospital were 51 males and 70 females. The

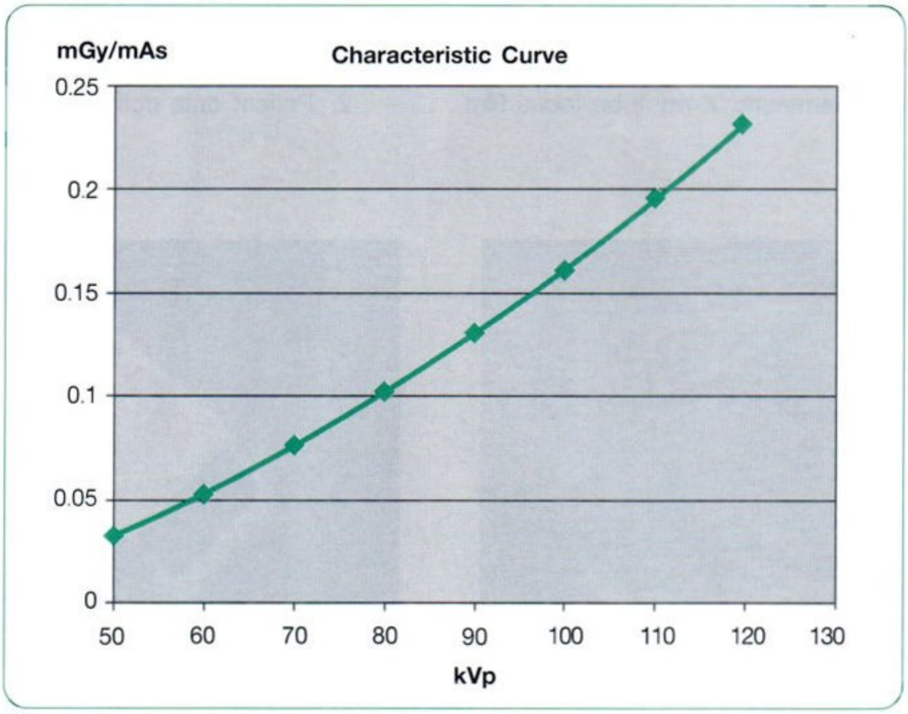


Fig.2 The linear relation between kVp and mGy/mAs

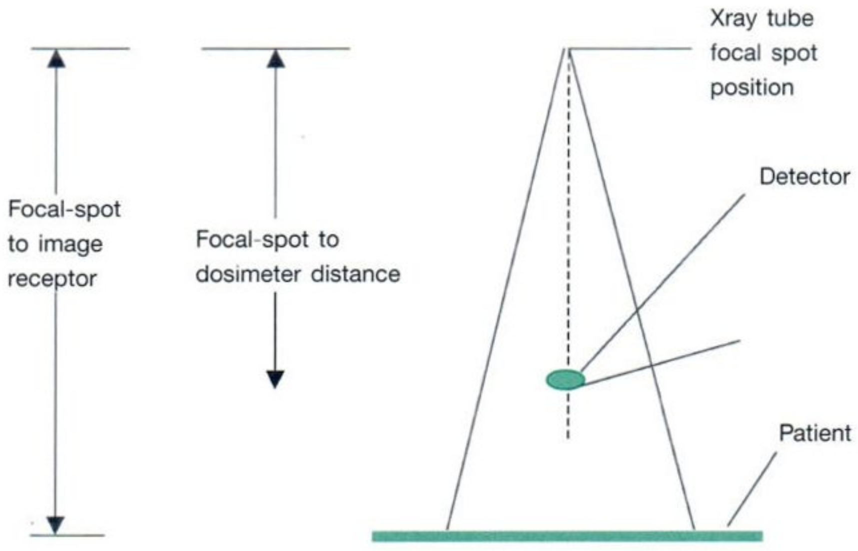


Fig.3 Geometry used for X- ray output measurements

Table 1 The information from 121 patients who underwent IVP at Songklanagarind Hospital

Gender		Age (years)			Weight (kg)			Height (cm)			BMI (kg.m^{-2})		
Male	Female	Ave	Min	Ma	Ave	Min	Max	Ave	Min	Max	Ave	Min	Max
51	70	54	20	80	65	43	96	163	148	180	24.45	15.76	33.6

Fig.3 An X-ray image during IVP procedure

images were taken for each projection as the exam in fig.3. The age range was 20-80 years old, the weight was 43-96 kg, the height 148-180 kg and the body mass index was 15.76-33.60 kg.m^{-2}. The average entrance surface dose for all 7 projections was 1.90-2.99 mGy. The maximum ESD was recorded at projection 6 of urinary bladder of 11.84 mGy which exceeded the Dose Reference Level of 10 mGy per projection. The third quartile per projection was calculated and range was 2.0-3.47 mGy. Those values were much less than the DRL of 10 mGy. The scatter plot on body thickness and ESD showed the poor relation between both parameters. The ESD increases as the body thickness increases. The urinary bladder received the

