



# Evaluation of Radiation Exposure During Sentinel Lymph Node Biopsy in Breast Cancer: A Retrospective Study

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## Abstract

**Introduction** Sentinel node biopsy (SNB) is the standard of care for nodal staging in breast cancer. Currently, radioisotope-guided SNB is the standard technique. We have undertaken this study to analyse radiation exposure during SNB for breast cancer over a significant period of time.

**Methods** The study was conducted over a period of 41 months and included 183 patients. The radioisotope was usually administered the day preceding the surgery at a dose of 40 MBq ( $\pm 10\%$ ), and a lower dose of 20 MBq ( $\pm 10\%$ ) was given if injected on the day of surgery. The radiation exposure was measured by dosimeters worn by the surgeon and surgical assistant.

**Results** The surgical procedures performed were mastectomy and SNB (56 patients), wide local excision and SNB (109 patients), and SNB alone (18 patients). The median time interval between the injection and surgery was 19.3 h, and median duration of surgery 93 min. The annual exposure for the surgeon was 0.125 mSv (range 0.01–0.03 mSv) and for the assistant was 0.265 (range 0.01–0.13 mSv).

**Conclusion** Contrary to other studies, we found the radiation exposure in the assistant was higher than that in the surgeon and we think this is because the assistant is positioned closer to the injection site during the procedure. However, the cumulative levels of radiation with SNB were very low and significantly below the permissible limits. The timing of injection, type of breast surgery and duration of procedure did not affect the levels of radiation exposure.

## Introduction

Sentinel node biopsy (SNB) has become the standard of care for nodal staging in clinically node-negative breast cancer [1–3] and melanoma [4, 5]. This procedure provides accurate staging of the lymph nodal regions and avoids the morbidity associated with lymph node dissection. The combination of radiopharmaceutical agent and dye (dual technique) is the recommended method as it has high

identification and low false-negative rates [6]. Apart from its use in early breast cancer and melanoma staging, radioisotope-guided SNB is increasingly being used in breast cancer following neoadjuvant therapy [7] and is being explored for use in head and neck, gastrointestinal, penile and gynaecological cancers [8–12].

With the widespread acceptance of radiopharmaceuticals, it is important to study the radiation exposure to the medical personnel. There have been studies which have analysed the radiation exposure to the surgical team and pathologists, albeit in controlled conditions using small numbers and over short periods [13–16]. Our study primarily aims to study the radiation exposure to the surgeon and surgical assistant during SNB for breast cancer over a

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significant period of time. We also studied the relation of exposure to the type of procedure, duration of surgery and timing of isotope injection.

## Method

This study was conducted between September 2015 and January 2019 in the Wirral Breast Unit, Wirral University Teaching Hospital. The patients included in the study were those who underwent SNB using radioisotope for clinically node-negative breast cancer. Following discussion with the trust Research Department, we were advised that an Ethical Committee approval was not required for this retrospective study.

The radiopharmaceutical used was Tc-99m nanocolloid. The injection was administered in the Nuclear Medicine department usually in the afternoon preceding the day of surgery. A dose of 40 Mega Becquerel (MBq) ( $\pm 10\%$ ) was injected in the periareolar area. On the day of surgery, a reduced dose of 20 MBq ( $\pm 10\%$ ) was given.

During surgery, blue dye was given in the periareolar area to facilitate dual-technique identification of sentinel node. Hand-held gamma probe (Neoprobe GDS) was used to identify and verify the sentinel node. More recently, we have avoided the blue dye when there was a good gamma probe reading in the axilla.

The radiation exposure was measured with a thermoluminescent dosimeter worn by the surgeon and surgical assistant at the chest level. The surgeon wore the device during surgery throughout the study period and the surgical assistant for 13 months. The devices were worn out of personal interest and were not standard practice in the unit. The device was sent to Integrated Radiological Services (IRS) Ltd, Liverpool, for analysis every 2 months. The surgeon and assistant did not undertake any other procedure related to radiation exposure during this period, and when not in use, the dosimeters were stored in the surgeon's office well away from any radiation source.

