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OCCUPATIONAL EXPOSURE STUDY IN PROFESSIONALS ACTING IN THE SURGICAL CENTER DURING SURGICAL ARC PROCEDURES

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Abstract. The new coronavirus (SARS-CoV-2), which causes the disease known as COVID-19, has reached a pandemic level since its emergence in December 2019, in Wuhan, China, generating global concern, above all, to health systems. whereas surgical procedures can accelerate and aggravate the progression of COVID-19, situations where surgery cannot be delayed, it is necessary to ensure adequate facilities to achieve optimal care with maximum safety. In the current context of the SARS-CoV-2 pandemic, for patients requiring surgery, a protocol should be implemented addressing preoperative preparation, intraoperative management and postoperative surveillance with a view to avoiding complications and ensuring the safety of patients and the health team. Asymptomatic patients with COVID-19 undergo rapid deterioration after surgeries and therefore the surgical area, in the context of the pandemic, faces a need for several adaptations. Fluoroscopy equipment, C-arm fluoroscopy, are widely used for minimally invasive procedures, it is safe and effective, these equipments provide exposure of occupational doses since these procedures have a relatively high exposure time and due to the proximity of professionals to the tube. Due to the exposure of routine practitioners, more detailed monitoring is necessary to evaluate the exposure of these individuals for their radiological protection. The present study aims to evaluate the dose in the occupationally exposed individuals of the surgical center of the Hospital Vitória Anália Franco in São Paulo metropolitan center, Brazil. To this end, dosimeters were distributed among the multidisciplinary team that works in the surgical center, with the purpose of capturing the exposure rates emitted by the equipment during the procedures. The equipment used in the study was a GE C-arm, model OEC Elite 7900. With this, the doses received by the professionals who work in the service during the procedure were estimated, and the impact on the health of the collaborator was assessed, given the dosage obtained in the study. Based on the result obtained, it is shown that it is possible to have a control so that no professional is

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exposed more than is allowed. This control can be achieved through the use of obligatory PPEs, as well as the dosimetry of all professionals working with radiation in the surgical center. In addition, professionals should stay as far away from the scattering source of radiation as possible during procedures. We concluded that it is necessary to carry out a program of optimization and training of the professionals, as well as making dosimeters available for all professionals who participate in procedures with the use of radiation.

Keywords: Exposure; Dosimetry; C-arm; Radiological protection.

INTRODUCTION Information about the clinical characteristics and the results of patients infected by COVID-19 submitted to surgery is still rare. Testing should be performed on patients pre-operatively, in case the test is not available, evidence-based prevention measures need to be adopted. If there is uncertainty regarding the diagnosis of COVID-19 of patients, appropriate PPEs should be provided for health professionals (ACS, 2020). Considering the COVID-19 test at the preoperative moment may favor the evaluation of risks and benefits to perform or postpone surgical procedures during the pandemic (NAHSHON et al., 2020). Non-essential elective or endoscopic surgeries should be postponed if possible, depending on the patient's clinical situation.

In essential elective surgeries, such as oncology, the risk and benefit factors of carrying out the procedure should be evaluated, as well as the ideal moment for carrying out the procedure. This occurs because patients with malignancies can progress or present symptoms that require urgent care (BRAZIL, 2020c).

Main complications and harms that require surgical procedure to be carried out in an elective manner:

- With indication of urgent elective, with completion of the procedure in up to 2 weeks:
  - Cardiovascular procedures;
  - Scheduled Cesarean;
  - Closed fractures;
  - Vascular aneurysm repair.

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- With indication of elective (essential), with completion of the procedure from 1 to 3 months:
  - Cancer surgery and biopsies;
  - Hernia repair;
  - hysterectomy;
  - Reconstructive Surgery.

All patients suspected of COVID-19 who require surgical intervention should be treated as positive until proven otherwise in order to minimize the spread of infection (COCCOLINI, 2020).

The use of ionizing radiation in the hospital environment was essential to improve the level of diagnosis, since it made possible an improvement in the quality of the images, symbolizing a great advance in the area of health. However, appropriate and conscious use is needed, under practicable conditions of safety, thus ensuring the protection of multi-professional teams, the public and the environment. (CURY, et al., 2019)

During the procedure, images of the region to be studied are generated by means of a continuous beam of X-rays, which needs the medical team to be always present, in order to increase occupational exposure (SILVA, 2011). This exposure is of concern to health workers who use ionizing radiation. Everyone should be aware of the risk and respect the triad of time, distance and shielding.

