THE USE OF VIRTUAL REALITY FOR TRAINING PROFESSIONALS OF NUCLEAR MEDICINE

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ABSTRACT

The use of virtual reality has become an important tool for training purposes, with emphasis to those procedures that involve risk to professionals, as those associated with occupational exposure to ionizing radiation in nuclear medicine services. According to the basic safety standards (BSS), published by International Atomic Energy Agency (IAEA), the qualification and training of all personnel of a nuclear medicine service should be performed periodically in order to ensure its understanding and better performance of their respective duties. In face of that, this work consists in research, analysis and unification of requirements and specifications for the radiological protection of nuclear medicine workers, specifically those of radiopharmacy. To this end, a detailed study of the radiological safety and workflow related to radiopharmacy procedures is under development considering the radiological recommendations and safety standards of nuclear medicine services. As a result, it is expected a set of information that will enable the development of a virtual training environment in radiological protection for such professionals aiming the development of skills and the improvement of competencies by means of the simulation with lower cost, unlimited number of repetitions of training, without interference in the laboratory routine and the primary purpose of this work: in safe conditions.

1. INTRODUCTION

Nowadays, the use of virtual reality (VR) applications has become popular in several areas for the feasibility of reproducing and simulating real situations with lower cost, due to the reduced use of physical objects. In the area of health, education and training are the themes for RV applications [1]. According to Sales (2010), the medical community has been looking for alternative forms of training. In this context, VR inserts itself in order to improve existing training techniques [2]. In the nuclear area, trainings based in simulations have also become an important alternative for safe learning, especially in procedures where the practice by traditional means subjects the professionals to exposure to ionizing radiations.

Nuclear Medicine (NM), a medical specialty that allows treatments and diagnoses of metabolic and functional anomalies, using radioactive compounds, requires training and continuous qualification of the workers of this area. According to the International Atomic Energy Agency (IAEA), approximately 35 million of nuclear medicine exams are performed worldwide per year [3].

In Brazil, according to data from the National Nuclear Energy Commission (CNEN), there are 432 nuclear medicine services (NMS’s) [4].

According to the Basic Safety Standards (BSS) published by the IAEA and the CNEN Norms, some actions must be ensured for the qualification and training of these professionals, improving the understanding and performance of their respective functions, both for the
performance in normal situations of routine, as well as in situations of incidents and accidents [5, 6].
Therefore, this article consists of researching, collecting, analysing and unification of information regarding safety procedures, standards and recommendations, in order to enable the use of a virtual environment to train occupationally exposed individuals (OEI) of a radiopharmacy in a NMS.

2. VIRTUAL REALITY

There are several definitions of the term “Virtual Reality”, but in general it refers to an immersive experience based on 3D graphic images generated by computer. Silva et al. (2015) define VR as a group of technologies and techniques developed to integrate users and computer systems, whose objective is to provide the user with the sensation of being living in a virtual world through advanced interfaces [7]. The first VR applications emerged in the Second World War with flight simulators. With the advent of the technological revolution, software and hardware increasingly advanced and with lower cost, the VR has become popularized and gained market in diverse areas.

2.1. VR Applied to Health

Properties like immersion, interaction and presence make VR a tool of interesting application in the health area, capable of reproducing real situations in safe virtual environments. In the applications of VR directed to the medical area, can be highlighted applications for training of surgical procedures, medical 3D imaging, teaching of anatomy, virtual physiotherapy, among other rehabilitation simulations, games and collaborative systems. The applications for educational and training purposes are the most explored in the field of medicine.

2.2. VR as Teaching Tool

VR applied to education has become more visible since the early 1990s. The VR brings together attributes that make it the ideal tool for multiple situations and contexts of research and learning. Immersed in the virtual environment, the user can develop a natural and intuitive behavior, acting like he does in the real environment and through interaction, receiving a response to his actions [8]. In Braga (2001), is list among the reasons that demonstrate the potentialities of VR: the power of illustration, which for some processes and objects is larger compared to other media; and the possibility of the learner developing the work at his own pace.

3. REGULATIONS AND RECOMENDATIONS

For this article, initially, international recommendations and CNEN regulations for nuclear medicine services were analyzed. There is a desirable international consensus on the safety standards published by the IAEA, based on the recommendations of the International Commission on Radiological Protection (ICRP) and information from the United Nations Scientific Committee on the Effects of Atomic Radiation (UNSCEAR).
For situations of planned exposures such as nuclear medicine practice, the BSS includes the required requirements applicable to the occupational exposure category. Among them, requirement 26 regarding the responsibility of employers and licensees to provide information, instructions and training appropriate for protection and safety. The CNEN NN-3.05 establishes that the licensee of the nuclear medicine service shall ensure OEI training, with maximum annual frequency, to perform in normal work situations and in situations of incident or accident.

Regarding the responsibilities of OEI, it is stated in Art.12 of CNEN NN-3.05 that in addition to the responsibilities mentioned in others CNEN’s resolutions, the OEI should receive initial training in good radiation protection, laboratory and radiopharmacy practices covering the minimum topics described in Table 1.

