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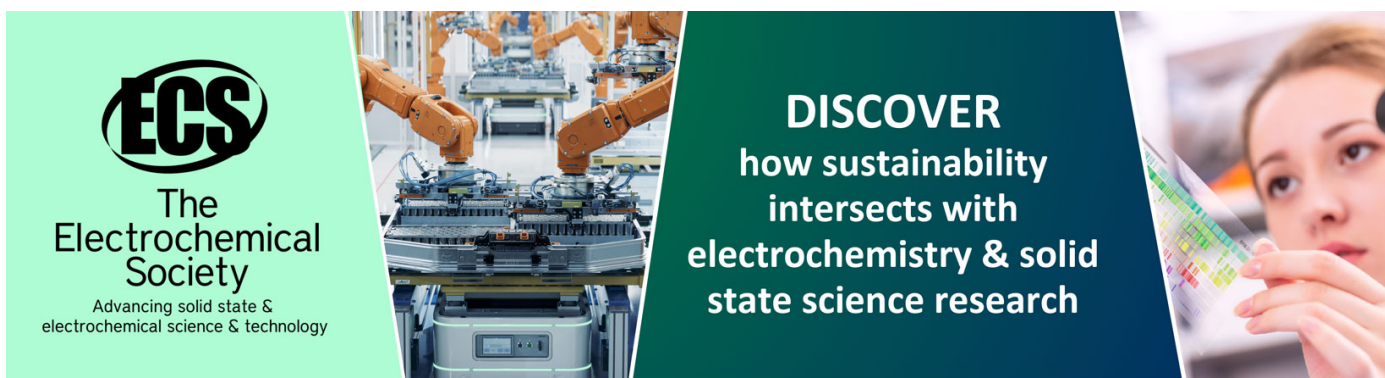
Importance of patient radiation protection in computed tomography procedures

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Importance of patient radiation protection in computed tomography procedures

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Abstract. The aim of the present work was to describe the importance of establishing a strong patient radiation protection program in computed tomography (CT) departments. Radiation protection in computed tomography (CT) deserves special attention since CT is the largest contributor to patient radiation exposure in diagnostic radiology. Radiation protection in CT examinations has been recommended by international organizations as well as AIEA program. As part of our proposals is the dose reduction in CT systems used, ALARA principle application and the enshrined the international guide regulations for the protection of patients were based on. For our staff working with ionizing radiation in CT departments is supervised under national authorities by legal limits but for patient radiation protection has not been involved in the national legislation.

1. Introduction

The story began in 1895, when a German physicist discovered a new kind of rays. This is almost 120 years. The X-rays are used every day around the world for imaging of patients in more than 10 million diagnostic radiology procedures [1, 2]. The development of diagnostic imaging processes has, since its discovery, proved to be able to bring the human population great benefits when used for diagnosis. Diagnostic radiology is the field of medicine that uses imaging exams and procedures to diagnose a patient. The development of diagnostic imaging has been the result of a fruitful relationship between doctors, radiographers, physicists and equipment manufacturers. Since of the CT scanning was first described by Godfrey Hounsfield and the first prototype EMI scanner was installed in 1972 at Atkinson Morley's Hospital. These radiography techniques have displaced many of the older X-ray techniques and this process will continue. CT scanners for diagnostic radiology procedures is related with magnificent imaging but at the same time is enshrined with relatively high patient dose contribution.

The Organization for Economic Co-operation and Development (OECD) from its report in 2016 [3], describes the number of scanners for computed tomography in selected countries per million inhabitants, as of 2016 in which appear 107.12 devices per million inhabitants in Japan. In the same



figure Mexico appearing as the country with the lowest value, it has 5.89 devices per million inhabitants. But if this value is compared with that obtained by the same organization in 2005, México had 3.95, this value increased. The rest of the countries are pictured in figure 1.