The use of appropriate radiological protection equipment (RPS) becomes indispensable with respect to radiological protection. Thus, in an occupational monitoring program, the points of greatest importance and care are: working hours, training and training of employees, personal dosimetry and routine examinations (SOUZA; SOARES, 2008). In addition, several measures adopted to protect the patient also end up protecting the occupationally exposed individual (OI), such as the reduction of fluoroscopy times and image acquisition, use of low doses, lower frequency of pulses, use of collimators, among other measures (CANEVARO, 2009).

The medical team, in the procedures guided by fluoroscopy, being always present in the room and close to the patient, is exposed mainly to the scattered radiation and to the leakage radiation. For this reason, "as ionizing radiation cannot be perceived by the human senses, often, even for lack

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of knowledge about its health risk, it ends up not being a reason for great concern on the part of professionals" (GRONCHI, 2004, p. 24).

According to Nunes et al. (2016), the operating physician receives dose values higher than other team members due to its proximity to the X-ray tube. The nursing technician receives lower doses by moving around at different points in the operating room according to the doctor's need, not always being close to the radiation source. The X-ray technician receives relatively low doses because it is located on the outermost part of the procedure table, that is, more distant from the X-ray source.

The mechanisms of action of radiation can be direct or indirect. The direct mechanism is when the radiation interacts directly with important molecules, such as those of DNA, and mutations or even cell death can occur. The indirect mechanism, on the other hand, is when radiolysis occurs or the water molecule breaks, forming free radicals that can damage the DNA and other important molecules (Okuno, 2013).

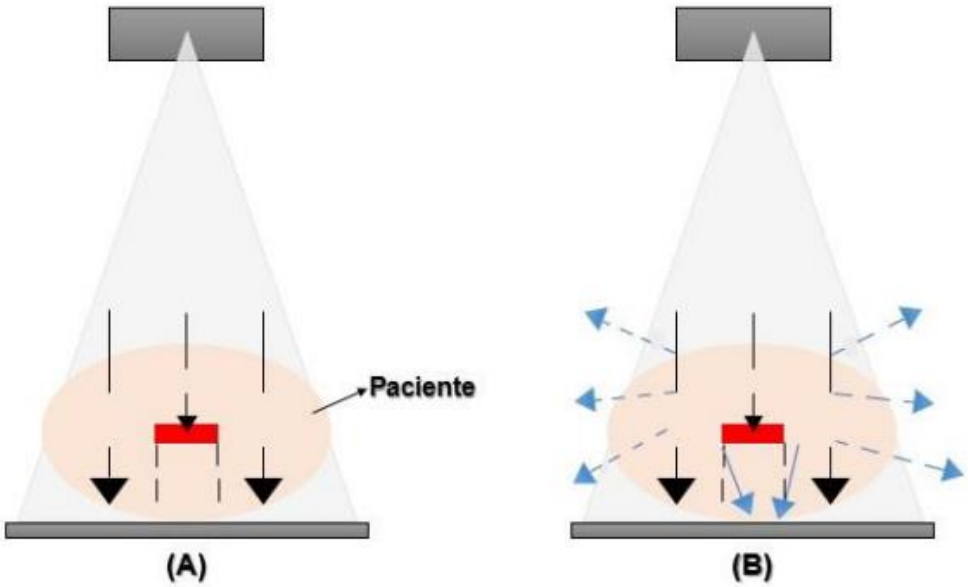

Figure 1—Interaction of radiation with the patient. Ideal situation, without spreading (A). Real situation, the patient is a means of spreading radiation (B). Source: PURPLE, p. 18, 2018

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Radiological protection

The National Nuclear Energy Commission (CNEN), in its norm CNEN-NN 3.01/2011, and the National Health Surveillance Agency (ANVISA), in its Ordinance MS 453/98, define as radiological protection or radioprotection the set of measures aimed at protecting human beings and their descendants against the possible undesirable effects caused by ionizing radiation. This system of radiological protection must encompass all those directly and indirectly involved in the practices, that is, it must take into consideration medical exposures (patients), occupationally exposed individuals (IOE) and the public (individuals in general).

