Report on the radiation exposure in the Orthopedic and Traumatology surgical staff
Principles, legal framework, and situational analysis in Argentina

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How to quote this article: Vivas M, Herrera H, Guyot JP, Santini Araujo G, Dello Ruso B, Castellini J. Report on the radiation exposure in the Orthopedic and Traumatology surgical staff. Principles, legal framework, and situational analysis in Argentina. *Rev Asoc Argent Ortop Traumatol* 2018; 83(3): 210-213. doi: 10.15417/issn.1852-7434.2018.83.3.821

Abstract
Over the past few years Orthopaedics Surgery has made great progress, and so has the use of imaging intensifier at the operating theatre. The aim of this study is to revise the biological principles of radiation and the current legal framework, and to make a brief revision of the current Argentine state of affairs.

Key words: Radiation; Orthopedic surgery.

Informe sobre la radio-exposición en el personal quirúrgico de Ortopedia y Traumatología. Principios, marco legal y análisis situacional en la Argentina

Resumen
La cirugía ortopédica ha avanzado mucho en estos años y, con ello, el uso de la intensificación de imágenes en el quirófano. El objetivo de este informe es revisar los principios biológicos de la radiación, el marco legal actual y hacer una breve reseña sobre la situación actual en la Argentina.

Palabras clave: Radiación; cirugía ortopédica.

Introduction

The surgical treatment of fractures by either mini-invasive or open techniques has achieved better functional results, less joint rigidity and greater patients' satisfaction as compared with classical results by cast treatment with immobilization for a long time. The same goes for orthopaedic reconstructive surgery, which is getting progressively better results with less invasive procedures as time goes by.

These techniques have been gaining acceptance until becoming the therapeutic reference pattern today. Therefore, exposure to radiation in patients and health staff increased while imposing intraoperative controls on devices which emit ionizing radiation. It goes without saying that we should educate ourselves about the appropriate radiation level we are to be exposed to and about protection for people exposed to radiation and its potential complications (patients, operating theatre staff and surgical teams).

The aim of this report is to promote acknowledgement about ionizing radiation in surgical environments and during orthopaedic surgery, to inform about national and in-

Conflict of interests: The authors have reported none.

ternational rules which standardize appropriate radiation use, to show the results of the assessment undertaken at Orthopaedics Departments with accreditation from the *Asociación Argentina de Ortopedia y Traumatología (AAOT)*, and to show the current scene in day-to-day practice.

Harmful mechanisms from ionizing radiation

"Radiodiagnosis" is referred to the number of procedures for exploration and visualization of anatomic structures in the body that use X-rays. The continuous emergence of new techniques and indications increase the number of medical procedures that use X-rays day after day.[1]

Ionizing radiations generated during exposure to radiation interact with living organisms providing their mass with energy and producing ionization in their molecules. This type of energy triggers physical-chemical transformations which can induce changes in biologically important molecules which, in turn, can cause ultimate biological effects. Such effects are determined by the amount of energy absorbed by the tissues exposed to radiation. It is believed that people suffer average 2.1 mSv by environmental radiation and at some locations they can suffer from 8 to 20 mSv.[2]

Effects on exposed organs can be classified into stochastic and non-stochastic.

Stochastic effects: They do not have an "exposure threshold", and the probabilities of these effects are considered to be proportional to the amount of absorbed radiation. The most important examples of stochastic effects are cancer and genetic mutation induction.

Non-stochastic effects: They are also called "acute effects"; they occur when the amount of absorbed energy exceeds the "threshold". One example of non-stochastic effect is hematological figures alterations. The dosimeters used to assess the radiation that impacts the sensor use the following units:

For absorbed doses in tissues or organs: Gray (Gy) (Table)

- It is equal to 1 J/kg
- Previously used unit: Rad
- Equivalence: 1 Gy = 100 Rad

For equivalent doses and effective doses: Sievert (Sv)

- It is equal to 1 Gray due to radiation and tissue quality factors.
- Previously used unit: Rem
- Equivalence: 1 Sv = 100 Rem

Table. Radiation dose absorbed by the region

Exploration	Impacting superficial dose (mGy)
Abdomen, anteroposterior	10.0
Lumbar spine, anteroposterior, posteroanterior	10.0
Lumbar spine, lateral	30.0
Lumbosacra spine, lateral	40.0
Skull, anteroposterior	5.0
Skull, lateral	3.0
Skull, posterolateral	5.0
Mammography	10.0
Pelvis, anteroposterior	10.0
Thorax, lateral	1.5
Thorax, posteroanterior	0.3
Dental	7.0

Regulatory entities

The Argentine State, following recommendations from specialized international organisms,[3] has the duty to inform the population, to enable premises and control them, to control staff exposure at work and public exposure to radiation in general by two specialized bodies dependant on the National Government—one for radiation originated in radioisotopes and the other one for X-rays.

The former is the Nuclear Regulatory Authority created by the National Law on Nuclear Activity 24,804, issued on April 2nd 1997 and its Regulating Edict issued on November 27th 1998.

The latter is the National Health Ministry, whose function is performed by Law 17,557/67 and its Regulating Edict 6320/68.

