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SENTINEL LYMPH NODE SCINTIGRAPHY IN CUTANEOUS MELANOMA USING A PLANAR CALIBRATION PHANTOM FILLED WITH TC-99M PERTECHNETATE SOLUTION FOR BODY CONTOURING

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Abstract

Background and aims*. Melanoma is a disease that has an increasing incidence worldwide. Sentinel lymph node scintigraphy is a diagnostic tool that offers important information regarding the localization of the sentinel lymph nodes offering important input data to establish a pertinent and personalized therapeutic strategy. The golden standard in body contouring for sentinel lymph node scintigraphy is to use a planar flood source of Cobalt-57 (Co-57) placed behind the patients, against the gamma camera. The purpose of the study was to determine the performance of the procedure using a flood calibration planar phantom filled with aqueous solution of Technetion-99m (Tc-99m) in comparison with the published data in literature where the gold standard was used.*

Methods. *The study was conducted in the Department of Nuclear Medicine of Oncology Institute "Prof. Dr. Ion Chiricuţă" Cluj-Napoca in 95 patients, 31 males and 64 females. The localization of the lesions was grouped by anatomical regions as follows: 23 on lower limbs, 17 on upper limbs, 45 on thorax and 10 on abdomen. The calibration flood phantom containing aqueous solution of Tc-99m pertechnetate was used as planar source to visualize the body contour of the patients for a proper anatomic localization of detected sentinel lymph nodes. The radiopharmaceutical uptake in sentinel lymph nodes has been recorded in serial images following peritumoral injection of 1 ml solution of Tc-99m albumin nanocolloids with an activity of 1 mCi (37 MBq). The used protocol consisted in early acquired planar images within 15 minutes post-injection and delayed images at 2-3 hours and when necessary, additional images at 6-7 hours. The acquisition matrix used was 128x128 pixels for an acquisition time of 5 - 7 minutes. The skin projection of the sentinel lymph nodes was marked on the skin and surgical removal of detected sentinel lymph nodes was performed the next day using a gamma probe for detection and measurements.*

Results. *The sentinel lymph nodes were detected in 92 cases and confirmed with the gamma probe during the surgical procedure. The localization of the lymph nodes was as follows: for the tumors localized on lower limb 23 lymph nodes were localized in inguinal region, for the tumors localized on upper limb, 17 lymph nodes were localized in axilla, for the tumors localized on the thorax, 40 lymph nodes were localized in axilla and 3 were localized in the inguinal region; for the tumors localized on the abdomen, 1 lymph node was localized in axilla and 8 lymph nodes was localized in inguinal region. Regarding the negative sentinel lymph node cases, 2 cases were registered for primarily lesions localized on thorax and 1 for a lesion localized on abdomen. According to histology, 26 cases revealed lymphatic metastatic invasion. Dose rates measured at 1m from the calibrator phantom had an average value of 3.46 μSv/h (SD 0.19) and at 1.4m, the value was 2.57 μSv/h (SD 0.22). Dose rates measured at the same distances from the Co-57 planar flood source had a average values of 32.5μSv/h (SD 0.11) respectively 24.1 μSv/h (SD 0.14).*

Conclusion. *The planar calibration flood phantom is an effective tool for body contouring in sentinel lymph node scintigraphy and offers accurate anatomical information to efficiently localize the detected sentinel lymph nodes in melanoma, being for the first time used and mentioned as a pertinent alternative in our department.*

Keywords: sentinel lymph node, melanoma, calibration planar phantom, Co-57 flood source, lymphoscintigraphy

