Workload Spectra and Occupational Dosimetry in Interventionist Radiology

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Abstract. Interventionist radiology is one of the imaging modalities which provides higher staff doses. This occurs firstly because the professionals involved on the conduction of the procedures must be close to the patient, and also because the workload required for generating adequate images is substantially high. Therefore, national standards and international recommendations of radiation protection specify the use of lead aprons, thyroid protector and individual monitoring. The workload spectra of 247 interventionist procedures were registered. These angiographic procedures were grouped on 149 cardiac, 66 neurological; and 32 peripheral ones. Additional information regarding the patient age, sex and weight were also obtained. The professionals conducting the procedures were grouped on three categories: physician 1, physician 2 and nurse. These categories are basically related to the proximity of these professionals to the patient during the procedures; and, consequently, are related to the individual doses received. Each staff category was monitored for a group of procedures using thermoluminescent dosimeter (TLD) specially selected and calibrated to the purpose of this work. The evaluated workload spectra presented peaks around 75 kV and 110 kV for cardiologic investigations, and around 65 kV for neurology, and an approximately uniform distribution for peripheral procedures. The results of the workload evaluation presented 61.3 mA.min per patient in neurological angiographic procedures, 99.0 mA.min per patient in peripheral angiographic procedures, and 170.7 mA.min per patient in cardiac procedures. The mean individual doses evaluated per procedure were on the intervals from (0.003±0.001) mSv to (0.101±0.022) mSv for neurology angiography procedures, from (0.004±0.001) mSv to (0.104±0.022) mSv for peripheral angiography procedures, and from (0.124±0.023) mSv to (0.189±0.048) mSv for cardiac procedures. These workload and dose values can be used as institutional reference levels in order to establish preventive programs for protecting the staff conducting interventional radiology procedures.

KEYWORDS: dosimetry; interventionist radiology; occupational doses

1. Introduction

Interventional procedures use specialized equipment in order to evaluate and monitor the dynamic systems of the human body. These procedures are widely employed in dedicated hospitals and surgery centers around the world [1] using dynamic methods to diagnose the diseases and to perform therapeutic treatment. The procedures that stand out during the surgery are the cardiac catheterization and coronary, brain and peripheral angiograms. The doses received by the medical team involved in these procedures are relatively high compared to other radiological procedures. The reason is that these teams remain a few meters from the patient who, upon receiving X-radiation from the

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equipment, produces scattered radiation in various directions. Thus, part of this scattered X-radiation reaches the team increasing its occupational dose. Because each patient requires the establishment of a particular surgical strategy, it is not possible to establish standard operating procedures for this type of radiological procedure. It results that predicting staff doses is a complex task. Fluoroscopy time during these interventional procedures is long and there is a large number of records using radiographic (photospot) or cine mode. Nowadays, it is known that these are the diagnostic procedures which provide higher staff and patient dose levels.

In the literature, two basic approaches related to dosimetric aspects in interventional radiology can be found. The first one concerns the doses to patients when they are submitted to such procedure [2]. Other studies refer to the adoption of the magnitude of the dose-area product (DAP) as a reference for the establishment of standards to patient dosimetry during interventionist radiology [3-6]. For the staff, the establishment of both standards to personal dosimetry and to area surveys can be found.

Works reporting radiation protection issues in interventional radiology, along with the development of methods for evaluating the performance of equipment for this purpose, are of great importance and they are receiving special attention from medical [7] and scientific [8-11] communities, as well as from regulatory agencies[12-15] throughout the world. They are especially important since there are records of occurrences of deterministic effects, such as skin burning in patients [16], after interventional procedures been conducted. The other dosimetric approach found in the literature refers to the doses received by workers who, in their normal operational routine, are within environments where surgical procedures for interventional radiology are conducted. The doses to which these workers are subjected are strongly dependent on the type of procedure [17], the anatomical characteristics of the patient [18], the proper use of devices and garments for personal protection, the ability and the training of the surgeon and the characteristics of equipment [9,11,23,14], and the relative position of these workers with respect to the x-ray equipment [20-22] and the patient[25-27]. There are also ongoing discussions about how best to monitor these individual workers' doses [28-29].

