Clinical and Translational Imaging (2023) 11:615–624
https://doi.org/10.1007/s40336-023-00554-8

PICTORIAL ESSAY

Detailed preoperative lymphatic mapping by lymphoscintigraphy for sentinel node identification: a pictorial essay

Francesca Iuele[1] · Cristina Ferrari[1] · Paolo Mammucci[1] · Dino Rubini[1] · Giusi Pisano[2] · Luca Zagaria[3] · Giuseppe Rubini[1]

Received: 4 February 2023 / Accepted: 14 March 2023 / Published online: 6 May 2023

Abstract
Pre-operative lymphatic mapping for sentinel node identification is essential for accurate staging in patients with several solid cancers and for important prognostic implications. ^{99m}Tc-labelled colloid lymphoscintigraphy and intraoperative sentinel lymph node detection using a gamma probe represent a well-established nuclear medicine technique and a detailed imaging method thanks to the advent of hybrid multi-modality SPET/CT. Through the description of numerous clinical cases, different in terms of cancer type and fields of application, we aimed to bring out the strengths and advantages of pre-operative lymphoscintigraphy that make it still today incomparable to other techniques.

Keywords Sentinel node biopsy · Lymphoscintigraphy · Aberrant drainage · Interval lymph node · Merkel cell carcinoma · Single photon emission computed tomography · ^{99m}Tc-labelled colloids

Introduction

Lymphatic mapping with ^{99m}Tc-nanocolloid, including preoperative lymphoscintigraphy and intraoperative sentinel lymph node (SLN) detection using a gamma probe, is a well-established technique. It is the standard of care for lymph node staging of several types of cancers, including breast cancer and melanoma patients with clinically negative lymph nodes. Over time, many other cancer histotypes have benefited from this nuclear medicine tool, mainly due to technological improvements and innovations, primarily the advent of hybrid tomographic imaging. However, other techniques have been developed in last years: indocyanine green (ICG) fluorescence, superparamagnetic iron oxide nanoparticles, and contrast-enhanced ultrasound using microbubbles. While each technique has its own advantages/disadvantages, they have shown variable results across studies, small patient numbers, and short patient follow-ups. Therefore, they should be considered still experimental until there is definitive evidence that they are accurate in SLN biopsy (SLNB) with a low false negative rate [1, 2].

Case reports

Five clinical cases were illustrated in our retrospective pictorial essay including a relapsed breast carcinoma, a squamous cell carcinoma of the tongue, an epidermoid carcinoma of the vulva, a Merkel cell carcinoma of the lower eyelid and a recurrent melanoma of the foot. Through the description of the following clinical cases, we aimed to bring out the strengths and advantages of preoperative lymphoscintigraphy that make it still today incomparable to the new emerging techniques.

Clinical case #1

A 57-year-old woman had a history of invasive ductal right breast carcinoma, located in the upper outer quadrant. For the evidence of bilateral axillary node involvement on

✉ Giuseppe Rubini
giuseppe.rubini@uniba.it

1 Section of Diagnostic Imaging, Interdisciplinary Department of Medicine, University of Bari Aldo Moro, Piazza Giulio Cesare 11, 70124 Bari, Italy

2 Section of Nuclear Medicine, University Department of Radiological Sciences and Haematology, Università Cattolica del Sacro Cuore, Rome, Italy

3 Nuclear Medicine Unit, Fondazione Policlinico Universitario A. Gemelli IRCCS, Rome, Italy

staging CT, she underwent neoadjuvant chemotherapy followed by quadrantectomy and SLNB after lymphoscintigraphy (ypT0N0). After 2 years, a routine mammography showed a relapse in the right breast cancer: histopathologic analysis revealed non-special-type invasive carcinoma (ER/PR-, Herb2neu 3 +, Ki67 30%). No regional or distant metastases were detectable on restaging CT imaging.