Background and aims

Melanoma is a disease that has an increasing incidence worldwide, being a health problem for persons exposed at risk factors like: sunburn, high UV exposures, family history of melanoma and red or blond hair [1]. Usually the prognosis of localized melanoma is good, but it changes if regional or distant metastases are present [1]. A very important prognostic indicator for disease evolution is the identification of regional metastatic lymph nodes, when intermediate thickness melanoma (1-4 mm) is considered [2]. The American Joint Committee on Cancer recommends that for tumor thickness greater than 1 mm sentinel lymph node biopsy (SLNB) to be performed [3]. For tumor thickness lower than 1 mm, SLNB is recommended when risk factors like ulceration or mitotic rate >1 per mm2 are present [2]. Regarding high risk melanomas with tumor thickness >4 mm, the recommendation for SLNB is controversial because of the high probability of regional and systemic metastases [2]. In some studies it has been demonstrated that the evaluation of sentinel lymph node plays a prognostic role for the patients with high risk melanoma (tumor thickness >4 mm) [2]. It is well known that the risk in patients with melanoma, increases with tumor thickness and in melanomas with thickness greater than 1 mm the probability to have clinically occult metastases is approximately 20% [1]. The lymphatic drainage is very unpredictable, so clinically is ineffective to estimate the localization of potential lymphatic metastases [3], therefore historically speaking, it was necessary to develop a more accurate method for sentinel lymph node mapping. In 1992 sentinel lymph node procedure has been introduced and the initial rate of sentinel lymph node detection was approximately 82% [3]. Sentinel lymph node detection and mapping is a very important tool in tumor staging for melanoma patients. Therefore, sentinel lymph node scintigraphy is mandatory when SLNB is recommended, having a very high sensitivity in detection of sentinel lymph node [4]. The technique is multidisciplinary and consists in several steps combining preoperative lymph node mapping and intraoperative lymph node detection using a gamma probe to detect radioactivity in sentinel lymph nodes. The technique was introduced by Morton in 1992 [5] and from that point suffered consistent changes that improved the sensitivity and the specificity of the method that now is widely adopted by international and national diagnostic and therapeutic guidelines in melanoma patients [1,2,6–9]. Preoperative sentinel lymph node mapping consists in the injection of a radiopharmaceutical based on albumin nanocolloids labeled with Tc-99m [1,10], available and authorized in Europe. The injection is performed subcutaneously around the tumor or around the surgical scar at distance no larger than 1 cm in 4 or multiple aliquots [1]. For body contouring the golden standard is to use a Co-57 flood source placed on the opposite side of

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the patient, to offer a transmission image and reveal the body contour of the patient for a better localization of the sentinel lymph nodes [1,11]. Early static and delayed static planar images should be acquired in different angles and for a more accurate anatomic localization in some cases SPECT/CT acquisition may be also indicated. The skin projection of the sentinel lymph node is marked on the skin. Typically, the surgical identification and removal of the sentinel lymph node is performed in the same day as lymphoscintigraphy or may be performed in the next day. The surgical technique is based also on additional control of the lymphatic drainage with blue dye injected at the tumor site. The identification of the sentinel lymph node is controlled also using a gamma probe that can measure the radioactivity in the surgical bed and the radioactivity of the identified lymph node [1].

The aim of the study is to evaluate the effectiveness in body contouring of a planar flood calibration phantom filled with homogenous aqueous solution of Tc-99m pertechnetate and to evaluate the identification rate of the sentinel lymph node in comparison with validated golden standard procedure according to published literature.

Methods

Patients and selection criteria

The study was conducted in the Department of Nuclear Medicine of Oncology Institute "Prof. Dr. Ion Chiricuță" Cluj-Napoca in 95 patients, 31 males and 64 females and approved by the ethics committee. The localization of the lesions was grouped by anatomical regions as follows: 23 (24.21%) on lower limbs, 17 (17.89%) on upper limbs, 45 (47.37%) on thorax and 10 (10.53%) on abdomen. The inclusion criteria were: patients diagnosed with cutaneous melanoma presented for sentinel lymph node evaluation. The exclusion criteria were: presence of clinical lymph nodes suspected for lymphatic metastases and pregnancy.

Patient preparation

No specific patient preparation was performs. However, the patients were informed about the procedural steps and informed consent was obtained before the procedure. The localization of the primarily tumor was identified and any dressing articles or jewelry that may impair the lymphatic drainage or the image acquisition were removed. Local disinfection was performed to ensure aseptic conditions.

