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Research Article

Interior design model proposal for nuclear medicine imaging rooms

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Abstract:

Innovative design approaches to prevent radiation contamination in nuclear medicine departments have been examined. Nuclear medicine departments are high-risk areas for radiation contamination due to the use of radioactive materials. The strategies employed to prevent the spread of radiation in the design of these departments have been detailed. Theranostic approaches, which utilize radiopharmaceuticals in both diagnostic and therapeutic processes, have been emphasized, and the measures aimed at minimizing radiation exposure for patients, personnel, and the public have been evaluated. The proposed design model suggests a spatial arrangement that separates the movement pathways of patients, personnel, and caregivers to minimize the risk of radiation contamination. In conclusion, it has been demonstrated that the integration of appropriate architectural design principles can significantly reduce the risk of radiation exposure in nuclear medicine departments, thereby ensuring a safe environment for both patients and healthcare professionals.

1. Introduction

With the development of technology, the use of devices that emit radiation at levels that threaten human health has become widespread. It turns out that in structures where such devices are located, design based on strength is not sufficient, and sufficient impermeability must be ensured and they must be designed appropriately against radiation effects. Therefore, in addition to basic principles such as sufficient strength and sufficient hardness, the need to protect such structures exposed to harmful rays and the people using these structures from these negative effects is of great importance. In such structures where radiation is intense, people need to create a protected area to avoid being exposed to the effects of radiation. The most important element in creating these areas is the placement of a protective element between the radiation source and the environment exposed to radiation [1].

When looking at the hot laboratory (Radiopharmacy laboratory) design rules, it is noteworthy that there are

differences between countries. However, general planning activities, good production rules, aseptic working conditions and radiation protection principles must be taken into consideration and paid attention to.

The term "theranostics", formed by combining the words "diagnostics" and "therapy", generally means bringing together diagnosis and treatment techniques in the process of disease management [1-3]. Funkhouser was the first to use the term Theranostic [4]. Radiopharmaceuticals, referred to as theranostic agents, are often used in oncology diseases, but are also used in the diagnosis of other diseases (neurological, myocardial) and in the treatment of some of these diseases. For example, radiopharmaceutical treatments applied in hyperthyroidism, thyroid Ca and prostate cancer are examples of these.

2. Theranostic Approaches

Theranostic approaches, which are formed by combining diagnosis and treatment methods, combine the results obtained from diagnosis with target-specific treatment. Thus, these radiopharmaceuticals can be applied as a patient-specific personalized medicine approach (Figure 1). Considering the characteristics of theranostics, it aims to monitor the response to treatment from the patient's perspective and to ensure and increase the effectiveness and safety of the drug. The management of the treatment in theranostics is carried out by the combination of multifaceted disciplines such as pharmacogenomics, imaging, treatment and targeting [3,5].

Figure 1. *Theranostics and components*

As theranostic systems, imaging methods such as MRI (magnetic resonance imaging), CT (computed tomography), optical imaging, USG (ultrasonography) and SPECT single-photon emission computed tomography, nuclear medicine PET [positron emission tomography imaging] is used (Figure 2).

Figure 2*. Theranostics*

Figure 2: PET: Positron emission tomography; SPECT: Single photon emission computed tomography. Imaging methods in theranostic systems. Widespread clinical use of Nuclear Medicine imaging procedures is newer than in other specialties. Therefore, it is known that nuclear medicine applications began in the first quarter of the 1950s. Looking at the nuclear medicine methods used for diagnostic purposes, radioactive iodine scans (or 99mTc pertechnetate scan); octreotide scans; Metaiodo-benzyl-guanidine (MIBG) and parathyroid imaging for endocrinopathies. Positron emission tomography/computed tomography imaging using 2-[18F]fluoro-2-deoxyglucose (18FFDG) has also been developed and appears to be used in oncological, infective, vascular, and neurodegenerative disorders [6].

Nuclear medicine imaging procedures are therefore an important part of patient care and service in many medical specialties [7]. The application of ionizing radiation for diagnostic and therapeutic purposes in clinical medicine should be kept within a safe limit according to the ALARA (as low as reasonably achievable) principle [8]. Therefore, while it is the responsibility of all healthcare providers to equip themselves with up-to-date and appropriate information on radiation safety, the design of these areas is also very important.

In the fields of nuclear medicine, radiopharmaceuticals applied to the patient for diagnosis and treatment purposes are sources of radiation during and after the patient is in the clinic. In order to prevent patients waiting for imaging and treatment in the clinic from being exposed to radiation (iodine 131), the nuclear medicine laboratory (hot room), injection room and radioactive waiting rooms must be designed and planned to prevent radioactive contamination. The purpose of this study is DESIGN planning and applications that provide protection in areas where theranostic applications are made in nuclear medicine.

3. Design Principles

Architectural and interior design plans are very important to prevent radiation contamination in nuclear medicine clinics. If direct access is provided to radioactive patient waiting areas and patient imaging areas, exposure to both employees and patient relatives will be eliminated.

Design strategies that prevent radioactive contamination are shaped around the following key principles: radiation shielding, ventilation systems, material selection, waste management, and personnel safety.

In areas where radioactive substances are used, strong shielding materials must be employed to prevent radiation from spreading to other sections. Structural shielding creates a physical barrier between radioactive sources and the environment, preventing the leakage of radiation.

Construction Materials: Commonly used materials for radiation shielding include lead, barium concrete and steel plates. Lead sheets are particularly common for walls, ceilings, and doors. Barium-containing concretes, due to their high density, effectively absorb gamma radiation [9].

Doors and Windows: Radiation-proof doors are essential, especially in hot rooms and other areas where radioactive materials are handled. These doors are typically lead-lined and should have automatic closing mechanisms. Windows, if necessary, should be made of lead glass but should be kept to a minimum.