Lymphoscintigraphy was performed the day before surgery, injecting four periareolar intradermal doses of ^{99m}Tc-nanocolloids into the right breast. Anterior planar imaging showed no SLN (Fig. 1a). The lymphoscintigraphy was completed with Single Photon Emission Tomography integrated with Computed Tomography (SPET/CT) which revealed radioactivity in one left axillary node. No ipsilateral (right) axillary lymph node was visualized (Fig. 1b–e).

The day after lymphoscintigraphy, the patient underwent right skin-sparing mastectomy and bilateral SLNB: one lymph node was removed from the left axillary region and two lymph nodes from the right axillary region (detected intraoperatively with ICG). The final pathological analysis revealed micrometastases in the left SLN only.

Take Home Message: lymphoscintigraphy with SPECT/CT detection plays an important role in identifying aberrant lymph drainage, especially in patients with relapsed breast cancer and clinically negative lymph nodes.

Clinical case #2

A 61-year-old woman presented with a history of lichen planus of the tongue within the past year, for which she was regularly monitored. An excisional biopsy of the left dorsal tongue margin was performed, revealing a micro-invasive squamous cell carcinoma. Physical examination, CT scan, and head and neck MRI revealed no suspicious lymph nodes, resulting in a cT1N0 staging.

After a multidisciplinary team discussion, SLNB was indicated. To reduce pain and the risk of patient movement, local anaesthesia with lidocaine spray was administered. Subsequently, three submucosal injections of ^{99m}Tc-nanocolloids were performed around the scar, in the left margin of the tongue. To avoid contamination with radioactive saliva and to reduce the oral radiotracer absorption, bleeding was controlled with gauze. In addition, immediately after the injection, the patient was asked to rinse the oral cavity and avoid swallowing [3].

Image acquisitions started with dynamic projections in the left lateral view, followed by static anteroposterior and left lateral acquisitions (Fig. 2a, b, c). Two areas of increased uptake in the left latero-cervical region were observed, referable to the SLNs (Fig. 2c). They were confirmed by the following SPECT/CT which helped with accurate anatomical localization of the lymph nodes (Fig. 2d, e).

On the same day, the patient underwent left partial hemiglossectomy and SLNBs. They resulted negative at histopathological examination.

Take Home Message: in cases with complex anatomy, hybrid imaging is fundamental for correct and accurate anatomical localization of sentinel lymph nodes.

Clinical case #3

An 88-year-old patient with discomfort and pain in the pelvic region underwent vulvoscopy which revealed an ulcerative lesion (7 cm) occupying the left labium majus and the periclitoral region bilaterally, suggestive of an HPV lesion. The biopsy resulted in a well-differentiated G1 epidermoid carcinoma. Complete abdomen contrast-enhanced CT (ceCT) showed no retroperitoneal lymphadenopathies and sporadic enlarged lymph nodes in the groin area suggestive of reactive adenopathy. Accordingly, no suspicious lymph nodes were present on palpation.

SLNB was performed 3 months later through intradermal injections of ^{99m}Tc-nanocolloids in the four cardinal points around the lesion, prior application of an anaesthetic cream (Lidocaine + Prilocaine) [4]. Afterwards, the patient underwent planar lymphoscintigraphic mapping (dynamic images, early and late static images) which showed three areas of increased uptake, all located in the left groin. No areas of increased uptake were visible in the right side (Fig. 3a, b). SPECT/CT was subsequently performed, which revealed, in addition to the SLNs in the left inguinal region, another area of fainter uptake in the right inguinal site, allowing for the identification of SLNs bilaterally (Fig. 3c, f).

The next day, the patient underwent a radical vulvectomy and SLNBs were negative for metastatic invasion.

Take Home Message: thanks to its high resolution, sensitivity, and three-dimensional visualization, SPECT/CT allows the detection of additional sentinel nodes and their exact location, aiding in accurate pre-surgical planning.

