DOSES AND DETRIMENT TO PATIENTS FROM VASCULAR AND INTERVENTIONAL RADIOLOGY

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ABSTRACT

A survey was conducted on 1389 patients to establish the representative values of doses for different types of vascular and interventional X-ray examinations in Tenerife (Spain). Two large-area transmission ionization chambers were used for the measurements and a Monte Carlo computer program for calculations. Tabulated results of characteristic quantities for each type of procedure are presented. The collective effective equivalent dose is 9 man-Sv. The detriment, following ICRP-26, was 0.077, and 0.092 when all stochastic effects were taken into account.

INTRODUCTION

Vascular-Interventional Radiology (VIR) is a merging of classical vascular diagnostic radiology and new interventional radiology, developed from the Seldinger technique and applied in the field of therapy in addition to that of diagnosis. In VIR procedures two X-ray beams (radiography and fluoroscopy) are normally used to study patients' different anatomical areas. These procedures routinely involve several films, each of which would be difficult to classify in standard views. In fluoroscopic screening the radiologist may spend several minutes manipulating the position or the size of the X-ray beam over the region of interest. Although the doses to patients in VIR procedures are highest between X-ray examinations, the radiological impact on the population is small because of the low frequency involved with these types of procedures. The dosimetric data for some procedures carried out in France are presented in a paper published by Macciá et al. (1).

In the present paper the results for 8 different vascular and interventional radiology examinations and procedures are given. The patients were inhabitants of the province of Tenerife (Canary Islands), which has a population of approximately 700,000.

EXPERIMENTAL MEASUREMENTS

1830 VIR procedures of 1389 patients were studied. To obtain dosimetric data, two large-area transmission ionization chambers (Diamentor, PTW) were used. With this equipment the dose-area product for 435 procedures was obtained using the cameras for each X-ray tube (radiography and fluoroscopy). The sample is representative of the total number of studies. In all procedures technical and medical parameters were registered. To determine the dose-area product for each procedure, we found the corresponding figure per unit of mAs, irradiated area and number of radiographs or fluoroscopy screening times. When the dose-area product was known, the entrance skin dose (ESD) and energy imparted (EI) to each patient were calculated. The value of EI can be used as a measure of radiological effect on patients. Our results are shown in Table 1.

TABLE 1.- MEANS (with CV %) OF DOSE-AREA PRODUCTS, ENTRANCE SKIN DOSES AND ENERGY IMPARTED PER PROCEDURE.

	NUMBER OF PROCEDURES	DOSE-AREA PRODUCT ($cGy \times cm^2$) radio-graphy	DOSE-AREA PRODUCT ($cGy \times cm^2$) fluoro-scopy	ENTRANCE SKIN DOSE (mGy) radio-graphy	ENTRANCE SKIN DOSE (mGy) fluoro-scopy	ENERGY IMPARTED (mJ)
THORACIC ARTERIOGRAPHY	68	2381 (37)	180 (98)	39 (37)	13 (99)	180 (35)
ABDOMINAL ARTERIOGRAPHY	440	5047 (41)	574 (124)	120 (46)	43 (137)	405 (44)
LIMBS ARTERIOGRAPHY						
Upper	51	607 (107)	197 (99)	1622 (109)	1715 (99)	62 (90)
Lower	380	2758 (44)	213 (192)	6017 (58)	1843 (193)	207 (45)
PHLEBOGRAPHY						
Abdominal	36	1768 (70)	195 (148)	6924 (64)	2450 (132)	144 (77)
Upper limbs	42	382 (124)	0	704 (57)	0	29 (145)
Lower limbs	263	697 (58)	0	1645 (32)	0	45 (42)
EMBOLIZATION	43	4064 (81)	1948 (92)	90 (74)	147 (92)	470 (64)
ANGIOPLASTY	56	2906 (77)	1310 (77)	66 (86)	99 (77)	329 (62)
BILIARY PROCEDURES	82	1764 (67)	1953 (84)	38 (66)	148 (92)	337 (63)
NEFRO-URINARY PROCEDURES	338	444 (205)	750 (153)	17 (203)	57 (110)	159 (153)
MISCELLANEOUS	33	199 (70)	583 (105)	52 (63)	44 (105)	173 (85)

We used the ESD values to calculate the organ doses, with the aid of a PC computer program, based on the Monte Carlo method, supplied by the Center for Devices and Radiological Health, Rockville, Maryland. This program did not give us the doses for breast, bone and "remainder". We assume the hypothesis of a constant relationship between doses to near anatomical organs when they are explored by X-ray with similar projections (irradiated area, technical parameters, etc.). The values of individual organ doses presented by Jones and Wall (2) were used to obtain those relationships. Hence our results, which are shown in Table 2.