According to the CNEN-NN Standard 3.01, radiological protection can be based on three principles: justification, dose limitation and optimization. Justification consists of medical exposure associated only with practice that produces benefits for the patient or society. Dose limitation means that the patient can receive only the required dose, obeying a limit, and only at the place of interest. And the optimization says that the dose in the patient should be the lowest possible, but without losing the quality in the examination.

The CNEN specifies a monetary coefficient per unit of collective dose, for quantitative analyzes of the optimization of the shielding, which should not be lower, in current national currency, than the value equivalent to US$ 10000/person-sievert.

Individual Dose Limitation

Individual dosimetry is a radiological protection procedure, obligatory for people who are occupationally exposed to ionizing radiation, according to the norms and regulations of the National Nuclear Energy Commission (CNEN), the National Health Surveillance Agency (ANVISA) and the Ministry of Labor.

Normal exposure of individuals should be restricted so that neither the effective dose nor equivalent doses in the organs or tissues of interest caused by the possible combination of exposures from authorized practices exceed the values set out in Table 1.

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Table 1: Annual dose limits for occupationally exposed individual (OIE) and public (CNEN -

Annual dose limits [1]			
Quantity	**Organ**	**IOE**	**Public**
Effective dose	Whole body	20 mSv [2]	1 mSv [3]
Equivalent dose	Crystalline	20 mSv [2]	15 mSv
	Skin	500 mSv	50 mSv
	Hands and feet	500 mSv	-

[1] The term annual dose shall be considered as a dose in the calendar year, in the period from January to December of each year.

[2] Arithmetic mean over five consecutive years, provided that it does not exceed 50 mSv in any one year.

[3] In special circumstances, an effective dose value of up to 5 mSV in one year may be allowed, provided that the mean effective dose over 5 consecutive years does not exceed 1mSV per year.

ANVISA's Ordinance 453 (1998) states that all individuals who work with X-rays for diagnostic or interventional purposes must use the personal dosimeter throughout the working day. In Brazil, the periodicity of individual external dosimetry is monthly, according to current regulations. Thus, the monitoring devices are used for the period of 30 days.

MATERIALS AND METHODS

Radiation-emitting equipment, as follows:

The equipment used in the study was an arc in C GE, model OEC Elite 7900, figure 2. This estimated the doses received by the professionals who act in the service during the procedure, and assessed the impact on the worker's occupational health, in view of the dosage obtained in the study.

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Figure 2 – C-arm Illustration, OEC 7900 Model, GE Healthcare Brand. Source: Biomedis, Available: https://bimedis.com/ge-oec-fluorostar-7900-m7555. Access: 10 May 2022

Dosimeters:

Model: OSL - Optically Stimulated Luminescence Dosimetry, figure 3.

It uses insulating or semiconductor material that, on being stimulated by light, after being exposed to ionizing radiation, acquires luminescent property with intensity proportional to the amount of radiation absorbed over a period of time.

Inlight Sapra - Front View Inlight Sapra - Back View

Figure 3: Optically Stimulated Luminescence Dosimetry. Source: Sapra Landauer, Available at https://www.sapralandauer.com.br/protecao-radiologica-saiba-sobre-os-principais-aspectos-normas-e-tecnologias-empregadas/tecnologias-utilizadas-na-dosimetria-e-protecao-radiologica/; Accessed May 10, 2022.

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MicroSTARii dosimeter reader, figure 4.

Figure 4: MicroSTARii dosimeter reader. Source: Sapra Landauer, Available at https://www.sapralandauer.com.br/produtos-e-servicos/microstarii-leitor-sem-fio-ideal-para-medir-doses-especificas-individuais-de-radiacao/, Accessed 10 May 2022.

The MicroSTARii system reader offers practical solutions for radiological protection. It is ideal to measure specific individual doses of radiation in patients. It is compact, lightweight, portable, wireless and delivers immediate results, anywhere, through software customized for medical applications and dosimetry. The equipment uses aluminum oxide detectors (Al2O3) to measure radiation exposure and carries out the reading of the data using OSL technology, based on optically stimulated luminescence.

Individual protective equipment (PPEs) plumbiferous.

Methodology:

This study was conducted in the period from January to May 2022, and is considered a research with documentary data collection.