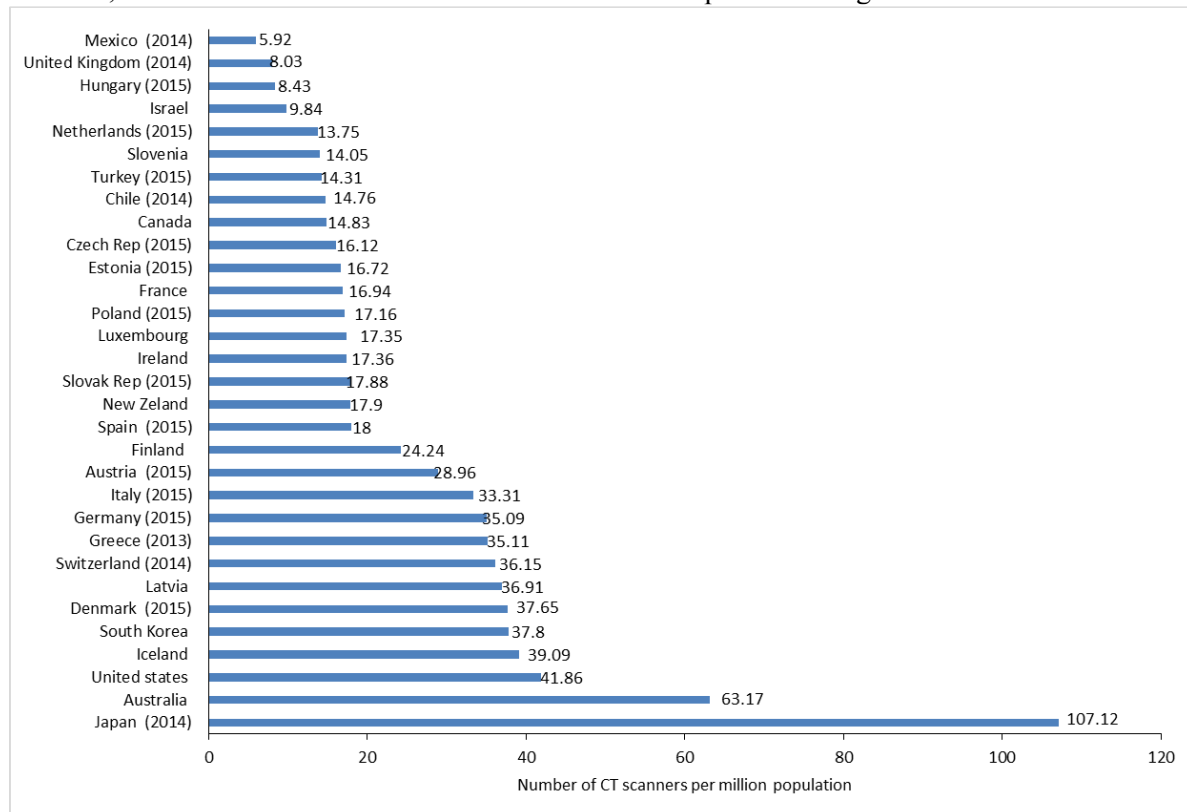


Figure 1. Number of CT scanners per million population in selected countries

The Centro Nacional de Excelencia Tecnológica en Salud (CENETEC-SALUD) [4] of Mexico, (National Committee on Biomedical statistics) in 2016 published in its annual report about the number of CT scanners in Mexico. Figure 2 describes the number of CT scanners distributed in Mexico land. This indicator was measured in the numbers of CT devices for each Mexican state, in the figure should be noted that Mexico City has 21 % of de total of CT scanners distributed in all the country. If we consider the CT scanners installed in Metropolitan urban (Mexico City and part of State of Mexico) this percentage is increased still 24%. In the same figure, we can observe that just 5 CT scanners are located in the State of Nayarit. But the most surprising news is Campeche State, as it can be seen, the Campeche state not showed a CT scanner device.