For each procedure, we studied the correlation of radiation exposure to the injected dose, time interval between injection and surgery, type of surgery and duration of surgery.

## Results

The study was conducted over a period of 41 months. A total of 183 patients were included in this study. The parameters studied are outlined in Table 1. The median age was 60 years (range 29–86 years). The surgical procedures performed were mastectomy and SNB (56 patients), wide local excision and SNB (109 patients), and SNB alone (18

**Table 1** Parameters studied

Median age: 60 years (range 29–86 years)
Type of surgery
Mastectomy and SNB: 56
Wide excision and SNB: 109
SNB alone: 18
Interval between injection and surgery: 19.3 h (2.3–24.3 h)
Duration of surgery: 93 min (30–217 min)

patients). Dual technique (radioisotope and blue dye) was used in 153 patients and only isotope in 30 patients. The median time interval between the injection and surgery was 19.3 h (range 2.3–24.3 h). The duration of surgery was a median of 93 min (range 30–217 min).

The analysis of the radiation exposure is shown in Table 2. The annual exposure for the surgeon was 0.125 mSv (range 0.01–0.03 mSv). The readings were consistent throughout the 41-month period with only one value at 0.03 mSv. The assistant's readings were in the range of 0.01–0.13 mSv with an annual exposure of 0.265 mSv. There were fluctuations in the readings for the assistant, and most values were higher than that of the surgeon as shown in Fig. 1.

## Discussion

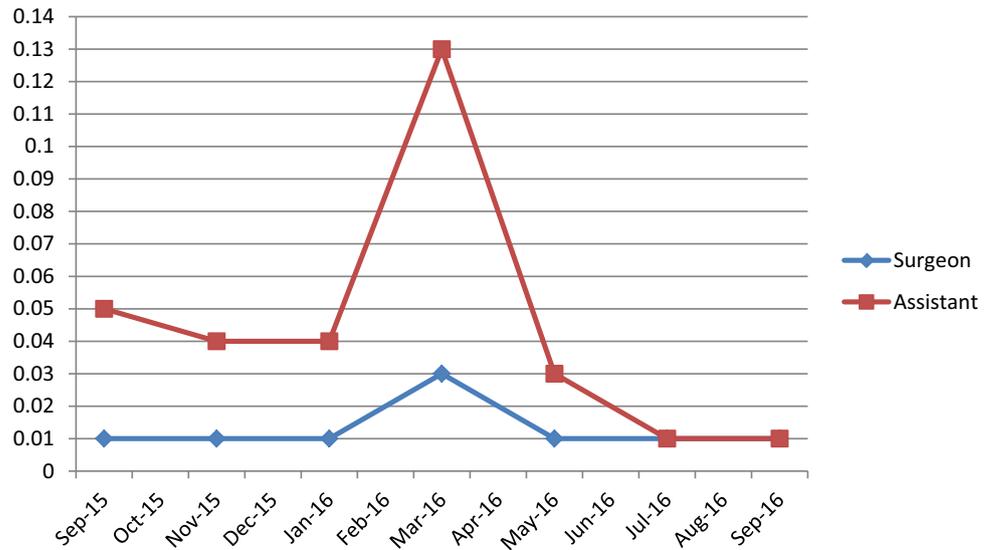
The concept of SNB was introduced by Cabanas [17] with the use of lymphangiograms for the management of penile cancers. Various tracers have been tried subsequently, and the blue dye technique was widely accepted following its description of use in melanoma by Morton et al. [18] and in breast cancer by Giuliano et al. [19]. Use of radioactive tracers for identifying sentinel nodes was first reported by Alex et al. in 1993 [20].