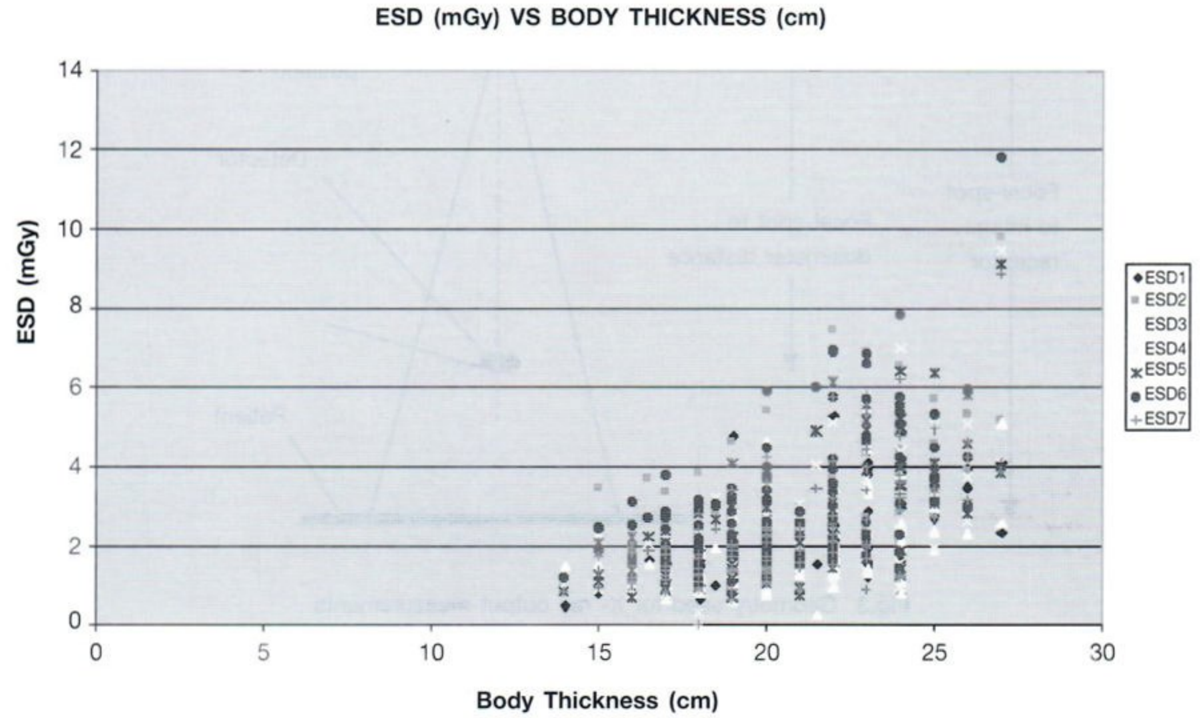


Fig.4 The correlation between the patient skin dose (mGy), ESD and body thickness (cm)

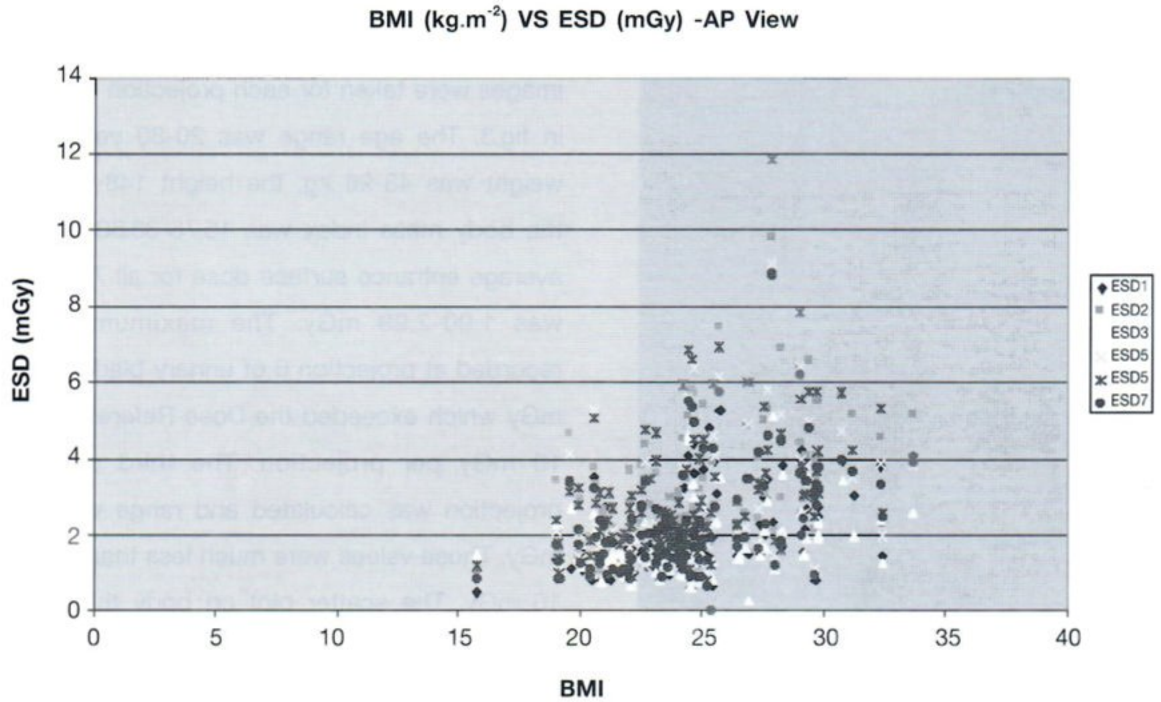


Fig.5 The relation between the patient skin dose of 7 projections (ESD, mGy) and the Body Mass Index (kg.m^{-2})