The Hospital Vitória Anália Franco develops a series of actions in order to contain the risk to the exposure to the physical agent, ionizing radiation arising from the use of radiology, based on rules of the National Health Surveillance Agency (ANVISA), the National Council of Nuclear Energy (CNEN) and Norms of the Ministry of Labor.

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In order to ensure the safety of the patient and people involved in the radiodiagnostic routines, the Hospital Vitória Anália Franco is pressing for a Control and Radioprotection program guaranteeing safe practices, through the use of personal protection equipment and collective protection equipment, not exposing to unnecessary risks.

The study was carried out through an audit provocation, from the accrediting body, Joint Commission International (JCI), referring to the dosage of exposure of the multidisciplinary teams that work in the surgical center, during a procedure that uses C-arm, since only the radiologist, operator of the equipment made use of the dosimeter.

Thus, 08 dosimeters were distributed among medical staff, nurses and nursing technicians, in order to evaluate radiation exposure doses during the occupational routine in procedures that emit ionizing radiation.

Upon dosimeter delivery, the Specialized Services in Safety Engineering and Occupational Medicine (SESMT) provides the employee with instructions regarding radiological hazards and radiological protection procedures, in writing, upon receipt and instructions regarding correct use, keeping these protocols filed with SESMT.

The employees who received the dosimeters will give knowledge of the results of the monthly doses, signing the monthly report, which is in the room of the SESMT, being under the responsibility of the leaders to forward them.

Personal protective equipment is provided to employees exposed to the physical risk of ionizing radiation as recommended by the Ministry of Labor's regulations, being arranged in examination rooms, sectors where the procedures are carried out and in the mobile equipment itself (C-arm).

All occupational exposures are monitored through dosimeters provided by specialized contracted company and licensed by the Nuclear Energy Commission (CNEN). (Through filing the user's register). The normal occupational exposures of each individual, arising from all practices, are controlled so that the values of the limits laid down in Resolution-CNEN n° 12/88 are not exceeded.

The study was divided into three stages:

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1- An observational part, which consisted in the monitoring of the routine of surgeries that used equipment emitting ionizing radiation. The number of professionals within the room and their disposition were observed.

2- Definition of multidisciplinary team for sampling to be researched and analyzed.

3- Observation of the positioning of each individual, the type of intervention, the radiological protection (EPR) equipment used and the positioning of the individual dosimeters used by the team during the procedure.

RESULTS AND DISCUSSION

Based on the data, a dose collection report was issued by 8 collaborators, being multidisciplinary team acting in the surgical center, during procedure with radiation emission, as table 2, below:

OSL Apron dosimeters - over the apron

Values in mSV

Suggested period: january/2022 to may/2022

Sector: Hospital Vitória Anália Franco

Reg. CNEN 901694-10-02-5

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Table 2: Individual Dose Collection Report - Hp (10) - Source: Sapra Landauer Radiological Protection Advisory Service - Code: 29680-6

CODE	SSN (CPF)	USER NAME	DOSE	JAN	FEB	SEA	APR	MAY	ACC. DOSE
29680,007-5	093.6**.***-41	A.Q.R	ANR	ANR	ANR	ANR	ANR	ANR	0,0
29680,002-4	361.9**.***-09	C.H.F	ANR	ANR	ANR	ANR	ANR	ANR	0,0
29680,001-2	198.1**.***-14	C.S.B	ANR	ANR	ANR	ANR	ANR	ANR	0,0
29680,003-6	399.7**.***-65	D.M.R	ANR	ANR	ANR	ANR	ANR	ANR	0,0
29680,006-3	385.0**.***-93	D.O.B	ANR	ANR	ANR	ANR	ANR	ANR	0,0
29680,008-7	027.5**.***-65	F.O.M	ANR	ANR	0,1	ANR	0,1	ANR	0.2
29680,004-8	350.2**.***-82	M.M.A	ANR	ANR	ANR	ANR	ANR	ANR	0,0
29680,005-1	353.3**.***-32	S.E.S	ANR	ANR	ANR	ANR	ANR	ANR	0,0
Legend: ANR - Read below the logging level (values below 0.1 mSV)									

The dosimetry of the 8 professionals was evaluated and 1 dosimeter, presented dose above the detectable limit after reading (0.2 mSv).

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In spite of the professionals receiving a dose below that permitted by the norm, the study shows that a professional is exposed to measurable radiation levels and, therefore, should be monitored monthly. The PPE health assessment revealed that everyone was healthy.