The present work was based on the concept of workload distribution, introduced by Simpkin[30], and recently incorporated the methodologies for calculations of structural barriers for radiological rooms[31], to determine the doses to technical staff involved in interventional radiological procedures as daily routine. The results of the methodology proposed for this work could be used for estimating of occupational doses. Consequently, it provides the establishment of strategies which allows the preventive management of cases of radiological risk for members of these teams. In this work, issues related to the doses in patients were not addressed, but for the variables which influence the doses to occupationally exposed individuals working inside interventional radiological rooms.

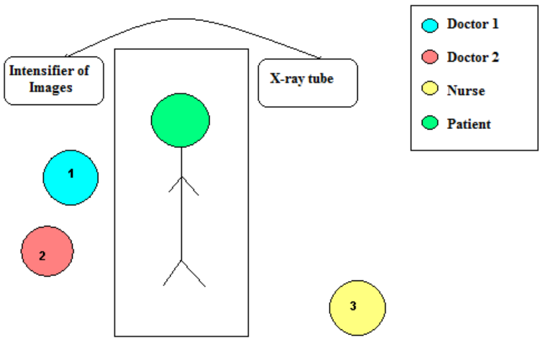
2. Methodology

2.1. Dosimetric Monitoring

During the interventionist procedure the workers involved (physicians and nurse) used a package containing two TLD's (TLD 100, Harshaw, inc.) each one. The packages with the TLD's were set in standardized positions in protective clothing used by professionals involved in surgical procedures, represented in Fig. 1. The position of the team (physicians and nurse) during an interventionist procedure is shown schematically in Fig. 2. The TLD readings were related to absorbed dose through a calibration curve obtained with known irradiations with X ray beams. The personal dose values were calculated according to the directions of the Brazilian regulation: absorbed doses are multiplied by 1.14 to obtain personal dose values, and 1/10 of it is considered the effective dose to the person monitored [35]. A total of 200 procedures were monitored by using this method.

Figure 1: Illustration of TLD badge positioned on the lead apron used for staff protection in an interventionist procedure

Figure 2: Position of staff and patient in an interventionist procedure



2.2. Determination of the workload spectra

The collection of the workload spectra was done through monitoring surgical procedures in two hospitals in the city of São Paulo: INRAD and INCOR. This monitoring was carried out from the control booth of the equipment. The collected data contained information regarding the procedure, such as its identification, fluoroscopy time, current and voltage used. Information about the patients, such as age, weight and sex was also collected.

The workload, W, of each studied procedure was determined from the respective workload spectra, W(V) as:

$$W = \sum_{V} W(V) \quad (1)$$

where:

$$W(V) = \frac{I(V) \times t}{N} \quad (2)$$

In this equation, *I(V)* represents the current, *t* is the fluoroscopy time and *N* the number of patients undergoing interventional procedures. A total of 247 procedures were monitored in order to obtaining the workload spectra data.

3. Results

A comparative plot of the workload spectra regarding the three groups of procedures studied is shown in Fig. 3. Fig.4 and Fig.5 show the comparative results between the workload spectra collected in the present work, and the same data published by Simpkin[30] for cardiology and peripheral procedures, respectively.

Figure 3: Comparative plots of workload spectra for three groups of interventional procedures studied.