Based on the figure 2 the frequency on the volume of CT procedures in Mexico City and around it is high. The collective dose population should be high. Considering the figure 2, this should be not forgotten that CT is a computerized X-ray imaging procedure in which a narrow beam of X-rays is aimed of a patient and quickly rotated around the body, producing image that is processed by the computer in order to generate cross-sectional images of the patient. Then, the volume of these medical procedures have been increased in the medical devices in Mexico. So, the collective dose population could be increased. The latest report of the United Nations Scientific Committee on the Effects of Atomic Radiation (UNSCEAR) estimates suggest that there are about 4 billions X-ray examinations per year [5]. This frequency is about 12% higher than the period 1996-2000 and 30% higher than the previous estimate for the period 1991-1996 [6].

The UNSCEAR Committee in the same publications reported the collective dose of CT contribution, the frequency is about 35% during the period 1991-1996 and 40% during the period 1996-2000. But the highest contribution is observed for the period 2000-2010 with 62%. The percentage contribution from CT collective dose from medical X-ray examinations is pictured in figure 3.

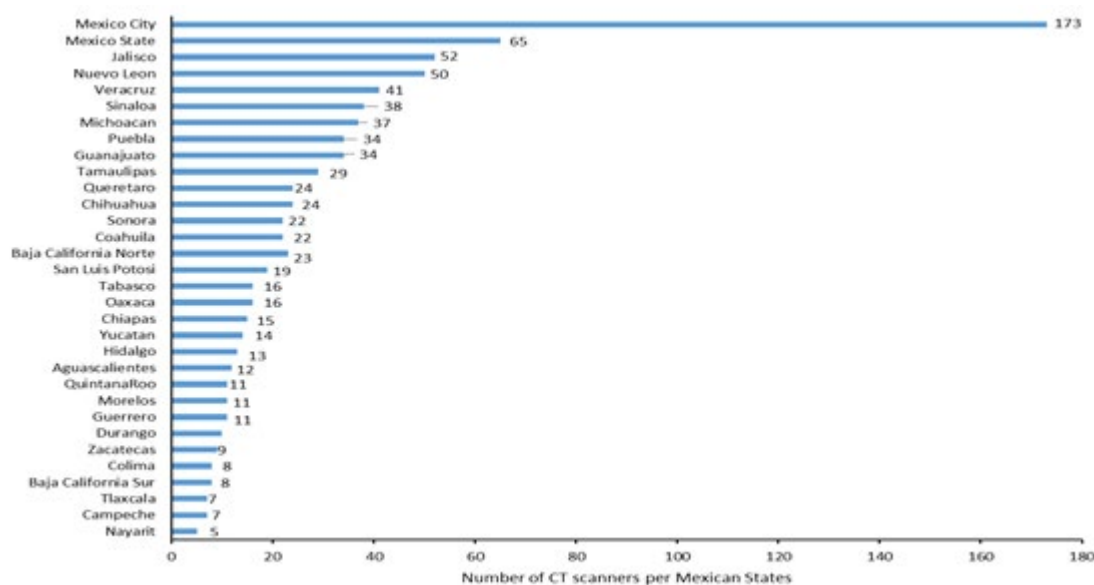


Figure 2. Number of CT scanners per Mexican States

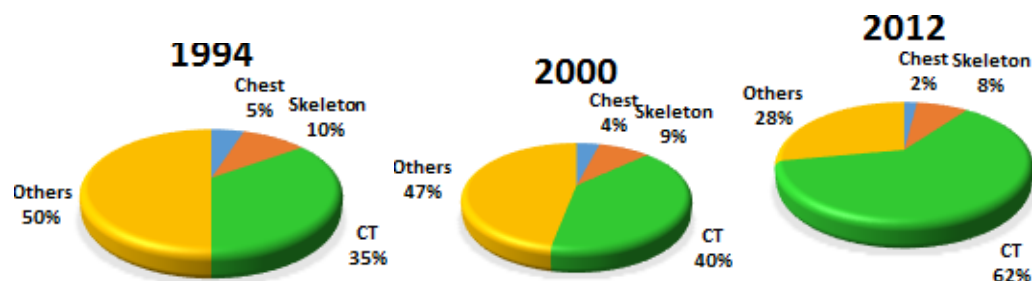


Figure 3. Collective dose in 2007 from CT scans

As a consequence, the dramatic increasing trend in annual CT examination frequency and the significant dose per examination have an important impact on the overall population dose due to CT exposures [7-8]. Recent publications have confirmed the upward trend in the contribution of CT to the total collective dose from medical examinations [9]. The European data for head CT scanning are comparable to the reported mean effective doses, being in the range 1.6 – 1.8 mSv [10]. In the United States, optimization of CT examination has become an important topic with a high level of public interest [9]. As consequence of this, it is generally agreed that the greatest need for a dose determination is urgent in the area of CT. However, this is where the largest dosimetric problems occur. Under these circumstances, the majority of publications on radiation safety in CT are concerned to radiation protection of medical staff. World statistics indicate a growing trend in the annual number of medical procedures as well as in the number of facilities in diagnostic radiology, at the same time, the number of OEW is increased. This explains the growing concern of scientific societies and regulatory bodies for the aspects related to radiological protection of the patient [11-17]. In order to protect OEW against the harmful effects of X-rays without this conspire against the benefits associated with its benefits application in CT departments, radiation protection for OEW is based on three basic principles suggested by the ICRP Committee: dose limitation, justification, and optimization [18]:

Dose limitation, apart from the obvious benefit of improving human health, it is very important to ensure the medical personnel's safety. Justification means that the examination must be medically indicated and useful. The radiation exposure should do more good than harm. This means that, by introducing a new radiation protection of patient program, by reducing existing exposure, or by reducing the risk of potential exposure, one should achieve sufficient individual or societal benefit to offset the detriment it causes. Optimization means that the imaging should be performed using doses that are as low as reasonably achievable (ALARA), consistent with the diagnostic task. The likelihood of incurring exposures, the number of people exposed, and the magnitude of their individual doses should all be kept as low as reasonably achievable, taking into account economic and societal factors

2. Radiation protection of patient

The concept of patient dose assessment in radiology was not in place in the world still the last decade. Radiation protection in computed tomography (CT) deserves special attention since CT is by far the largest contributor to patient radiation exposure in diagnostic radiology. Recognizing the increasing emphasis that patient safety needed, the IAEA initiated an International Action Plan (IAP) in 2002 during the International Malaga Conference [16] and a program on Radiation Protection of Patients (RPOP) was established. The aim of the IAP was coordinate international efforts to provide guidance on the radiation protection of patients. In 2011 the International Commission on Radiological Protection (ICRP) published recommendations and guidance on the protection of patients [19]. The radiation protection of patient program in CT department of our hospital was implemented during the last year. Physician, technicians, and Medical Physics in joint with ICRU and other international organizations a strong harmonization of radiation protection of patient program was designed and implemented [20]. The radiological protection of the patient program was based on the first two principles (justification and Optimization). The International Commission on Radiological Protection (ICRP) has pointed out that dose limitation is not applicable for patient radiation safety [21]. Justification was harmonized in three levels and it was applied the IAEA and the European Commission (EC) suggestions [22]. The first of them, is that medical uses of X-rays provide more benefit than risks. Secondly, relates for specified procedures with a specific objective. Thirdly, the justification was done on an individual basis. Optimization in patient radiation protection refers to the attempt to reduce radiation dose on the patient as much as reasonably possible, this is used the minimum dose to obtain the quality of the image that guarantees compliance with the diagnostic purpose.