With the increased utilisation of SNB in management of breast cancer and melanoma, and potential use in other cancers, it is important to have information about the amount of radiation exposure to medical personnel. The Health and Safety Executive Guidance 2017 states that there is no safe level of radiation exposure [21]. The ICRP recommendation for health workers is a maximum dose of

**Table 2** Radiation exposure

	Annual mSv	Range
Surgeon	0.125	0.01–0.03
Surgical assistant	0.265	0.01–0.13

**Fig. 1** Dosimeter values of surgeon and assistant



20 mSv per annum. The dose limit for the general public is up to 1 mSv per year. For pregnant health workers, the radiation exposure limits are similar to that of the general public [22].

Our study has one of the largest cohorts of patients, and we have looked at the exposure pattern over a significant period of time to look for any variations. The study was performed using standard techniques, and this is unlike other studies which were performed under controlled conditions and may not reflect daily clinical practice. We found that the cumulative radiation exposure to the surgeon and surgical assistant was well within the recommended limits. There was no difference in the radiation exposure with regards to the timing of the injection, type of surgery and duration of procedure.

The Health and Safety Executive Guidance 2017 further discusses factors which affect the radiation exposure, and these include the exposure time, distance from the source and shielding. These factors are part of the ‘as low as reasonably achievable’ (ALARA) principle for minimising radiation exposure [21]. The paper by Kimura et al. studied these factors and was mainly aimed at risk in pregnant physicians. They discuss that exposure dose is related inversely to the distance and directly to the time of injection, and concluded that the posture of the surgical doctor and the procedure have an impact on the radiation exposure. They also found that wearing protective clothing equivalent to 0.25-mm lead resulted in a median 66% reduction in exposure doses [13]. Klausen et al. [14] studied exposure in 96 procedures, and concluded that the radiation exposure is related to the distance from the patient and time of the procedure. In a small study of 36 procedures by Coventry et al. [16], they found the extremity radiation was higher in breast cancer compared

to melanoma surgery and attributed this to the distance of the surgeon from the injection site and direct contact with the tumour. Overall, in the above studies, the exposure was well within the recommended limits though the surgeon amongst other medical personnel received the highest exposure.

In our study, contrary to other papers, we found that the exposure was higher in the surgical assistant. We do not know the exact reason for this finding, but we noticed that the assistant is closer to the injection site during the procedure than the surgeon. The assistant stands on the side of the tumour just superior to the extended arm and is constant in position. The duration of contact between the patient and the surgical team was similar, and the positioning of the team was the only possible reason we could speculate as a cause for this difference in reading.

Kimura et al. [13] in the 47 procedures they studied found the median exposure dose was 3 $\mu$ Sv, and using this value they concluded that 333 surgeries need to be performed to reach the safe exposure dose of 1 mSv. The annual whole-body exposure in our study for the surgeon was 0.126 mSv; and to achieve the dose of 1 mSv, more than 450 procedures need to be performed. Similar calculations based on the assistant’s exposure of 0.26 mSv reveal that more than 200 procedures will need to be undertaken to reach the recommended exposure for general public and pregnant individuals.

The dose of radioisotope has also varied between the above studies. The exposure readings in our study were very low; and as discussed above, a high number of procedures can be performed without concerns about radiation exposure. We attribute this to using a low injection dose given on the day before the surgery; and if given on the day of the surgery, half the dose can be used. Exposure

readings at such low levels should be reassuring to all medical personnel including those pregnant.

Newer techniques of performing SNB are being tested. These include indocyanine green fluorescence, superparamagnetic iron oxide nanoparticles and contrast-enhanced ultrasound using microbubbles [23, 24]. The early results of these novel techniques showed non-inferiority compared to SNB and appear promising [25], and one of their advantages is no radiation exposure to the patient and staff, and therefore have a potential to replace radioisotope-guided SNB in the future.

## Conclusion

We found that the radiation dose was slightly higher for the surgical assistant rather than the surgeon; however, the cumulative levels of radiation with SNB were very low and significantly below the permissible limits. A low dose of radioisotope used on the day prior to surgery will ensure low radiation exposure to the medical personnel and make SNB a safe procedure. The timing of injection, type of breast surgery and duration of procedure did not affect the levels of radiation exposure.

## Compliance with ethical standards

**Conflict of interest** The authors declare that they have no conflict of interest.

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