Lymphoscintigraphy and Radiation – Occupational Exposure During Sentinel Node Assay

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Abstract

Ionizing radiation has many practical applications, but it is also, as it is well known, dangerous to human health. The purpose of this study was to estimate the dose and exposure for medical staff involved in sentinel node assay and to determine how safe this assay really is. The theoretical method was used for calculation. Three groups of medical staff were selected: nuclear medicine specialist, nuclear medicine technologist and a surgeon. The results obtained show that the most exposed staff member is nuclear medicine specialist and that dose received by the surgeon is smaller then the dose limit.

KEY WORDS: Lymphoscintigraphy, sentinel node, radiation exposure.

Introduction

The human body is permanently or temporarily exposed to various kinds of radiation, one of them being ionizing radiation. The ionizing radiation is a product of nucleus decay, acceleration of charged particles in electrical or variable magnetic fields and target collision (1). Because of their complex structure, living organisms are very sensitive to the influence radiation. It affects the living functions of cell and thus it affects tissues, organs and organisms themselves. Accordingly, two types of radiation influence can be distinguished: direct influence on atoms incorporated in the molecules of living tissue and indirect influence on atoms of the surrounding media, mostly water. The consequence of this influence is the change in the cell function. Ionization of living matter depends not only on the absorbed dose but on relative biological effect (RBE) as well. Relative biological effect can be produced by various types of ionizing radiation. The energy deposited by radiation causes serious effects in the matter and it changes its properties. A portion of the absorbed energy by mass unit of the exposed material is known as absorbed dose and it is expressed as SI unit Gray (Gy) $D = \frac{\Delta E_D}{\Delta m}$ (2). Equal doses of alpha, beta and gamma radiation will not produce the same effects in an organism. Therefore, the term equivalent dose is introduced. It is expressed in Sieverts (Sv). The equivalent dose is equal to the product of the absorbed dose and radiation quality factor wR. The radiation quality factor is one of the factors of modification used to describe biological effectiveness of radiation (2). The effective dose is the sum of products of equivalent dose and risk factor that corresponds to a specific tissue or organ. It is used to estimate the risk of radiation for the whole body, regardless of which parts of the body were exposed to radiation. $E = \sum_i w_{Ti} H_i$. w_{Ti} corresponds to the risks of the stochastic effects influencing the tissue i. According to the total stochastic effects on equally exposed body, risk factors values for various tissues and organs are given in the Table 1 (3). Application of ionizing radiation in medicine means adhering to the basic radiation protection principles: justification, optimization and dose limits for staff and public. The main aim of this study was to determine the dose rates and exposure in personnel directly involved in lymphoscintigraphy and biopsy of sentinel node. Lymphoscintigraphy is nuclear medicine assay used in early stages of malignant diseases and in therapy planning and predictions. The assay is performed in breast cancer and melanoma. Radionuclide used in this assay is ^{99m}Tc. ^{99m}Tc is gamma emitter with 140 keV and half time of 6,02 hours. Nano-colloid albumin labeled with 13 MBq of ^{99m}Tc is used as tracer.

TISSUE OR ORGAN	w
GONADS	0,2
BONE MARROW	0,12
COLON	0,12
LUNGS	0,12
STOMACH	0,12
BLADDER	0,05
BREAST	0,05
LIVER	0,05
ESOPHAGUS	0,05
THYROID	0,05
SKIN	0,01
BONE	0,01
OTHER	0,05
WHOLE BODY	1

TABLE 1. Risk factors of various body parts

Subjects and Method

Main requirements for sentinel node scintigaphy are:

- Radiopharmeceutical preparation. ^{99m}Tc pertechnetate is produced from ^{99}Mo/^{99}Tc generator. The vial, containing albumin colloid particles, is placed in a led container and by aseptic method 185 – 5550 MBq of ^{99m}Tc Sodium pertechnetate in 1-5 ml is added.
- Allowed activity for sentinel node scintigraphy is 13 MBq in the volume of 0,2 ml.
- Radiopharmaceutical is applied by intratumor or peritumor injection at breast carcinoma or melanoma location, intracutaneous injections in different places: near the tumor or along the scar.
- A nuclear medicine specialist performs the application.
- Gamma camera is an instrument for the detection and monitoring of lymph nodes drainage. Siemens dual head gamma camera with LEHR collimators was used.
- After the application of radiopharmaceutical, dynamic acquisition is made in the duration of 60 min, 60 x 1 fr/min.
- Following the dynamic acquisition, two static acquisitions are made: 10 minutes anterior and posterior images.
- Identification and localization of the sentinel node is done by Co-57 pen-marker, and after marking with pen marker a gamma probe is used. The probe is used for identification of the most sensitive node and verification of the node location.
- Marking of the node on the skin is made by the skin marker (8).