In accordance with the Program of Medical Control and Occupational Health (PCMSO) the Hospital Vitória Anália Franco, through Occupational Medicine carries out periodic examinations on all employees who use dosimeters, these examinations have a periodicity of six months or when an eventual exposure occurs that exceeds the tolerance limits provided for in the legislation. Part of these tests is the blood count with platelet count. The examinations are archived in the individual medical records of the employee in SESMT for a period of 30 years, making it obligatory for the service providers to make use of the dosimeters and to carry out the necessary examinations. The medical record should include information of the dosimeter user such as full name, date of birth, FPC, beginning of work with radiation, type of radiation, description of occupation and function.

Emergency situations refer to equipment failures, radiation leaks due to malfunction, and accidents due to excessive exposure involving X-ray sources, being detected at the time of the dosimeters reading. When there are records of doses above the tolerance limit the company sends us via telegram, e-mail, all observations and failures of equipment that are immediately communicated to the clinical engineering, in order to correct the failures and irregularities.
When the monthly dose exceeds 4.0 mSv the work doctor calls the user to appear at SESMT to carry out internal investigation and investigation of the causes of the high dose.

We can observe that the measures taken were of great help in the radioprotection of the occupationally exposed individuals (IOEs), mainly in the CC, since from these results it became evident that we were able to evaluate the exposure of the multidisciplinary team and that if we manage to implement the radioprotection in a complete manner, the professionals will be exposed to levels of exposure that are getting lower and lower. It is worth emphasizing that in the observational stage it could be noted that in the surgical center, during procedures that use the C-arm, there is always a high number of professionals within the room. As a measure of radioprotection, it is requested to remain inside the room, during the exhibition, only the

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professionals that are really needed. One strategy that can be adopted is to warn some professionals (expendable at the moment of scooping) to leave the room, to position themselves behind a screen and for there to be rotation of scales.

And finally, it is evident that in the institution evaluated, the use of dosimeters is essential for professionals who carry out procedures inside a surgical center. Evaluation of the amount of dose to which the professionals were exposed is necessary for dose monitoring above the allowed limit. Should this happen, the professional can be immediately relocated for his protection. Dosage monitoring helps in the assessment of doses received by professionals and should be used to optimize the location of professionals during exposure, improving the radioprotection of Occupationally Exposed Individuals (OSIs).

CONCLUSION and FINAL CONSIDERATIONS

Fluoroscopy is often used by professionals in medical and surgical specialties, and it is therefore necessary to train and raise the awareness of these professionals about the risks of ionizing radiation and incentives for the use of individual protections and recommendations for radioprotection to reduce doses compatible with the medical procedures to be performed.

The importance of the use of personal protective equipment for all professionals involved in procedures with the emission of ionizing radiation is evident. In addition to the plumbiferous apron and the thyroid protector, it can be seen that the use of plumbiferous glasses by the first operator, which remains closer to the patient, is also necessary because of the reduction of the annual limit of equivalent dose in the crystalline lens. As well as the use of non-passive dosimeters, it is already a reality in the practice of evaluating important parameters such as the occupational equivalent dose.

Risk analysis shows us that all practices should always follow the principles of justification and optimization, and that it is of fundamental importance to update the professionals who work in these procedures. It should also be considered that the same professionals can work in different workplaces, so occupationally exposed individuals (IOEs) should inform and make available to employers their dose reports.

With this, it is possible to improve the routines and work scales so that some professionals always remain in areas subject to the same level of dose restriction of free areas. This decreases the collective installation dose and may reduce costs of the individual monitoring program. It is also important to remember that this work analyzes a piece of equipment within a specific installation and suggests a methodology for estimating dose and from there classifying the areas in services that use a C-arm. The dose and effective dose rates found, albeit low, are not negligible. In the present study it was concluded that the occupationally exposed individuals (OIs) in the surgical center of the evaluated institution may be exposed to measurable dose levels. Therefore, dosimetric monitoring of professionals is recommended on a monthly basis. Furthermore, the continuing education of professionals who make use of ionizing radiation in the CC is of fundamental importance for there to be a reduction in the dose. Dose levels are expected to remain below the usual dose limits with regular training and establishing an appropriate Quality Assurance Program of procedures and equipment.

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