Radiopharmaceutical preparation and administration

Technetium-99m pertechnetate was obtained after the elution of the Molibdenum-99/Techetium-99m generator in aseptic conditions. Nanocoll, produced by GE Healthcare was used for radiolabeling with Tc-99m pertechnetate. Nanocoll is a radiopharmaceutical kit used in lymphoscintigraphy, containing 500 micrograms of human albumin colloidal nanoparticles. After labeling, the solution prepared for subcutaneous injection had an activity of 37 MBq in 1 ml. Each injection was performed subcutaneously and the volume was administrated in 4 aliquots around the primarily lesion under aseptic conditions.

Transmission planar source preparation and use

The planar calibration phantom was used for body contouring to offer an accurate localization of the sentinel lymph nodes. The phantom was filled with homogenous solution of 37 MBq Tc-99m pertechnetate and placed in the opposite side of the gamma camera's detector behind the patient, to offer a transmission planar uniform flood source (Figure 1). Measurements have been performed with an Inspector dosimeter to evaluate the dose rate from the planar calibration phantom at a standard distance of 1 m and at a 1.4m representing the maximum distance available for the patient to be positioned on the examination table between the phantom and camera's detector. The same measurements were performed at the same distance for the Co-57 planar flood source.

Image acquisition

Image acquisition was performed with a Siemens E.Cam SingleHead gamma camera set on 140 keV peak energy (15% energy window), with a low energy high resolution (LEHR) collimator. The acquisition matrix was 128x128 pixels, no magnification antero-posterior, postero-anterior and right/left lateral views being performed in accordance to the anatomical requirements and lymphatic drainage. The acquisition timing was as follows: early images within 15 minutes post-injection, delayed images at 2-3 hours post-injection and when no lymphatic drainage was revealed, additional images at 6-7 hours were performed. The acquisition time per image was 5 minutes (Figure 2). The images were reformatted to mask the injection site when necessary for a better visualization of the lymph nodes. The patients were positioned in the same position as on the operation table to avoid misleading information.

Lymph node identification and skin marking

After the identification of the sentinel lymph nodes on scintigraphic images, the skin projection was marked under dynamic control using a marker point source of Tc-99m and confirmed with the gamma probe. The gamma probe used is an Europrobe 2 device for gamma ray detection equipped with an angular probe. After skin marking, the patients were referred to the department of surgery for sentinel lymph node removal.