Clinical case #4

An 83-year-old female presented with a right lower eyelid lesion. The patient underwent excisional biopsy and histopathological analysis led to the diagnosis of Merkel cell carcinoma (MCC). Immunohistochemistry was positive for CK20 and CD56 and negative for TTF-1. Preoperative whole-body ceCT showed no lymph node involvement or distant metastases. The patient underwent lymphoscintigraphy, performed after two intradermal injections of ^{99m}Tc-nanocolloids in the perilesional right lower eyelid scar. Images were acquired starting from the dynamic anterior image of the head and neck region and then completed with

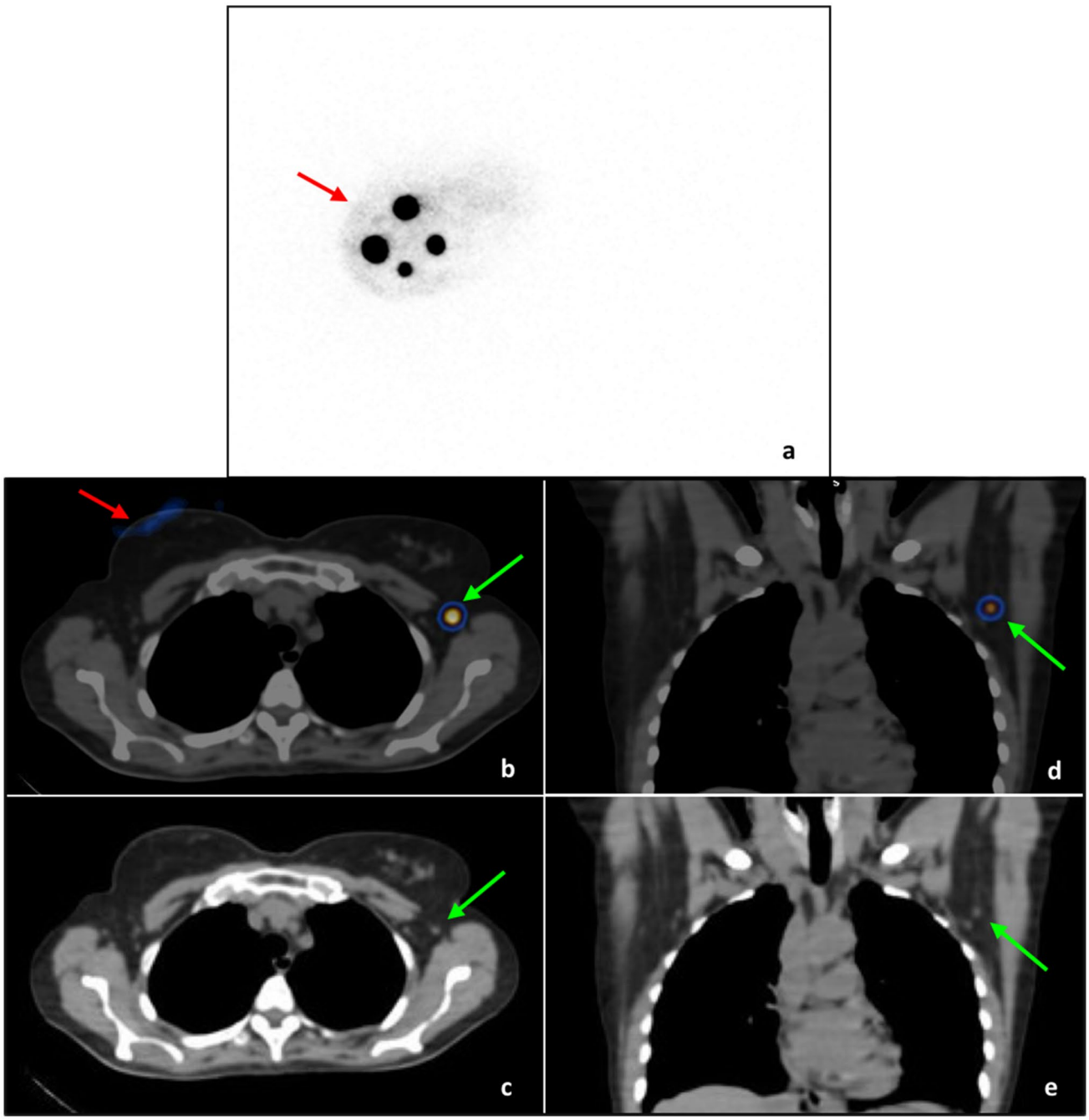
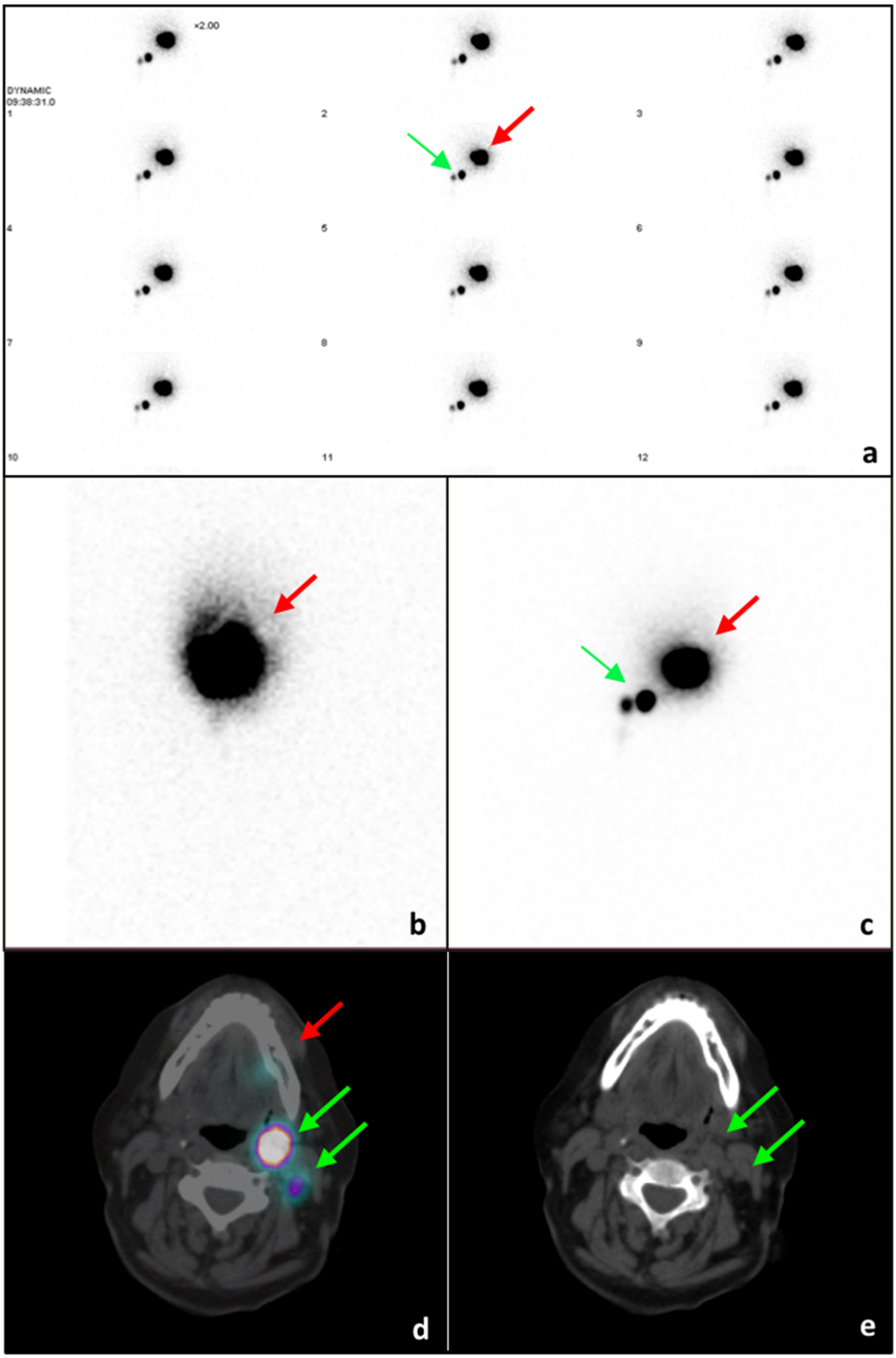