After the detection and marking of the sentinel node, the patient is sent to surgery, and the process of biopsy begins.

Methods

The theoretical model (D_R=nΓ/d_2) was used for calculation of dose rate and exposure during sentinel node assay. This model tried to introduce the work conditions of the staff involved in the process of lymphoscintigraphy and biopsy of sentinel node. The dose rate and exposure to hands and body at 1 meter distance are calculated for staff in contact with the source material and the patient in different stages of the assay. The model was made for different groups of staff:

- Nuclear medicine specialist during the application of radiopharmaceutical;
- Nuclear medicine technologist, who assists the specialist and operates gamma camera;
- Surgeon, during biopsy of sentinel node (2, 4 and 8 hours after administration).

	ACTIVITY (TIME, DISTANCE)	DOSE TO HANDS	DOSE AT 1M
NUCLEAR MEDICINE PHYSICIAN, APPLICATION	13 MBq (2 min, 0.5 cm)	17.248 mSv/h (0.57 mSv)	0.431 μSv/h (0.014 μSv)
NM TECHNOLOGIST	13 MBq (30 min, >1m)		0,43 μSv/h (0,43 μSv)
SURGEON, SURGERY AFTER 2 H	10,33 MBq (1 h / 0,1-1m)	34,26 μSv/h (34,26 μSv)	0,34 μSv/h 0,34 μSv
SURGEON, SURGERY AFTER 4 H	8,22 MBq (1 h / 0,1-1 m)	27,20μSv/h (27,20 μSv)	0,27 μSv/h (0,27 μSv/h)
SURGEON, SURGERY AFTER 4 H	5,17 MBq (1 h / 0,1-1 m)	1,7 μSv/h (1,7 μSv)	0,01μSv/h (0,01μSv)

TABLE 2. Estimation of the dose and exposure at sentinel node study

It was necessary to make a correction for the factor of decay $e^{-\lambda t}$, where λ is decay constant and t is time interval from the moment of administration of radiopharmaceutical to the time of measurements.

Results and Discussion

- Nuclear medicine specialist, holding syringe with 13 MBq of ^{99m}Tc between fingers (d=0,5 cm) in 2 minutes period of radiopharmaceutical application, will receive 0,37 mSv. In that period, at 1 meter distance from the source, dose to the body will be 0,014 μSv.
- Nuclear medicine technologist in a period of 30 minutes at 1 meter distance will receive dose of 0,21 μSv.
- For surgeon during one hour that is needed for this assay, depending on the period after the administration results were as follows:
- 2 hours after the administration of radiopharmaceuticals 10,33 MBq of administrated activity remains. In this case, surgeon will receive a dose of 34,26 μSv to hands and 0,34 μSv to the body.
- 4 hours after the administration, activity of ^{99m}Tc will be 8,22 MBq and dose to hands will be 27 μSv and to body 0,27 μSv.
- 8 hours after the administration the dose will be negligible (5,7 MBq). In this case the hands will receive a dose of 2,7 μSv and 0,02 μSv to the body.

An assumption is made that all the other staff present in the surgery theatre is at more than one meter distance from the patient, so the received dose is negligible.

Conclusion

After calculating the dose rate and exposure of medical staff during lymphoscintigraphy and biopsy of sentinel node our results showed that the most exposed professional was the nuclear medicine specialist. The nuclear medicine technologist was the second most exposed member of the staff. Surgeons and other medical personnel who work in the team, receive doses that are negligible and 2000 times bellow the dose limit. These results are in accordance with those found in studies (4), (5) and (6). The dose rate and exposure during the assay are minimal and there should be no fear of radiation and its consequences after this assay.

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