Protection against radiation

Radiologic protection sticks to three principles:

1. Justification for practice: Applications in which net benefits do not outdo harm will not be justified.

2. Respect for dose limits: The amount of radiation people get is measured by standards called "doses". There are different types of doses as considered by individuals, groups of people or the general population. On the other hand, individuals can be considered on the whole or by tissues/organs. The aforementioned authorities set the limits for such doses, which should be timely acknowledged; this is why it is necessary to count on systems which allow us to measure or estimate such radiation levels.
3. Optimization: Just contemplating dose limits is not enough. Levels of radiation should be reduced as much as reasonably possible by protection devices or changes in techniques.

From a practical point of view, these basic principles intend to reduce external radiation by reducing the following parameters:[1]

- *Distance:* The radiation source should be as distant as possible. It is worth mentioning that doses decrease in inverse proportion to distance (by the distance inverse-square-law).

- *Time:* It should be as short as possible. Doses are in direct proportion to time of exposure, if it is reduced to half the time. Doses decrease proportionally.

- *Armoury:* When time in combination with distance does not reduce the allowed radiation levels, it is necessary to interpose a barrier of absorbent material between the radiation source and the user.

There are no radiation limits for patients; however, there are regulated referential levels for radiodiagnosis and radioactivity levels to administer in gamma camera tests. Such levels, regularly assessed, should not be exceeded for the sake of good practices.

Recommendations from international bodies about protection against radiation in health state that, for health staff exposed to radiation, equivalent doses accumulated in five consecutive years will not exceed 100 mSv. [4] These doses should be distributed as homogeneously as possible during such period, never exceeding 50 mSv in any year.

Based on this, the national authority on the issue imposes that integrated equivalent doses in one year will never exceed 20 mSv, unless the authority fixes a different limit for any given premises.[3]

On the other hand, the International Commission on Radiological Protection has set the rules for radiation use that include dose limits.[5] The maximal admissible limit for yearly doses is 20 mSv for the body, 150 mSv for the thyroid gland and the eyes, and 500 vSv for the hands (International Guidelines, ICRP). Dose limits for unqualified staff (surgeons, for instance) is just 30% of these limits (i.e. 150 mSv for the hands).[6] In Germany, in professional workers, limits are 500 mSv for the hands, 150 mSv for the eyes and 300 mSv for the thyroid gland.[7]

Regulations on health protection against ionizing radiation (RD 783/2001) state that, according to their working conditions, people working on premises with radiological risk are classified in:

- Exposed workers: People who due to the circumstances they work under, usual or occasionally, are subject to a risk of exposure to ionizing radiation that may exceed any dose limit for the general public.

They are divided into two categories:

Category A: This category includes those who may get an effective radiation dose higher than 6 mSv per official year, or an equivalent dose higher than 3/10 of the limits of the equivalent dose for the eye lens, the skin or the limbs. It therefore includes the professionals who carry out their activity directly (with not structural armoury) in procedures such as Interventional Radiology, Haemodynamics and Urodynamics.

Category B: It includes students and trainees elder than 18 who, during their studies, are exposed to ionizing radiation.

Members from "the general population" are considered to be: unexposed workers, exposed workers outside their working schedules, users of health premises while they are not undergoing medical consultations with diagnosis or therapeutic purposes, and any other individual from the general population.

It is worth clarifying that there is neither rule nor law on radiation exposure that focuses on the orthopaedic surgeon as they do in reference to other specializations. Nonetheless, we should consider the orthopaedist surgeon as a professional to be included in Category A.

Argentine state of affairs: November 2016 assessment

The *Comité de Investigación de la Asociación Argentina de Ortopedia y Traumatología* (*AAOT* research committee) undertook a study on the use of radiation dosimeters at institutions at Orthopaedics Departments with accreditation from the AAOT. It consisted of electronic polls evaluating the use of dosimeters by both staff professionals and residents; moreover, we asked about assessment time, check-ups in dosimeters, figures that exceeded allowed radiation, and conditions associated with such radiation.

Out of 62 institutions, only 24 responded and, among these ones, just eight reported the use of dosimeters by both staff professionals and residents. In 80% of the cases, check-ups were carried out on a monthly basis by outsourced companies, and there was only one case in which radiation exceeded maximal allowed figures; there were no reports on any condition associated with radiation.

To conclude, we can affirm that the electronic polls taken at Orthopaedics Departments which dealt with the use and register of dosimeters among both staff professionals and residents at Orthopaedics Departments with accreditation from the AAOT had low impact, what might mean that although the issue awakens interest, acknowledgement and responsibility at institutions with respect to devices check-ups on optimal function are insufficient. We believe that these results are cause for alarm showing the need for promotion of awareness of protection against radiation in the surgical field; therefore, we suggest increasing our links to the Sociedad Argentina de Radiología (Argentine radiology society) which, together with the National Health Ministry, work on awareness plans, controls on devices for protection against radiation, equipment at institutions and more rules to increase care during surgery.

Last but not least, nowadays we are working with recognized members of the Sociedad Argentina de Radiología in the making of the "Good Radiological Practices" booklet. We aim at this publication working as guidelines that can be used by all orthopaedists exposed to ionizing radiation at the operating theatre or anywhere else.

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