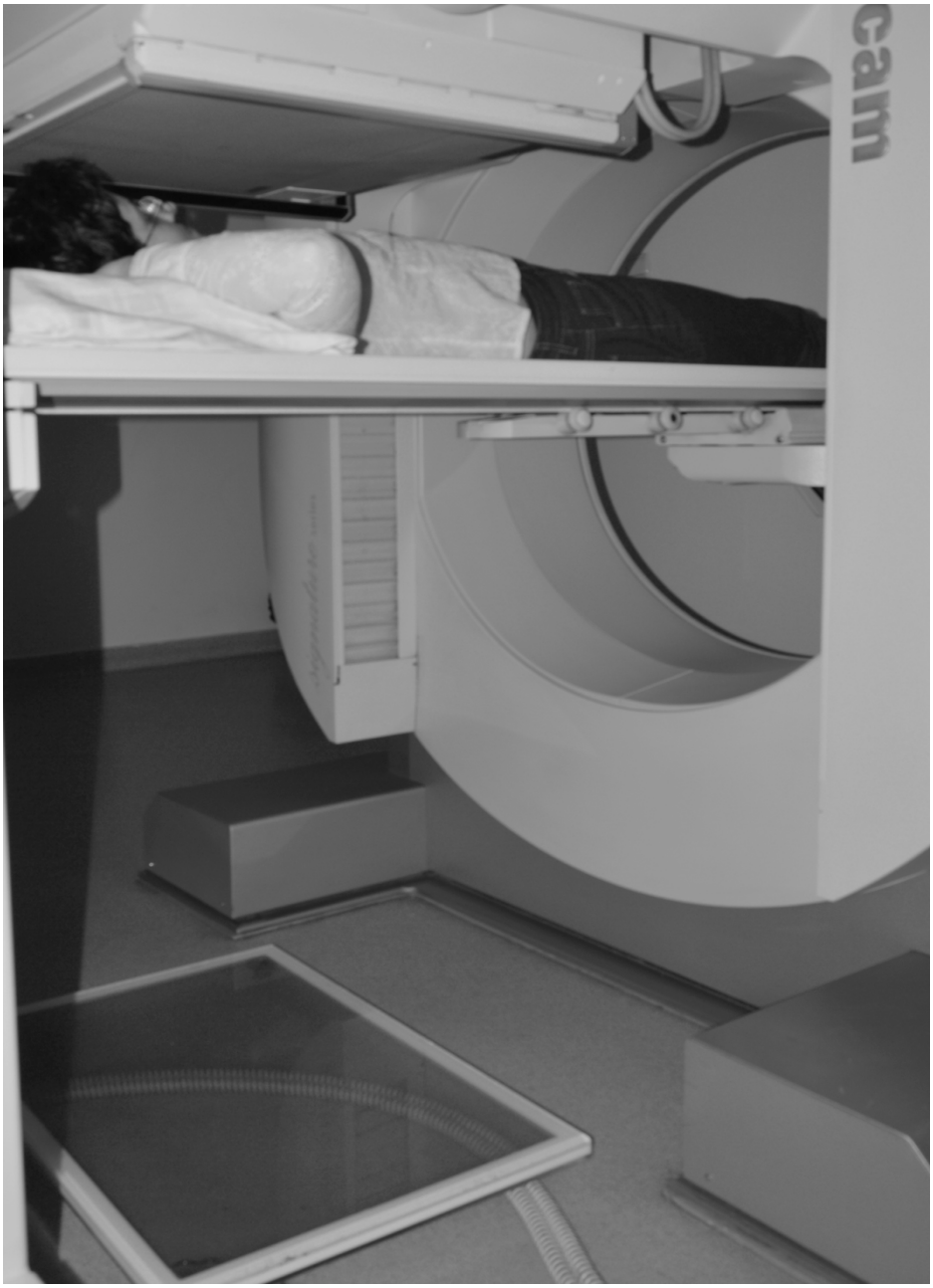

Figure 1. Planar calibration phantom used as planar flood source for body contouring in lymphoscintigraphy.

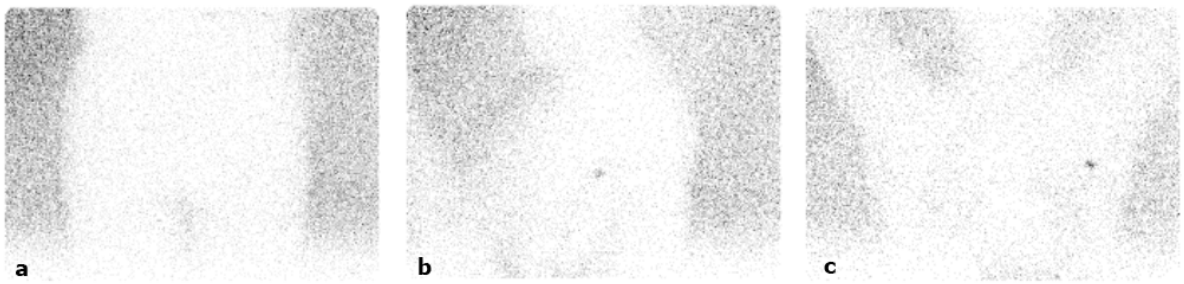

Figure 2. Lymphoscintigraphy for abdominal cutaneous melanoma; delayed images; no inguinal sentinel lymph node detected (a); left axillar sentinel lymph node on left lateral view (b) and anterior view (c).

Results

The sentinel lymph nodes were detected in 92 cases (96.84%) and confirmed with the gamma probe during the surgical procedure.