The materials used for surface coatings and equipment play a significant role in preventing contamination. These surfaces should be easy to clean to prevent the accumulation of radioactive substances.

Smooth and Non-Porous Surfaces: To prevent the accumulation of radioactive substances, smooth and impermeable surfaces should be used. Floors and walls should be resistant to chemicals and radiation, and preferably be smooth in structure [10]. An example of a Nuclear Medicine unit plan and design is given below.

4. Planning Unit Model

The risk of radioactive contamination is high during the preparation and administration of the radiopharmaceutical. From the moment the radiopharmaceutical is given to the patient, the patient becomes a source of radiation. In this case, both the staff and companions are exposed to radiation. Currently, in nuclear medicine units, the entrances and exits of healthcare technicians, patients, and companions are through the same door. Patients taken from the radioactive waiting room are brought to the imaging room by passing through the corridor. During this time, technicians, patients, and companions are in the same corridor. In this case, the work area becomes contaminated with radioactivity. The occupational exposure of technicians and the community exposure risks of companions increase. To prevent this situation, new space designs are needed for these units. A new

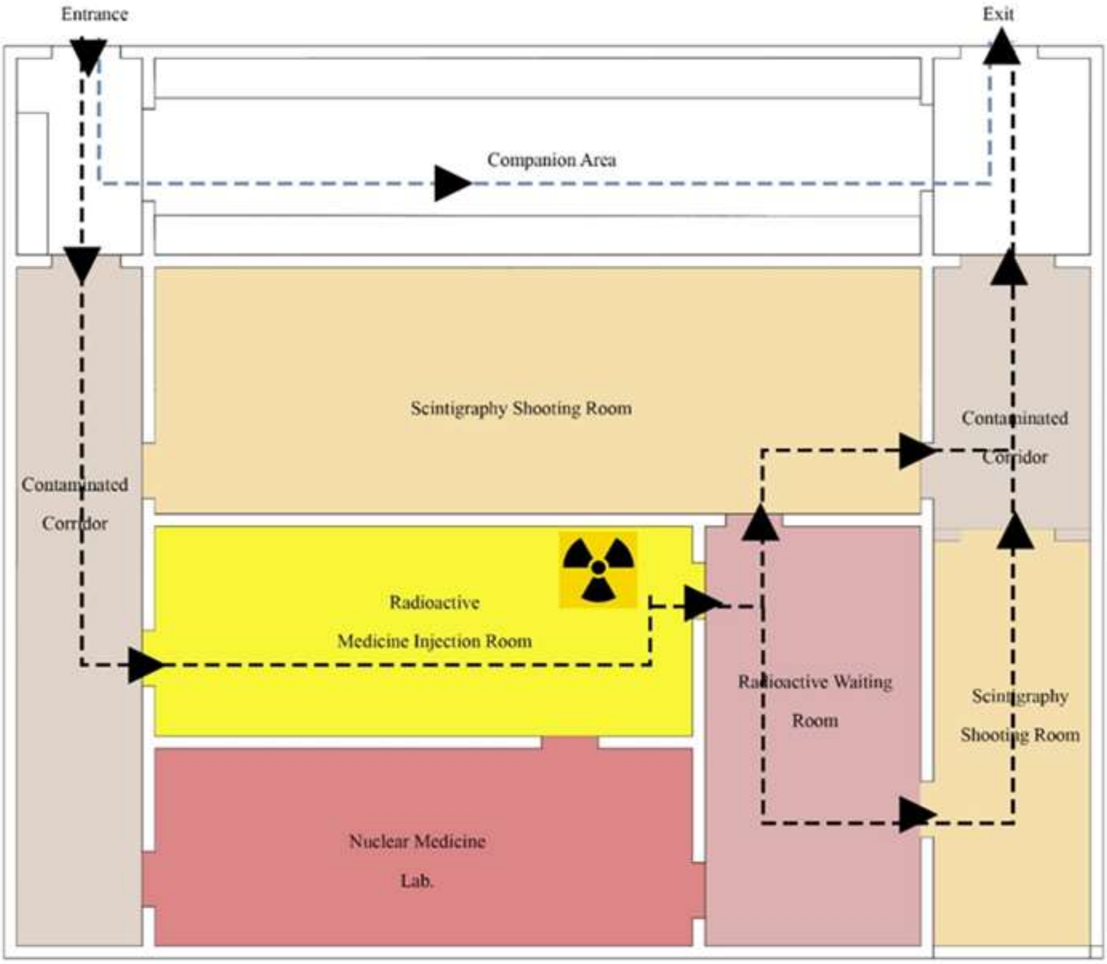

Figure 3. *Nucleer medicane design model*

design model for the nuclear medicine department has been developed, as shown in image-3, considering that separate doors should be used for entrances and exits, and patients should be taken directly to the imaging room to prevent radioactive contamination and protect healthcare workers, patients, and companions. As seen in the design model in Figure 3, corridors have been separated to minimize the risk of radioactive contamination exposure for companions and healthcare technicians. In addition to rapidlyadvancing medical services, the architecture of healthcare buildings must also be modified and renewed specific to the departments; otherwise, occupational and public health exposure will increase. As the radiation is important there many different works reported on this topic [11-26].

5. Conclusions

A design that prevents radioactive contamination in nuclear medicine units must not only involve structural shielding and ventilation but also include considerations of material selection, waste management, and personnel safety. These elements, when integrated properly, ensure that radiation does not harm either personnel or the environment. Proper design measures create a safe environment for both patients and staff while minimizing exposure to radiation.

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- **Ethical approval:** The conducted research is not related to either human or animal use.
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