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Radiation exposure of the surgeons in sentinel lymph node biopsy

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Background: Sentinel node biopsy (SLNB) is the standard of care for breast cancer treatment and it is getting wide acceptance in Iran. The radiation safety of the procedure has been investigated under controlled conditions, but the standard dose of radiotracer and techniques are not always observed in the community setting. The aim of this study was to assess the magnitude of the absorbed doses of radiation to the hands of operating surgeons. *Materials and Methods:* Twenty consecutive SLNB procedures were studied. Radiation dose to the hands of the surgeons was measured by placing lithium fluoride thermoluminescent dosimeters (TLDs) in the surgeons' glove. The radiation dose to the abdomen and thyroid area was measured by placing TLDs at these areas. The injected dose of radiotracer, the time interval to the surgery and the duration of the surgery were recorded. *Results:* The injected dose of radiotracer ranged from 0.1 to 5 mCi. The highest absorbed dose was recorded by TLD, placed on the non-dominant hand third finger (189.1 μSv). Mean recorded doses were higher for non-dominant hand second finger (53.49 ± 24.60 μSv). The measured absorbed doses for the abdominal and thyroid area were lower than those for the fingers. *Conclusion:* This study has confirmed the procedure safety, even with high dose of radiotracer. Nevertheless, it is advisable to use the lowest dose of the radiotracer to avoid the waste of resources. **Iran. J. Radiat. Res., 2012; 10(1): 53-57**

Keywords: *Sentinel lymph node biopsy, radiation dose, radiotracer.*

INTRODUCTION

The concept of the sentinel lymph node was first introduced by Ramon Cabanas in relation to penile cancer in 1977 (1). The sentinel lymph node is the first node which receives lymphatic drainage from the primary tumor site (2). Sentinel node biopsy was first performed in patients with skin melanoma using vital blue dye for lymphatic mapping (3). With the introduction of pre-operative lympho-scintigraphy and intra operative detection of gamma radiation, the technique was further improved. Several studies have demonstrated the accuracy of the procedure for the prediction of nodal metastasis in the entire regional nodal basin in patients with breast cancer and melanoma (4).

Nowadays, sentinel node biopsy is considered as the standard of care for breast cancer treatment in many centers and is performed with the use of radiotracer alone or with concomitant use of blue dye. It is also increasingly used for other types of cancers such as gastrointestinal, head and neck, vulvar, penile and prostate cancer (5-7).

Despite low activity, the use of radioactive labeled tracer creates exposure to radiation of medical staffs that perform the procedure. There have been reports of radiation safety of this procedure, but all studies were performed under controlled conditions using standard doses of radiotracers (8-13). However, in Iran, the procedure is going to be more popular, but there are a lot of variations in the used radiotracer dose in sentinel lymph node biopsy.

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This study is performed to assess the absorbed radiation dose of surgeons at different body sites during sentinel node biopsy in breast cancer patients. Remaining operation theatre personnel will receive less radiation dose compared to the surgeon, due to further distance from the patient.

MATERIALS AND METHODS

The study was performed in 3 different centers (Imam Khomeyni hospital, Khatam-ol-Anbia hospital and Iranian Center for Breast Cancer). Twenty consecutive breast cancer patients who were candidate of axillary sentinel node biopsy were studied in these three centers between July 15 and September 30, 2009. The radiotracer materials (^{99m}Tc on albumin colloid) were injected at nuclear medicine department of the centers. The activity of the tracer ranged from 0.1 to 5 mCi in 0.25 ml of the solution. The dose of the injected radiotracer, the time interval between the injection and surgery and also duration of the surgery were recorded. The time of injection of radiotracer was recorded on the lympho-scintigraphy report and the time of beginning the surgery was recorded. The time interval between injection of the radiotracer and surgery was calculated accordingly. No intervention was performed in the dose and injection site of the radiotracers or the surgery.

Surgery procedure

The patients were selected for mastectomy or breast conserving surgery as indicated. The injection of the radiotracer was performed on the day of surgery or the day before it depending on the schedule of the operating theater and the working hours of the nuclear medicine department. Highly sensitive thermo-luminescent dosimeters (TLDs) were placed in the second and third finger inside the gloves of the surgeon. One TLD chip was also attached on the abdominal wall of the surgeon at the level of the operation table, and one was placed on his/her neck over the thyroid area.