Table 2 The calculated entrance skin dose for 7 projections as the average, minimum and maximum values in mGy

	kVp	ESD1	ESD2	ESD3	ESD4	ESD5	ESD6	ESD7
Ave	81	1.90	2.93	1.72	2.22	2.39	2.99	2.25
Min	72	0.51	0.96	0.29	0.32	0.71	0.80	0.66
Max	88	5.30	9.82	5.13	9.47	9.12	11.84	8.85
3rd quartile		2.10	3.47	2.0	2.68	2.76	3.44	2.70

highest ESD of 11.84 mGy and the body thickness at the pelvis was 27 cm. as in fig.4. The relation between the body mass index and the entrance surface dose was shown in fig.5 of the scatter plot of increasing BMI resulted in the increasing ESD. The ESD from projection 1, scout view, and patient number was shown in bar graph as in fig.6.

Conclusion

An intravenous pyelogram (IVP) is an x-ray examination of the kidneys, ureters and urinary bladder that uses iodinated contrast material injected into veins. State-of-the-art x-ray systems have tightly controlled x-ray beams with significant filtration and dose control methods to minimize stray or scatter

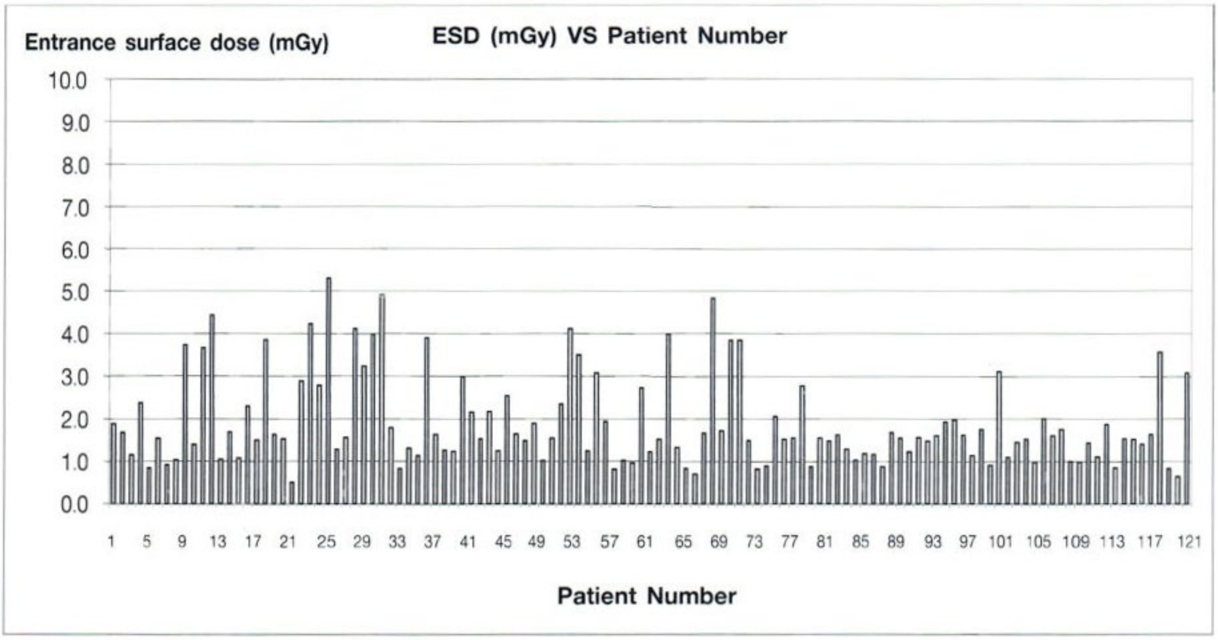


Fig.6 The bar graph of ESD (mGy) of scout view projection with the patient number.

radiation. This ensures that those parts of a patient's body not being imaged receive minimal radiation exposure.

Generally, the effective radiation dose from this procedure is about 1.6 mSv[3], which is about the same as the average person receives from background radiation in six months. From our study, the effective dose is only 0.38 mSv for the average ESD of 7 projections which is about a quarter of the international dose value.

The survey on the status of image quality and radiation dose to patients in IVP examination forms an important component of a quality assurance program. Knowledge of the image quality and patient dose level, as well as reasons behind poor quality and higher doses, provide a basis for setting corrective actions in order to optimize the protection of the patient in an effective manner. Patients expected to be informed about clinical risks including radiation risks 4,5 hence another aspect of the usefulness of patient dose data. The determination of the ESD and the DRL are the important part of the optimization process in diagnostic radiology.

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