RADIATION DOSE DURING ANGIOGRAPHIC PROCEDURES

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Abstract

The use of angiographic procedures is becoming more prevalent as new techniques and equipment are developed. There have been concerns in the scientific community about the level of radiation doses received by patients, and indirectly by staff, during some of these radiological procedures. The purpose of this study was to assess the level of radiation dose from angiographic procedures to patient at the Ottawa Hospital, General Campus. Radiation dose measurements, using Thermo-Luminescent Dosimeters (TLDs), were performed on more than 100 patients on various procedures. The results show that while the patient dose from the great majority of angiographic procedures is less than 2 Gy, a significant number of procedures, especially interventional procedures may have doses greater than 2 Gy and may lead to deterministic effects.

1. Introduction

In the last few years, the number, the type and complexity of interventional radiological procedures has dramatically increased. These changes were driven by improvements in equipment design, the need for improved patient prognoses and the necessity for more cost effective treatments. With the increased complexity of these procedures, the irradiation time has also increased, giving rise to concern about patient doses. There have been a few reports of deterministic effects from angiographic procedures, especially interventional procedures. For instances, Carstens et al have reported a case of radiation dermatitis after embolization [1], Freedman et al reported radiation burns during a transjugular intrahepatic portosystemic shunt (TIPS) procedure [2], Huda et al reported cases of temporary epilation after an neurological procedure [3], and Shope reported a few cases of radiation induced skin injuries from interventional procedures [4].

Following the reported cases of radiation damage from interventional procedures, the United States Food and Drug Administration had issued a bulletin to health care professional on the potential for radiation injuries from angiographic procedures [5]. This bulletin requests that the absorbed dose to the irradiated areas, likely to approach the threshold for radiation injury, be estimated for angiographic procedures, including interventional procedures. The area of interest when performing these evaluations for angiographic procedures is the skin area closest to the entrance X-ray beam since it will receive the largest amount of radiation.

2. Equipment and method

All procedures were done by the same team of radiologists using an Omnicon L Digital Subtraction Angiography (DSA) unit (Picker, Cleveland OH), utilizing 15 pulse/s fluoroscopy. The entrance doses were measured by placing several equally spaced packets of three thermo-luminescent dosimeters (TLDs) on the table under the patient's pelvis to cover the area exposed to radiation during the procedure. Three TLDs were used per packet to provide confidence for each measurement point. The TLDs used were TLD-100 (LiF) (Harshaw, Cleveland, OH). TLD-100 (LiF) has been shown to be appropriate for the measurements of both skin entrance and organ doses in diagnostic radiology [6]. Each TLD measures approximately 3 x 3 x 1 mm^3. The separation between the packets used was 10 cm

at first and was subsequently decreased to 3 cm. This change in the packet separation was made to increase the number of measurement points to confirm the radiation pattern of entrance dose. The TLDs were calibrated for the energies used during the procedures and were processed at Health Canada laboratories on a Harshaw Nuclear Systems Model 2000D TLD reader (Harshaw, Cleveland, OH). Technical data, such as the tube voltage, current, fluoroscopy time, the number of DSA images and the tube position were recorded for each procedure.

3. Results

The skin entrance doses and pertinent information for angiographic procedures are presented in Table 1. The values presented are the average for all patients undergoing the specific procedure. The numbers in parentheses show the range of values measured for each category.

Table 1. Results of the radiation dose measurement for diagnostic angiographic procedures

Procedure	# of proc.	Patient weights (kg)	Irradiation time (min.)	# images	Dose (mGy)
Aorta/Iliac Arteries					
Translumbar aortogram	3	99 (70-136)	3.5 (2.3-5.2)	88 (76-104)	162 (45-299)
Iliac artery angioplasty & stenting	3	71 (68-84)	20.5 (3.8-43.1)	88 (43-190)	1,028 (161-2,560)
Carotid Artery					
Carotid artery angiogram	1	64	3.3	97	80
Carotid artery angioplasty & stenting	1	74	27.3	93	188
Embolization					
Embolization of liver tumours	8	78.5 (48-117)	20.2 (12.7-43.5)	144 (56-473)	2,062 (137-9,329)
Uterine Artery Embolization	28	73 (53-120)	29.2 (13.3-54.1)	124 (66-241)	1,289 (383-3,363)
Abdomen					
Inferior Vena Cava filter placement	2	66 (64-68)	3.0 (2.9-3.1)	25 (22-27)	44 (41-47)
Abdominal angiogram	3	79 (50-114)	6.8 (4.8-8.1)	243 (163-311)	935 (138-2,450)