TABLE 2.- **MEANS (with CV %) OF ORGAN DOSES** (mGy) **AND EED (mSv).**

	LUNG	RED BONE MARROW	THYROID	TRUNK	GONADS	UTERUS	BONE	BREAST	REMAINDER	EED
THORACIC ARTERIOGRAPHY	9.7 (35)	1.4 (35)	36.1 (37)	3.3 (34)	0.00	0.00	3.5	21.1	3.2	5.5
ABDOMINAL ARTERIOGRAPHY	6.2 (60)	4.6 (47)	0.04 (107)	14.1 (40)	5.0 (160)	14.8 (62)	7.8	3.0	33.3	12.5
LIMBS ARTERIOGRAPHY										
Upper	0.2 (300)	0.2 (88)	0.00 (407)	0.7 (87)	0.2 (217)	0.2 (110)	0.6	0.03	0.2	0.2
Lower	0.05 (51)	2.1 (52)	0.00 (84)	6.8 (49)	5.0 (82)	14.2 (49)	4.2	0.1	15.6	6.3
PHLEBOGRAPHY										
Abdominal	0.9 (213)	1.5 (89)	0.08 (367)	4.6 (78)	8.8 (91)	8.4 (53)	2.5	0.4	10.6	5.8
Upper limbs	0.02 (72)	0.1 (103)	0.00 (419)	0.4 (87)	0.2 (119)	0.1 (61)	0.3	0.00	0.1	0.1
Lower limbs	0.00 (66)	0.3 (81)	0.00 (123)	1.2 (83)	1.5 (69)	2.9 (45)	0.6	0.00	2.8	1.3
EMBOLIZATION	8.4 (121)	6.1 (76)	0.1 (305)	11.8 (79)	3.7 (164)	8.1 (111)	9.2	3.9	24.1	9.8
ANGIOPLASTY	2.0 (149)	4.3 (73)	0.01 (121)	8.6 (78)	4.5 (116)	7.7 (92)	6.3	1.6	18.1	7.5
BILIARY PROCEDURES	3.9 (68)	3.8 (67)	0.02 (69)	6.7 (57)	0.5 (208)	2.0 (70)	5.3	1.4	13.0	4.8
NEFRO-URINARY PROCEDURES	0.9 (119)	1.5 (98)	0.00 (133)	2.1 (79)	0.7 (221)	1.2 (155)	2.1	0.3	3.9	1.6
MISCELLANEOUS	14.5 (62)	7.1 (44)	0.1 (54)	20.0 (40)	4.9 (155)	9.4 (67)	10.4	6.7	42.5	4.0

Our values for organ doses and equivalent effective doses are, generally, lower than those presented by Maccia et al., although it is difficult to draw a comparison since we are unfamiliar with some of the technical aspects of their examinations.

The calculation of detriment poses some difficulties because the ICRP-26 (3) definition contains a certain degree of ambiguity. In fact, we obtained the detriment (fatal and severe hereditary effects) using the risk factors proposed in the above publication although modified by the factors of probability of expression as a function of age at exposure proposed by Wall (4). The relationship between energy imparted and detriment as presented by this author has been used by us to derive another value for detriment. To obtain the detriment corresponding to all stochastic effects we have used the above risk factors and the mortality rates as severity factors. The values were 0.077 (for the two first methods) and 0.092 for the last one. The values were corrected where clinical terminal patients were not considered. Account was also taken of this consideration in calculating the value of the collective effective equivalent dose (CEED). The correction can be established at 15% lower than the uncorrected values.

CONCLUSIONS

1.- EED (mSv) and EI (mJ) for VIR procedures are related by the expression: $E=0.025\ EI^{0.99}$.

2.- CEED due to 1830 VIR procedures in Tenerife was 9 man-Sv. The dose rate per 100,000 inhabitants of Tenerife in 1990 was estimated to be 0.7 man-Sv.

3.- The relationship between detriment for stochastic effects (Dse) and EI(mJ) can be formulated by: $Dse=4375\ EI^{0.897}$.

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A COMPARISON OF THE EFFECTIVE DOSE EQUIVALENT, H_E, WITH THE WEIGHTED DOSE, W_D, FOR THE SIX-YEAR-OLD PEDIATRIC PATIENT EXPOSED TO CT EXAMINATIONS. J.C. Blechinger, J.R. Prince, Pediatric Radiological Research Laboratory, Department of Radiological Sciences, University of Oklahoma Health Sciences Center, Oklahoma City, Oklahoma 73190.

The effective dose equivalent, H_E, introduced by the ICRP to describe radiation risks to radiation workers, has since been applied to members of the general public. Although some data are available on H_E's from medical exposure to CT, no data are available for pediatric exposures. We present estimates of H_E from a GE 9800 CT scanner for the 6-year-old pediatric patient and compare these data to the weighted dose, W_D, proposed by Beninson and Sowby [1].

The computed tomography dose index (CTDI) was measured and compared to the literature [2]. CTDI data were then used to estimate organ doses from data in [2]. Ponderation factors from [1] were used to calculate W_D for both male and female patients.

The measured CTDI was 1.2 cGy/100 mAs at 120 kVp. Results of H_E and W_D calculations are summarized in Table 1.

Table 1. Estimates of H_E and W_D for the 6-year-old pediatric patient for various CT examinations in Sv/Gy.

Examination	# of Slices	H_E	W_D (Males)	W_D (Females)
Head	11	0.041	0.042	0.043
Chest	14	0.252	0.132	0.443
Abdomen	12	0.120	0.105	0.207
Torso	30	0.705	0.605	1.276

There are substantial differences in risk factors estimated from H_E and W_D. There is also a substantial difference in risk factors between male and females in this age group.

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