The localization of the lymph nodes was as follows: for the tumors localized on lower limbs 23 lymph nodes (25.00%) were localized in inguinal region, for the tumors localized on upper limbs, 17 lymph nodes (18.48%) were localized in axilla, for the tumors localized on the thorax, 40 lymph nodes (43.48%) were localized in axilla and 3 lymph nodes (3.26%) were localized in inguinal region and for the tumors localized on the abdomen, 1 lymph node (1.09%) was localized in axilla and 8 lymph nodes (8.69%) were localized in inguinal region (Table I). Regarding the negative sentinel lymph node cases, 2 cases were registered for primarily lesions localized on thorax and 1 for a lesion localized on abdomen.

According to histology from all detected sentinel lymph nodes, 26 cases (28.26%) revealed lymphatic metastatic invasion.

Dose rates measured at 1m from the calibrator phantom had an average value of 3.46 μSv/h (SD 0.19) and at 1.4m, the value was 2.57 μSv/h (SD 0.22). Dose rates measured at the same distances from the Co-57 planar flood source had a average values of 32.5 μSv/h (SD 0.11) respectively 24.1 μSv/h (SD 0.14) (Table II).

Table I. Primary tumor localization and sentinel lymph node localization related.

Primarily tumor localization	No. of cases	Sentinel lymph node localization	
		axillary	inguinal
Upper limb	17 (17.89%)	17 (18.48%)	-
Lower limb	23 (24.21%)	-	23 (25%)
Thorax	45 (47.37%)	40 (43.48%)	3 (3.26%)
Abdomen	10 (10.53%)	1 (1.09%)	8 (8.69%)

Table II. Dose rate expressed in μSv/h measured at 1 m and 1.4 m from the calibration planar phantom filled with aqueous solution of Tc-99m pertechnetate and respectively, at 1 m and 1.4 m from the Co-57 planar flood source.

Dose rate	measured at 1m		measured at 1.4m	
	from the Tc-99m calibration planar phantom	from the Co-57 planar flood source	from the Tc-99m calibration planar phantom	from the Co-57 planar flood source
Average value	3.46 μSv/h	32.5 μSv/h	2.57 μSv/h	24.1 μSv/h
Standard deviation	0.19	0.11	0.22	0.14

Discussion

The detection rate of sentinel lymph node in our study using the calibration planar phantom for body contouring was close to 100% (96.84%), the same as the detection rate published in literature [1,4,8] showing that the method does not impair the success rate of the method respecting the gold standard for body contouring. The calibration planar phantom used for this purpose does not affect the acquisition data and does not lead to false negative results.

Dose rate measured at 1m and 1.4m from the planar calibration phantom was 3.46 μSv/h (SD 0.19), respectively 2.57 μSv/h (SD 0.22). Related to the phantom's activity (37 MBq), the values will be expressed as follows: 0.094 μSV/MBq/h, respectively 0.069 μSv/MBq/h. These values are considerably lower than the dose rate caused by the Co-57 planar flood source published in literature (0.641 μSv/MBq/h) [11]. In addition to this discussion, it is important to mention that due to the fixed commercial available activities for the Co-57 source, this source has a medium radioactive risk (class B) in comparison to the calibration phantom filled with Tc-99m which has low radioactive risk (class C).

The planar calibration phantom filled with solution of 1 mCi Tc-99m pertechnetate used for body contouring in sentinel lymph node scintigraphy causes less irradiation to the patient and staff in comparison with the standard planar Co-57 flood source.

Using the calibration phantom filled with solution of 1 mCi Tc-99m pertechnetate for body contouring in sentinel lymph node scintigraphy an efficient optimization of the exposure for patients is achieved in accordance with the principles stated in the regulatory bodies' recommendations on radiation protection.

Using the calibration phantom filled with solution of 1 mCi Tc-99m pertechnetate for body contouring in

sentinel lymph node scintigraphy may allow to increase acquisition time for a better diagnostic sensitivity without causing significant irradiation due to its minimal exposure risk.

Conclusion

The planar calibration flood phantom is an effective tool for body contouring in sentinel lymph node scintigraphy. The method offers accurate anatomical information to efficiently localize the detected sentinel lymph nodes in melanoma.

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