

## **Chapter one**

### **Introduction**

#### **1.1 Nuclear medicine**

Nuclear medicine is defined as that medical specialty concerned with the use of unsealed sources of radiation in the diagnosis and treatment of disease (William D. et al 2003).

In diagnostic Nuclear Medicine, radiopharmaceuticals may be injected, inhaled or swallowed. Radiation emitted from the patient is then detected in order to provide information about structure and function. In therapeutic Nuclear Medicine, radiopharmaceuticals may be administered orally, intravenously, or into a cavity in order to treat disease, or provide palliative pain relief. (GopalB.Saha et al, 2006).

#### **1.2 Radiation protection**

Detrimental radiation effects are either prevented or minimized. This can be achieved by having the objectives of preventing the occurrence of deterministic effects and of limiting the probability of the stochastic effects to a level that is considered acceptable. In a nuclear medicine facility, consideration needs to be given to the patient, the staff involved in performing the nuclear medicine procedures, members of the public and other staff that may be in the nuclear medicine facility, careers and comforters of patients undergoing procedures. The ICRP system has three fundamental principles of radiological protection, namely. Any decision that alters the radiation exposure situation should do more good than harm. 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 (ALARA), taking into account economic and societal factors. (Bailey et al , 2014). The total dose to any individual from regulated sources in planned exposure situations other than medical exposure of patients should not exceed the appropriate limits recommended by the ICRP. In a nuclear medicine facility, occupational and public exposures are subject to all three principles, whereas medical exposure is subject to the first two only (Bailey et al , 2014).

The established dose limits are the upper limits for radiation exposure to individuals. The NRC has instituted the ALARA (as low as reasonably achievable) concept to reduce radiation

exposure to individuals to a minimum. The ALARA concept calls for a reasonable effort to maintain individual and collective radiation exposure as low as possible. Under this concept, techniques, equipment, and procedures are all critically evaluated. According to NRC Regulatory Guide, under the ALARA concept, when the exposure to a radiation worker exceeds 10% of the occupational exposure limit in a quarter (Action Level I), an investigation is made by the RSO, and the report is reviewed by the RSC. When the exposure exceeds 30% of the occupational exposure limit (Action Level II), corrective actions are taken or the licensee must justify a higher dose level for ALARA in that particular situation, but not to exceed annual occupational dose limit (GopalB.Saha, 2006).

**Table 2.1: Annual Dose Limits (Ref)**

Type of limit	Occupational	Public
Effective dose	20 mSv/year, average over defined periods of 5years <sup>b</sup>	1 mSv in a year <sup>c</sup>
Annual Equivalent Dose		
Lens of the eye	20mSv	15mSv
Skin	500mSv	50mSv
Hand and feet	500mSv	.....

Limits on effective dose are for the sum of the relevant effective doses from external exposure in the specified time period and the committed effective dose from intakes of radionuclides in the same period. For adults, the committed effective dose is computed for a 50 year period after intake, whereas for children it is computed for the period up to reaching 70 years of age with the further provision that the effective dose should not exceed 50 mSv in any single year. Additional restrictions apply to the occupational exposure of pregnant women. In special circumstances, a higher value of effective dose could be allowed in a single year, provided that the average over 5 years does not exceed 1 mSv/a. In 2011, the ICRP recommended that the occupational dose limit be lowered from the previous 150 mSv/ to 20 mSv/a, averaged over 5 years, and with no more than 50 mSv in any single year. The limitation on effective dose provides sufficient protection for the skin against stochastic effects. Averaged over a 1 cm<sup>2</sup> area of skin regardless of the area exposed. Exposure of workers may arise from unsealed sources either through

external irradiation of the body or through entry of radioactive substances into the body. The main precautions required in dealing with external irradiation depend on the physical characteristics of the emitted radiation and the activity as reflected by the specific dose rate constant as well as the half-life of the radionuclide (Bailey et al , 2014).

When a radionuclide enters the body, the internal exposure will depend on factors such as the physical and chemical properties of the radionuclide, the activity and the bio kinetics. Every type of work performed in a nuclear medicine facility will make a contribution to the external exposure of the worker: unpacking radioactive material, activity measurements, storage of sources, preparation of radiopharmaceuticals, administration of radiopharmaceuticals, patient handling and examination, care of the radioactive patient and handling of radioactive waste.