Fig. 1 Lymphoscintigraphy of a 57-year-old woman performed for relapsed right breast cancer, already treated with neoadjuvant chemotherapy and surgery (clinical case #1). **a** Planar static image, anterior projection, of the right breast. **b–e** SPET/CT images (Optima NM/CT 640, GE, Milwaukee, USA—128×128 matrix, angle rotation of 180 degrees for each detector, 20 s per view): **b** axial fused SPET/CT; **c** axial co-registered CT; **d** coronal fused SPET/CT; **e** coronal co-registered CT. (red arrow: site of four periareolar intradermal split doses of 37 MBq of ^{99m}Tc-nanocolloids; green arrows: SLN). While no SLNs were visualized on the planar image, hybrid images demonstrated aberrant lymphatic drainage by showing radioactivity in the contralateral axilla SLN. No ipsilateral node was visualized

a planar right lateral view showing two areas of radioactive uptake in the right side of the neck (Fig. 4a). SPECT/CT was performed to localize the spots, which revealed radioactivity within the parotid gland (interval lymph node) and right cervical lymph node (Fig. 4b–f). On the same day, intra-operatively, the tumour site was resected with a wide margin, and both interval and SLNs were reached by gamma probe, resulting not pathologically involved by frozen section examination (Fig. 4g–h). Adjuvant RT was not performed due to the patient's age.


×2.00
DYNAMIC
09:38:31.0
1
2
3
4
5
6
7
8
9
10
11
12
a
b
c
d
e

◂**Fig. 2** Lymphoscintigraphy of a 61-year-old woman performed for a micro-invasive squamous cell carcinoma of the left margin of the dorsal tongue (clinical case #2). **a** Imaging acquisitions started with dynamic projections (30 s per frame) of the head, in left lateral view for 15 min, followed by: **b, c** planar static acquisitions (5 min each), performed on a single-head gamma-camera (GE Millennium MG, United States): **b** planar static anterior view; **c** Planar static left lateral projection. **d, e** SPECT/CT obtained on a dual-head gamma-camera system (Symbia Intevo 2, Siemens, Germany—128×128 matrix, rotation angles over 360°, 15 s per view): **d** axial fused SPET/CT; **e** axial co-registered CT. (red arrow: site of three submucosal injections of ^{99m}Tc-nanocolloids (37 MBq) around the scar, in the left margin of the tongue, after local anaesthesia administration; green arrows: SLNs). Both planar and tomographic imaging detected 2 SLNs in the left latero-cervical region at two different anatomical levels. SPET/CT images aided in the correct and accurate anatomical localization of lymph nodes

Take Home Message: lymphoscintigraphy has a key role in identifying interval SLNs, particularly in the head and neck district which represents a challenge due to the complexity of this anatomical area. In this context, SPECT/CT imaging has become fundamental.

Clinical case #5

A 76-year-old woman presented a history of recurrent melanoma in her left foot. Seven years earlier she presented a pigmented lesion involving the plantar surface near the third interdigital space and the fifth toe of the same foot; the histopathologic finding revealed an acral melanoma (pT1a). Lesions were completely excised and skin abnormalities were repaired with a skin graft. During follow-up, 7 years later, she presented with new pigmented lesions in her left foot: in the third and fourth interdigital space and at the proximal end of the skin transplantation area on the fifth toe (Fig. 5a–c). The new skin biopsy of the lesions revealed acral lentiginous melanoma (positive for Melan A and HBM, pT2a). Despite similar histopathological characteristics and its development in proximity to the skin graft, it was collectively considered as a new primary tumour by multidisciplinary team of specialists. Preoperative whole-body ceCT showed no lymph node diseases or distant metastases. Therefore, on the day of surgery, the patient underwent lymphoscintigraphy, performed after three intradermal injections of ^{99m}Tc-nanocolloids in the perilesional area: two in the dorsum near the interdigital space and one in the lateral surface of the foot (Fig. 5d–f). A planar antero-posterior lymphoscintigraphy of the lower limbs acquisition revealed two inguinal and one upper lymph nodes; in addition, a dermal backflow of the left leg was recorded (Fig. 5g). SPECT/CT images confirmed the radioactive spots in the left inguinal and in iliac lymph nodes, and the dermal backflow of the leg (Fig. 5h–l). The patient was treated with an amputation procedure of the last three toes and SLNs were detected with a gamma probe and removed, resulting not pathologically involved. Then, in accordance with the last NCCN guidelines [5], the local radiation therapy on the site of resected primary tumor was chosen for the patient. Some months later, she developed a clinically evident lymphedema of the left lower limb.