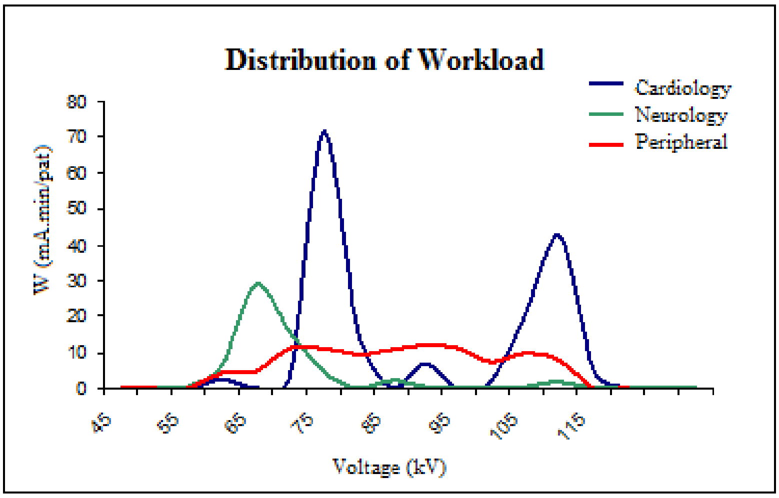


Figure 4: Comparative plots of workload spectra in cardiac procedures from Simpkin´s[30] study and this work.

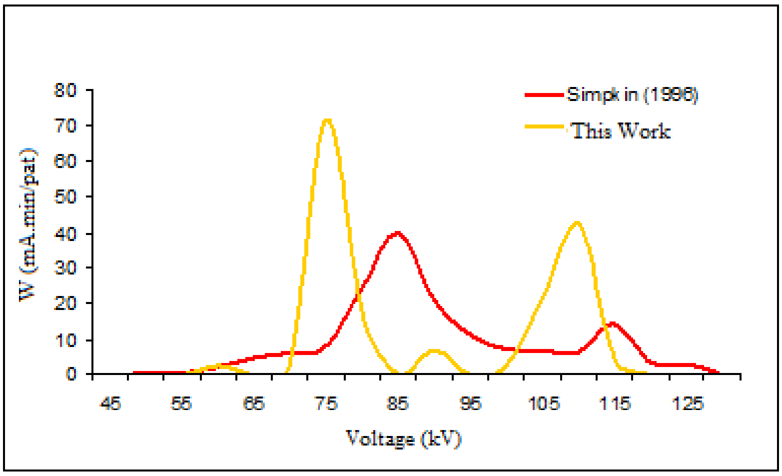


Figure 5: Comparative of workload spectra in peripheral procedures from Simpkin´s[30] study and this work.

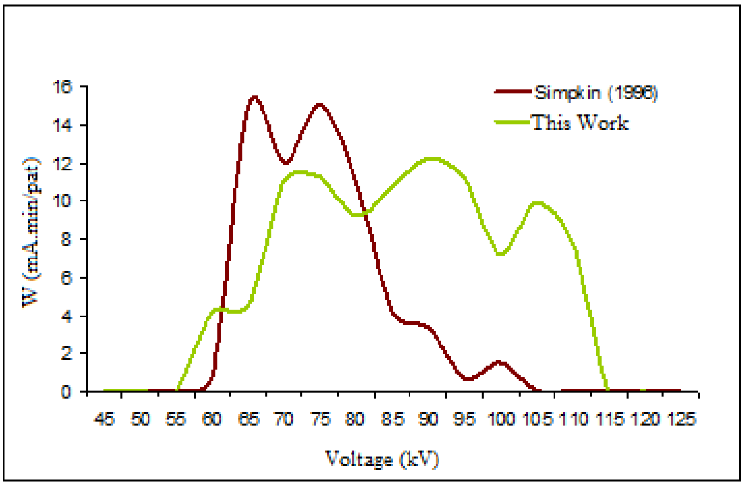
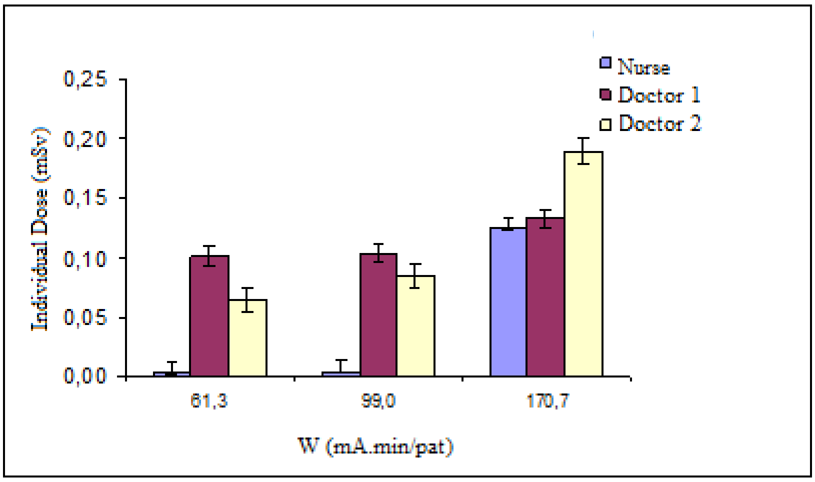