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<th>General Theoretical Topics</th>
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<td>Radiation and radioactivity</td>
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Still about the IOE’s responsibilities, according to Art.13 of CNEN NN-3.05, professionals who handle or administer radiopharmaceuticals, such as those in the focus of this study, should: correctly store the radionuclides and radiopharmaceuticals according to the guidelines of the NMS; Prepare and fractionate the radiopharmaceutical in accordance with the protocols established by the NMS; Record the activity prescribed and administered to the injected patient; Before conducting the radiopharmaceutical to the patient, check the quality control of radiopharmaceuticals, if the activity and the radiopharmaceutical comply with the requirements of the nuclear physicians; And the patient's unambiguous identification.

3. RADIOPHARMACY

The second part of this research consists in observing the procedures of a radiopharmacy, through visits, internal documents and specific literature. The radiopharmacy is the place where radiopharmaceuticals are prepared and dispensed in a service of nuclear medicine. There, procedures are performed such as the fractionation of the ready to use radiopharmaceuticals, the preparation of radiopharmaceuticals from prepared and approved reagent kits, and all necessary manipulation until dispensing of the material for use in diagnostic exams by imaging or therapy.

In the routine and in the work exceptions of a radiopharmacy's professionals, local rules and previously established procedures are taken into account in order to guarantee adequate levels of protection and safety. In the emergency plans and safety assessments of nuclear medicine facilities should contain information about what can go wrong and how it can be avoided or mitigated in case the error happens. In the preparation of the radiopharmaceuticals, for example, a certain amount of the material may be spilled.

3.1. Emergency Situations

In the N40 of the series of safety reports, published by the IAEA, there are examples of emergency situations and the actions to be taken [9]. Such actions compose a content of important approach in future RV training. In MN, any occurrence in which occur a leakage or spillage of radioactive material, characterizes an accident. Procedures for decontamination of surfaces, clothing, skin and instruments shall be described in the Standard Operating Procedures (SOPs) of the NMS and available for consultation of the OEIs.

In case of spill of small quantities of radioactive material, for example, disposable gloves and appropriate protective clothing should be worn. The first step is to quickly contain the spill with an absorbent pad to avoid spreading. Then the pad should be removed, and the contaminated area should be cleaned with a towel, from edge to center. Afterwards the area must be dry and a proof of cleaning must be performed. The cleaning cycle must be continued until the test indicates that the spill has been cleaned. A plastic bag should be used to store contaminated items. And suitable bags should be available as well as damp paper towels.

In case of spillage of large amounts of radioactive material, the procedures to be followed involve immediately informing the radiological protection supervisor to follow the cleaning directly. Absorbent pads should be thrown over the spill to prevent further spread of contamination. All people involved in the spill should leave the area immediately and they should be monitored when leaving the room.
In case of contamination of clothes, the clothing is removed and placed in a plastic bag labeled "radioactive".

In case of skin contamination, the area is immediately washed with care so that no lesions are caused, the procedure is repeated if it is verified that the contamination is diminishing, otherwise it must proceed with the proper registration.

These and other procedures, such as extractive of sources, damage to Technetium-99m generators and fires, should be clear, concise and unambiguous and should be visibly posted wherever their need is anticipated.

3.2. Typical Causes of Accident

According to IAEA (2005), some factors influence the frequency and severity of incidents and accidents, such as lack of OEI specialization, lack of operational documents in user-understandable language, poor, misunderstood or violated procedures, inconsistent use of different quantities and units, etc. Such factors contribute to accidental exposures of the professionals and the patient.

In the typical causes of accidents there are errors in communication, defective transmission of information, poor understanding of restrictions and protocols, or use of obsolete protocols, errors in patient identification, use of the wrong source, wrong radiopharmaceutical product or wrong activity, calibration and maintenance mistakes.

An example of an error occurring in a radiopharmacy is described in IAEA (2005) as follows: A patient referred for treatment of Graves' disease with 555MBq of 131I. The radiopharmaceutical assumed that the dose to be administered was 1073MBq instead of 555MBq, since a dose of 1073MBq was routinely used for Graves' disease at that hospital. Therefore, he requested a dose of 1073MBq of commercial radiopharmacy. The received dose was 1058MBq, and correctly labeled. When the radiopharmaceutical recorded the dosage on the computer after doing the activity measurement, he did not take note of the 555MBq dose on the referring doctor's prescription. In addition, the doctor who administered the isotope did not check the prescription. As a result, the patient's thyroid received about 319Gy rather than the intended 167Gy, an overdose of 91%.

4. CONCLUSIONS

The studies performed served as a basis for determining the needs of the work to be developed in the future.

The consolidation of safety and radiation protection information established by regulations with the information collected locally and in the scientific literature is important for the delimitation of the basic content to be implemented in a virtual training simulation. The professionals of the visited services recognized the need for an additional training tool for OEI and expressed approval of the proposal to use VR simulations to this. The use of VR for training purposes is interesting to evaluate the actions of the user, identifying hits, failures and difficulties. Training through VR is expected to be an efficient complementary method, since training can be done countless times and the learning can be designed in stages, facilitating content absorption by users, until required skills are acquired and the information assimilated correctly. In addition, this method does not interfere with routine installations and especially does not pose a risk of exposure to ionizing radiation.
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REFERENCES