3. Establishment of Diagnostic reference levels (DRL)

Due to high dose levels of exposure that can be produced by some CT scans, it is possible to observe secondary effects in patients undergoing CT procedures. For this reason, IAEA and other international organizations suggest establish recommendations for radiation dose in CT procedures. The concept of reference levels (DRL) in diagnostic radiology was developed as a tool for optimization of protection regarding patient exposure. Diagnostic reference levels (DRL) are defined as the measured values of radiation doses during a specific diagnostic procedure. The concept of DRL was introduced by the International Commission on Radiological Protection (ICRP) [19]. In 2001, the Committee 3 of the ICRP focused on the preparation of a specific document on this subject [20]. The DRL are intended for use in quality assurance (QA) programs in order to evaluate procedures and state of the equipment. It is a specific application concept in the medical exposures referred to dose levels in patient diagnostic radiology with "standard" characteristics, in Mexico. In order to DRL implementation, firstly, we are determining radiation dose for each patient procedure. At the end of this year we will analyze the experimental values in order to suggest DRL values for abdomen or skull studies. DRL values will indicate us the quality of equipment and procedures. Its numerical value should be established by a statistical method taking into consideration the 75th percentile of the measured doses distribution [23]. This value will be an indicator to identifying and eliminating the causes, so, the Gaussian curve will move to the left with the consequent decrease in the DRL value in order to obtain

optimization dose. It should not be forgotten that the DRL values are closed relation with quality of the image.

4. Recommendations

The implementation as well as the execution of the radiation protection of patient program at the CT department of Centro Medico Nacional 20 de Noviembre in Mexico City. Physicians, technicians, and medical physics joint with RPOP group proposed an action plan for the Radiological Protection of the Patient to optimize human and material resources. In this context, the figure of the physician prescribing a given practice, together with the specialist in diagnostic imaging, will be co-responsible for the application of the principle of justification acquires a new relevance. Regarding the optimization of the doses as well as the implementation of the DRL was acquire the figure of the specialist in medical physics was called to play a relevant role in the coordination of the actions as well as that of the specialized technician for the execution of the same. It is proposed to generate a plan of action for Radiological Protection of the Patient based on the Bonn Call for Action recommended by IAEA in order to call agreements and convergences with health authorities, scientific societies and professional associations. The modality proposed for the execution of this action plan was constituted on the next points:

1. Communication to patient about CT radiation benefits and risks
2. Considering international guidelines for CT examinations
3. Preparation of guidelines on indications for the request of CT examinations;
4. Promotion of actions tending to the implementation of quality assurance of CT device;
5. Discussion of procedures that contribute the optimization of CT doses;
6. Determination of diagnostic reference levels (NRD)
7. Promotion of training activities aimed at introducing of the radiation protection and radiation safety culture;
8. Promotion of the specialized training course on CT for radiologists and residents.

The main aim of the course is introducing the principle of radiation protection of patient as a balance between the benefit and the risk. This is, to avoid the unnecessary use of X-rays, adequately justifying each procedure. All procedures should be performed with minimum radiation dose. Potential radiation risks in the patient submitted to CT scans should be optimized if physicians, technicians, authorities and medical physics work under the same objective. The optimization of radiation dose during each CT procedure should be a mandatory. Our suggestion that is necessary to introduce the radiation protection program in medical schools. Hospitals should provide systematic and specific radiation protection courses for residents and physicians. Specific training courses focussed to professionals in CT establishments should emphasized in radiation protection to patient as the main objective. One type of specific education is proposed carried out by internet which has several advantage over other formats for health communicating. The main disadvantage of internet media is its lack of regulation. For the patient, the credibility of a medical site and the reliability of its contents are difficult to judge [24], but for Hospital's patient internet information should be sited in a special website. Patient radiation protection program in computed tomography (CT) deserves special attention since CT is the largest contributor to patient radiation exposure, this program should be a mandatory.

5. Conclusions

Based on the UNSCEAR reports, the number of CT scans is increased in Mexico City as well as in the world. The ICRP publications describe numerous CT overdoses. The implementation as well as the execution of the radiation protection of patient program at the CT department of Centro Medico Nacional 20 de Noviembre in Mexico City acquires importance for both authorities and staff to optimize CT dose on the patients. We proposed an action plan for the Radiological Protection of the

Patient taking into account human and material resources for just one objective, the CT dose patient optimization.

Acknowledgments

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