Fig. 6 presents personal doses to members per procedure to the team working in neurological interventionist procedures (workload 61.3 mA.min per patient), of behavior in the range of, peripheral procedures (99.0 mA.min per patient) and for cardiac procedures (170.7 mA.min per patient). These dose values were obtained from the TLD badges used by the first physician, second physician and the nurse, all of them using the monitor outside the lead apron.

Figure 6: Individual dose received by the medical staff and nurse during interventionist procedures.



The staff members were accompanied during the conduction of 247 interventional procedures. Table 3 show the relationship between the numbers of patients submitted to the procedures observed during the present work, the workload for each group, and the total dose received by the physicians, and the nurse during interventionist procedures.

Table 1: Comparative results of the number of monitored patients, the workload and the individual effective doses determined for interventionist cardiac, neurological and peripheral procedures.

Procedure	Staff	Patient´s Number	W (mA.min/pat)	Individual Dose (mSv) per procedure
Cardiology	Physician 1	149	170.7	0.189 ± 0.048
	Physician 2			0.134 ± 0.024
	Nurse			0.124 ± 0.023
Peripheral	Physician 1	32	99.0	0.084 ± 0.009
	Physician 2			0.104 ± 0.022
	Nurse			0.004 ± 0.001
Neurology	Physician 1	66	61.3	0.064 ± 0.008
	Physician 2			0.101 ± 0.022
	Nurse			0.003 ± 0.001
Total		**247**	**103.5**	

4. Conclusion

The value of the total workload achieved in the 247 observed procedures was 103.50 mA.min per patient. The individual interventionist procedures presented workloads per patient of 61.3 mA.min per patient for neurological, 99.0 mA.min for peripheral and 170.7 mA.min for cardiac procedures. According to Simpkin´s work [30] the workload of peripheral interventional procedures introduced the value of 64.1 mA.min per patient, and for cardiac interventional procedures the value found in the literature is 160.0 mA.min per patient both values similar to ours. For the TLD evaluated personal doses corresponding to 200 monitored interventional procedures from the total 247 procedures, the values found range from between (0.0003 ± 0.0001) mSv to (0.010 ± 0.002) mSv for neurological interventional procedures. For interventional peripherals procedures returned to the values of individual doses between (0.0004 ± 0.0001) mSv and (0.010 ± 0.002) mSv. It can be noted that the individual dose values of neurological and peripheral procedures are in the same range, differently from Cardiology which showed much higher values of individual dose for the three staff members monitored.

Considering that in average 25 neurological interventional procedures are conducted per week the individual weakly dose to both physician 1 and physician 2 in this case is (0.25 ± 0.10) mSv, and the weakly dose received by nursing assistants is (0.0075 ± 0.0008) mSv. The physicians who work in peripheral procedures receive an individual weekly dose of (0.26 ± 0.10) mSv and nurses receive individual weekly doses of (0.010 ± 0.002) mSv for the same 25 procedures per week. For cardiology an average of 50 procedures is conducted per week, so the dose to physicians in cardiac interventional procedures is (0.94 ± 0.34) mSv per week and for nursing assistants, (0.62 ± 0.23) mSv per week.

As a result of the implementation of this work, a set of data that have been carefully evaluated for conducting the association between the workload spectra and a formulation for determination of doses in clinical teams which participate in interventional radiological procedures as routine work. The results obtained regarding workload spectra and the effective doses were consistent with the literature. This study can be used for estimating of occupational doses and for the establishment of radiation protection strategies

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