Take Home Message: pre-operative lymphoscintigraphy is able to provide information about the functional status of lymphatic system, predicting the risk of developing lymphedema.

Discussion

The routine use of pre-operative lymphoscintigraphy for SLN identification is controversial due to the additional time required to perform the method and the higher costs associated with its application [6, 7].

However, additional information may be obtained from a pre-operative lymphoscintigraphy, otherwise lost.

The first case report demonstrated that lymphoscintigraphy plays an important role in detecting aberrant lymphatic drainage, especially in patients with relapsed breast cancer and clinically negative lymph nodes [8]. Contralateral axillary lymph node metastasis is a rare clinical condition in breast cancer patients and, according to the TNM classification, is more frequently considered M1 (stage IV), regardless of its origin [9, 10]. It can be caused by an anatomical modification in the lymphatic system, generated by surgical or radiotherapeutic treatments of primary breast disease [11–13], as in our case. Detection of metastatic disease in the contralateral axilla would have been impossible without the preoperative scan. Some centers eliminate pre-operative lymphoscintigraphy because of the predictability of breast lymphatic drainage into axillary nodes. However, lymphoscintigraphy is the only method to detect extra-axillary drainage sites, aiding surgeons especially in cases, where intraoperative detection rates are low due to patient-related factors, such as obesity and older age [6, 7]. Repeating SLNB in this setting of patients is feasible and accurate, also demonstrating a high negative predictive value [14, 15].

All the remaining clinical cases emphasize the key role of hybrid imaging. SPECT/CT significantly improves sentinel node detection due to its high resolution, sensitivity, and three-dimensional visualization, both for the number of lymph nodes identified and for the exact location [16, 17]. In our clinical case 3, SPECT/CT allowed localizing the SLNs in the Daseler's areas (Fig. 3), defining the relationship with the surrounding anatomical structures and finally helping an accurate pre-surgical planning. Moreover, as emerged from clinical case 4, SPECT/CT becomes of particular importance in a specific anatomical