One of the major problems in assessing the patient dose is that the range of doses for a specific procedure can be quite considerable. Table 2 shows the individual patient skin entrance dose for embolization of liver tumours. The entrance skin dose values presented are the maximum measured doses for each patient.

Table 2. Results of the radiation dose measurement for embolization of liver tumours

Patient	Age/sex	Weight (kg)	Irradiation	# images	Dose (mGy)
17	47 / M	84	13.1	69	1,032
22	56 / M	97	20.2	162	999
30	71 / F	50	23.2	95	222
35	59 / M	86	18.1	114	573
49	71 / F	48	18.0	108	137
51	68 / M	82	43.5	473	9,329
61	64 / F	117	12.7	74	3,273
63	40 / M	64	13.1	56	930
Average		*78.5*	*20.2*	*144*	*2,062*

4. Discussion

The measurement of patient doses is not an easy task. If properly handled, TLDs can provide an accurate value of skin doses. Unfortunately, TLDs are complicated to use and have limited usage in a clinical setting. Another method of measurement is the use of a detector to measure the dose-area product. The major drawback of the use of dose-area product measurement during angiographic procedures is that it is often difficult to relate the result to the skin dose or to a specific organ dose. This is especially true with angiographic procedures where patients are being irradiated at different angles and skin surface locations for various irradiation times.

In general, patient doses are greater in interventional procedures than in diagnostic angiographic procedures. Not all interventional procedures generate large skin doses. For example, the skin dose produced during the placement of an inferior vena cava filter is small. One of the most difficult problems in assessing the risk from an angiographic procedure is the large variability of skin doses for different patients. For each procedure, it is important to know the range of skin doses that can be attained since this range can be very wide. For example, the embolization of liver tumours, as demonstrated in Table 2, the range of skin doses is from 137 mGy to 9,329 mGy. Two of the eight patients received skin doses greater than the threshold level of 2 Gy. Other procedures show the same characteristics; for iliac angioplasty and stenting, the range of doses is from 161 mGy to 2,560 mGy, for uterine artery embolization, the range is from 383 mGy to 3,363 mGy, and for abdominal angiogram, the range is from 138 mGy to 2,450 mGy. The most important factors responsible for such large variations of skin doses are the size of the patient, the expertise of the operator, and the difficulty in performing the procedure.

Skin doses can be greater than 2 Gy for many interventional procedures. A complete assessment of the range of skin doses should be done to evaluate the risk of deterministic effects for specific procedures.

References

[1] CARSTENS, G.J., HOROWITZ, M.B., PURDY, P.D., et al., Radiation dermatitis after spinal arteriovenous malformation embolization: case report. Neuroradiol. **38** (1996) S160-S164.

[2] FREEDMAN, A.M., SANYAL, A.J., Complications of transjugular intrahepatic portosystemic shunts. Semin. Intervent. Radiol. **11** (1994) 161-177.

[3] HUDA, W., PETERS, K.R., Radiation-induced temporary epilation after a neuroradiologically guided embolization procedure. Radiol. **193** (1994) 642-644.

[4] SHOPE, T.B., Radiation-induced skin injuries from fluoroscopy. Radiographics **16** (1996) 1195-1199.

[5] FOOD AND DRUG ADMINISTRATION, Important information for physicians and other healthcare professionals: recording information in the patient's medical record that identifies the potential for serious x-ray-induced skin injuries following fluoroscopically guided procedures. Rockville, Maryland (1995).

[6] PRADHAN, A.S., SASANE, J.B., GOPALAKRISHNAN, A.K., et al, A TLD method for evaluation of radiation quality and measurement of entrance skin dose from diagnostic X-ray practices, Radiat. Prot. Dosim. (United Kingdom) **40** (1992) 49-52.