First, the surgeon localized sentinel lymph node using a gamma probe and sent it for frozen section evaluation and if it was involved by tumor, complete axillary dissection was performed. Then mastectomy or quadranectomy was performed to remove the breast tumor according to the plan of operation. TLDs were in sites till the end of the operation then they were sent to physics lab to be read out.

Dosimetric procedure

The measurements were performed with the use of highly sensitive thermo luminescent dosimeter circular chips (TLD) made of lithium fluoride (PTW, LiF:Mg,Cu,P, type GR200A) with dimensions of 4.5mm × 0.8mm. Their Linear responses were from 1μGy to 12Gy. Before each irradiation, all dosimeters were annealed following the recommendations of the producer, which is heating at 240ºC for 10 min followed by fast cooling (annealing was performed using a THELDO TLD-Oven). TLD chips were calibrated by Co-60 γ-rays with the mean energy of 1.25 MeV by the level of doses from 0.2 cGy to 10 cGy. TLDs calibration carried out for each chip individually to acquire element correction coefficient (ECC) and also group calibration to acquire dose calibration curve.

After 24 hours TLDs were read out using a LTM reader (Fimel, France) and the calibration curve obtained. The protocol procedure was: Preheating slope Q1: 6ºC/s ; Duration of plateau 1: 7s ; Preheating: 140ºC ; Heating slope Q2: 6º C/s ; Duration of plateau 2: 10s ; Heating: 245ºC .

RESULTS

The mean dose of injected radiotracer was 1.20 ± 1.54 mCi (range 0.1 to 5 mCi). The dose of injected radiotracer was 1 mCi or more in 10 patients and the others received less than 1mCi of radiotracer.

In all cases, the sentinel node was found easily. The mean time interval to operation was 11.01 ± 7.61 hours and the mean operation time was 90±40.11 minutes.

The mean equivalent doses of radiation to the surgeon's hands, abdomen and thyroid area are shown in table 1. The mean recorded dose was higher for the second finger of non dominant hand of the surgeon (53.49 ± 24.60 µSv).The measured doses for abdominal and thyroid area were less than those recorded for the fingers.

The mean absorbed radiation does, duration of operation and time interval to surgery were calculated for two groups of study population separately (i.e. those who received 1 mCi or more and those who received less than 1 mCi). The equivalent dose, time interval to operation and duration of the operation according to injected dose of radiotracer are shown in tables 2 and 3. As shown in these tables, the mean absorbed doses of the fingers were less in the group who received 1 mCi or more. It might be due to the shorter mean duration of the operation in this group (77.77 ± 42.50 minutes compared to 102.22 ± 35.71 minutes in the other group).

Table 1. The mean equivalent radiation doses of the hands, abdomen and thyroid of the surgeons for all patients (N=20).

Position	**Minimum** (µSv)	**Maximum** (µSv)	**Mean ± SD** (µSv)
Dominant hand ,2nd finger	9.90	137.90	46.27 ± 33.26
Dominant hand ,3rd finger	9.00	104.50	44.20 ± 26.09
Non-dominant hand, 2nd finger	21.90	98.80	53.49 ± 24.60
Non-dominant hand, 3rd finger	17.70	189.1	52.88 ± 38.73
Abdominal area	4.96	56.90	30.92 ± 17.14
Thyroid area	6.70	76.30	27.75 ± 20.06

Table 2. The mean equivalent radiation doses, time to operation and duration of the surgery in the group who received 1mCi or more.

Position	**Minimum**	**Maximum**	**Mean ± SD**
Dominant hand ,2nd finger dose (µSv)	9.90	56.20	29.63 ± 14.73
Dominant hand ,3rd finger dose (µSv)	10	62.70	30.51 ± 15.85
Non-dominant hand ,2nd finger dose (µSv)	25.30	77.90	49.23 ± 19.41
Non-dominant hand, 3rd finger dose (µSv)	17.70	76.30	42.24 ± 17.15
Abdominal area dose (µSv)	4.96	47.10	27.42 ± 17.14
Thyroid area dose (µSv)	6.70	76.30	26.63 ± 22.46
Time interval to operation (hours)	1	22	12.50 ± 8.08
Duration of the surgery (minutes)	45	180	77.77 ± 42.50

Table 3. The mean equivalent radiation doses, time to operation and duration of the surgery in the group who received less than1mCi.