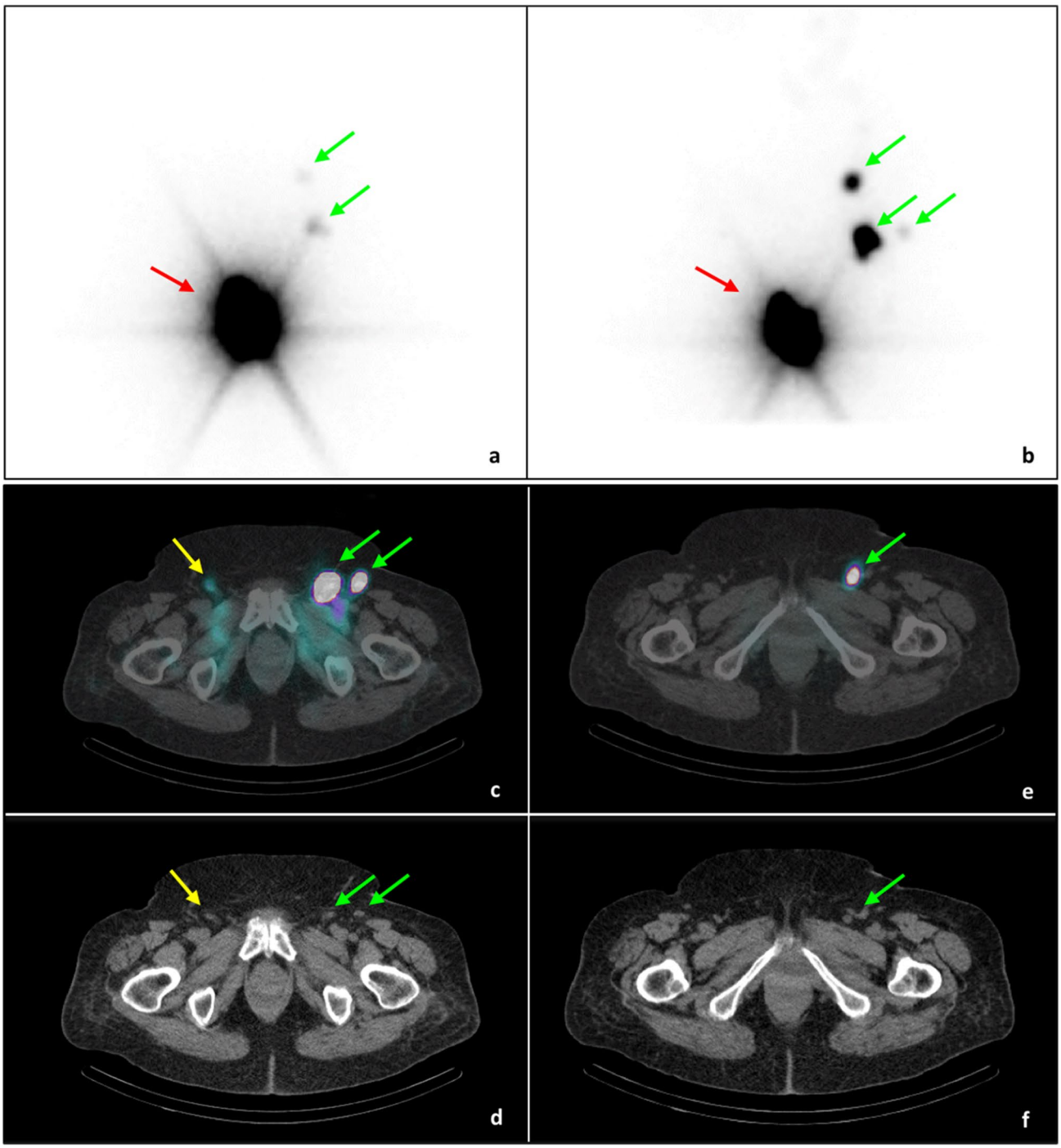


Fig. 3 Lymphoscintigraphy of an 88-year-old patient with newly diagnosed vulvar squamous cell carcinoma of the left labium majus and the periclitoral region bilaterally (clinical case #3). **a, b** Planar static images, anterior views (**a** early, **b** late) of the pelvis. **c–f** SPET/CT images (dual-head gamma-camera system, Symbia Intevo 2, Siemens, Germany): **c**, **e** axial fused SPET/CT; **d**, **f** axial co-registered CT. (red arrow: site of intradermal injections of ^{99m}Tc-nanocolloids (296 MBq) at the four cardinal points around the lesion, after application of an anaesthetic cream; green arrows: SLNs; yellow arrow: an additional contralateral node). Both planar and tomographic imaging detected 3 SLNs, all located in the left groin. SPECT/CT revealed, in addition to the sentinel lymph nodes in the left inguinal region, another area of fainter uptake in the right inguinal site (c, d, yellow arrow), allowing for bilateral identification of sentinel nodes