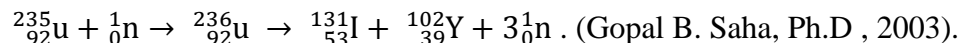
Generally, the annually effective dose to staff working full time in nuclear medicine with optimized protection should be well below 5 mSv (Bailey et al , 2014)

Therapeutic nuclear medicine requires special consideration because the high doses of radiation involved are at a level where a biological effect is produced. The levels of radiation constitute a much greater hazard to the patient, staff, and the patient's career and to the general public. In therapeutic nuclear medicine, the radionuclides used are often different from those used in diagnostic nuclear medicine; they are usually beta emitters with longer physical and biological half-lives. Therapy radionuclides may require different facilities to radionuclides used for diagnostic procedures, to ensure the safe preparation and administration of the radiopharmaceutical. Therefore, cancer has been treated with radiopharmaceuticals since the 1940s. The radionuclides originally used, including  $^{131}\text{I}$  and  $^{32}\text{P}$ , are still in use. (Publication Radiation Health Committee, 2008)

The role of the physicist in radionuclide therapy encompasses radiation protection, imaging and dosimetry. Radiation protection is of particular importance given the high activities of the unsealed sources that are often administered, and must take into account medical staff, comforters and careers, and, as patients are discharged while still retaining activity, members of the public. Regulations concerning acceptable levels of exposure vary from country to country. If the administered radiopharmaceutical is a  $\gamma$  emitter, then imaging can be performed which may be either qualitative or quantitative. (Publication Radiation Health Committee, 2008)

Thyroid cancer accounts for less than 0.5% of all cancers and there are 28000 new cases diagnosed each year in Europe and the United States Of America. Papillary and follicular thyroid cancer account for 80–90% of cases, with the remainder being anaplastic carcinomas, medullary carcinomas, lymphomas and rare tumors. Increased risk is associated with benign thyroid disease, radiation therapy to the neck and poor diet. As with benign thyroid disease, thyroid cancer has also been treated with radioiodine for over sixty years and in conjunction with total or near total thyroidectomy is widely used for an initial ablation of residual thyroid tissue. Up to 20% of cases may present with metastatic disease, usually to the lungs or bones although also to liver and brain. Treatment for distant metastases usually involves further and often higher administrations of radioiodine. This treatment is the most common application of radionuclide's for therapy and is very successful, with complete response rates of 80–90%. Nevertheless, the disease can prove fatal in a higher proportion of patients that are most at risk, which include the young and the elderly. (Bailey et al , 2014).

A variety of radionuclide's are produced in nuclear reactors. A nuclear reactor is constructed with fuel rods made of fissile materials such as enriched  $^{235}\text{U}$  and  $^{239}\text{Pu}$ . Many clinically useful radionuclide's such as  $^{131}\text{I}$ ,  $^{99}\text{Mo}$ ,  $^{133}\text{Xe}$ , and  $^{137}\text{Cs}$  are produced by fission of  $^{235}\text{U}$ . An example of thermal fission of  $^{235}\text{U}$  is presented below, showing only a few representative radionuclide's .



### **1.3 Problem of study**

Radiation protection (RP) for patients and staff is one of the main issues in nuclear medicine. UNSCEAR, ICRP and IAEA have devoted significant time over the last years to improve radiation safety in nuclear medicine. The radiation dose at the nuclear medicine department has variable amount at different parts hence the presence of persons inside the hot lab at any distance, isolated rooms, it is important to keep radiation doses as low as possible. Dealing with I-131 therapy usually gives high radiation dose any person who deals with I-131. It is likely that the staff of nuclear medicine department at Tumor Therapy and Cancer Research center – Shendi receive high radiation dose.

### **1.4 Objective**

#### **1.4.1 General objective**

To assessment of staff radiation dose during the application of iodine 131- Therapy at Tumor Therapy and Cancer Research center.

#### **1.4.2 Specific objective**

- To determine the staff radiation dose in iodine therapy.
- To measure which of the workers received high dose and the causes of this increase.
- Comparing the radiation dose with recommended ICRP standard dose limit.
- To study the Experian to radiation dose to the staff.
- To evaluate the effect of duration staff radiation dose.

### **1.5 Thesis Outline**

This thesis is concerned with the evaluation of staff doses in radioactive iodine 131 therapy. Accordingly, it is divided into the following chapters:

Chapter one is the introduction to this thesis. This chapter discusses the objectives and scope of work and introduces necessary background. It also provides an outline of the thesis.

Chapter two contains the background material for the thesis. Specifically it discusses the dose for all effective dose to the staff who work in Iodine – 131 therapy and calculations. This chapter also includes a summary of previous work performed in this field.

Chapter three describes the materials and a method used to measure dose for different staff whom working nuclear medicine therapy and explains in details the methods used for dose calculation.

Chapter four reveals and demonstrates the results of this study.

Chapter five presents the discussion, conclusion and recommendations of the thesis and gives suggestions for future work.