Position	**Minimum**	**Maximum**	**Mean ± SD**
Dominant hand ,2nd finger dose (µSv)	17	137.90	61.25 ± 38.65
Dominant hand ,3rd finger dose (µSv)	9	104.50	56.25 ± 27.97
Non-dominant hand ,2nd finger dose (µSv)	21.90	98.80	57.75 ± 29.34
Non-dominant hand, 3rd finger dose (µSv)	21.20	189.10	63.52 ± 51.20
Abdominal area dose (µSv)	7.06	56.90	34.07 ± 17.41
Thyroid area dose (µSv)	7.20	59.70	28.86 ± 18.84
Time interval to operation(hours)	1	18	9.67 ± 7.31
Duration of the surgery (minutes)	75	190	102.22 ± 35.71

DISCUSSION

The average activity of radiotracer used in the present study was rather high compared with most reports in the literature. Other studies used doses as small as 0.4 mCi to more than 2.7 mCi [10,12].A wide range of injected dose was used in this study (range 0.1 to 5 mCi). In one case, 4 mCi was injected on the day of operation. The reason for this wide range of radiotracer dose might be due to the fact that SLNB is a rather new procedure in Iran, so many centers do not have enough experience in the performing procedure, and there is no standard protocol available for nuclear medicine departments about the dose of the radiotracer. They use higher doses to avoid the possibility of losing sentinel node.

In the present study, the 2nd finger of the non-dominant hand received the greatest dose which is due to the fact that the surgeons used non-dominant hand to handle the specimen while working by a surgical instrument with their dominant hand. This resulted in a shorter distance between non-dominant hand and contaminated tissue in comparison with the dominant hand.

The radiation doses in the group with injections of less than 1 mCi were higher compared to the group who injected 1 mCi or more. This is due to the longer surgery duration in the first group. It should be mentioned that the sentinel node was found in all cases regardless of the injected doses even for one patient with injected dose of 0.1 mCi the day before surgery. There are other studies which have measured the radiation exposure in sentinel node operations.

Our results confirmed that the radiation doses to the surgeons' hands are very low as it was shown in previous studies by Nejc *et al.* [9], de Kanter *et al.* [14] and Klausen *et al.* [10]. Nejc *et al.* [9] used TLDs to measure the absorbed doses of radiation to the hands of the physician who injected the radiotracer, the surgeon and the scrub nurse. Maximum recorded dose was 164 µSv for the physician injecting radiotracer and 22 µSv for the surgeon performing the operation. The absorbed dose for scrub nurse was similar to the surgeon. They concluded that the maximum recorded dose during sentinel node biopsy in their study was 2200 times smaller than 1-year dose limit. Similarly de Kanter *et al.* [14], reported radiation dose to the theatre nurse, the pathologist and his assistant was beneath the detection limit of 10 mSv. The highest measured doses were in the hands of the surgeon and his assistant (17 ± 61 mSv). Klausen *et al.* [10], also measured radiation dose to the hands and abdomen of the surgeons by TLD and reported the mean skin dose (±SD) to the hand and the abdominal wall were 0.04 ± 0.04 mSv and and 0.01 ± 0.02 mSv respectively.

Considering dose limit of 500 mSv for skin according to National Council on Radiation Protection & Measurements (NCRP) report, a surgeon could perform more than 9000 sentinel node procedure without exceeding the dose limits.

In our country, a surgeon rarely performs more than 100 SN biopsy annually. This means that considering the injected doses in this study, the surgeons might not have anxiety about the radiation dose above recommended limits.

Considering ALARA principle which emphasizes making every effort to reduce the risks of radiation exposure, and the fact that sentinel node was successfully found with radiotracer doses as small as 0.1mCi, the authors have recommended avoiding high doses of radiotracer in this procedure.

This study has confirmed the safety of the sentinel node biopsy even with higher doses of injected radiotracers. Nevertheless, paying attention to the successful finding of the sentinel node with doses as small as 0.1 mCi, it would be a waste of resources to use higher doses.

CONCLUSION

The surgeon performing the sentinel node biopsy procedure is only exposed to a minimal radiation risk, far below the maximum permissible despite the wide range of injected dose of radiotracer. Nevertheless, it is recommended to provide standard protocols for nuclear medicine departments for the procedure of SLNB which will lead to reduced dose of radiotracer and safer procedures.

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