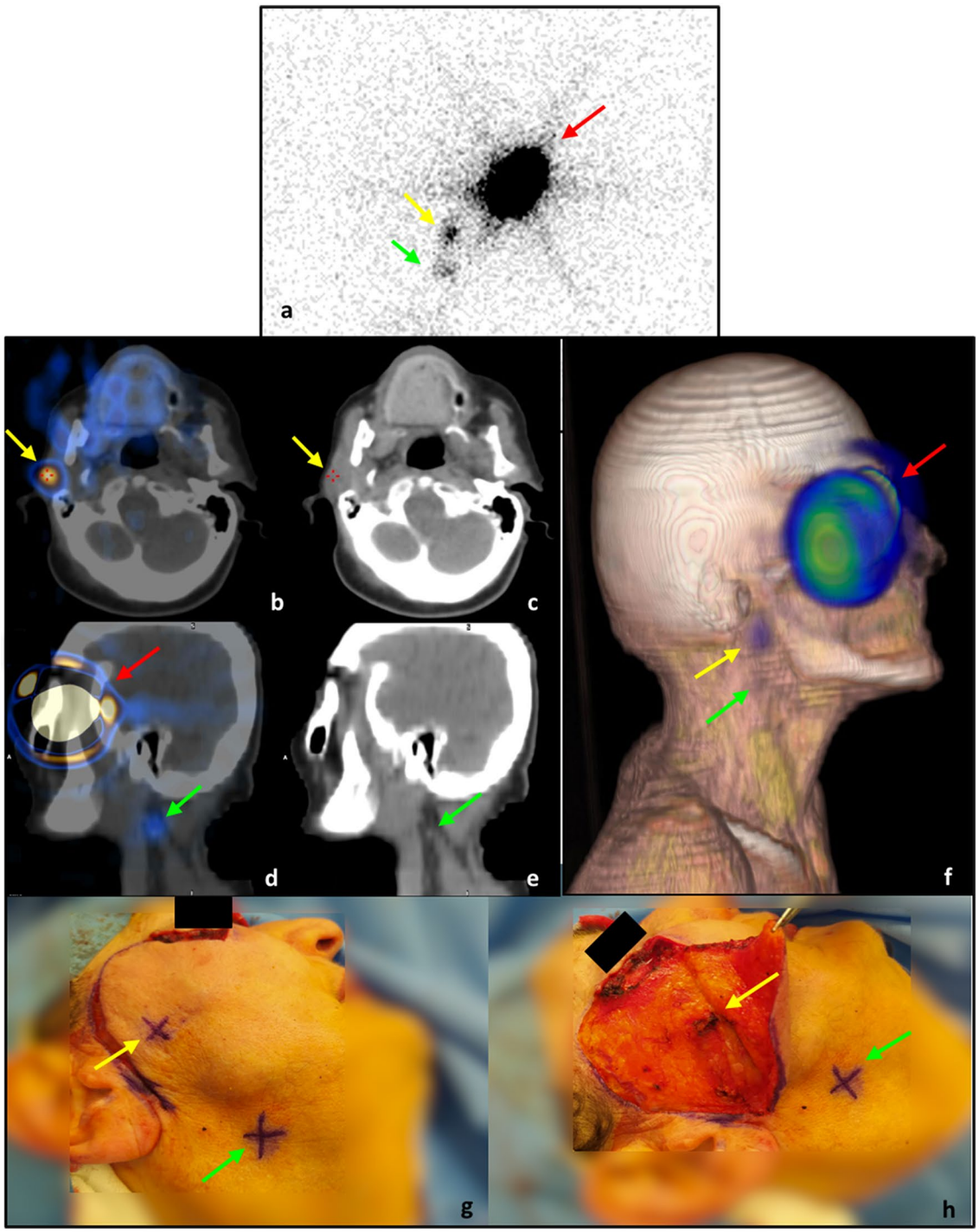


Fig. 4 Lymphoscintigraphy and surgical intervention of an 83-year-old female with a Merkel cell carcinoma of the right lower eyelid (clinical case #4). Imaging acquisitions started with dynamic anterior image of the head and neck region (1 min/frame for 20 min), carried out on a dual-head gamma-camera (Optima NM/CT 640, GE, Milwaukee, USA) and followed by: **a** planar static acquisitions (preset-counts: 300 Kcounts), right lateral view of the head. **b–f** SPET/CT images (SPET: 128 × 128 matrix, angle rotation of 180 degrees for each detector, 20 s per view): **b** axial fused SPET/CT; **c** axial co-registered CT; **d** sagittal fused SPET/CT; **e** sagittal co-registered CT; **f** MIP and 3D reconstruction. **g, h** Intraoperative SLNs detection and surgical removal (red arrow: site of 2 intradermal perilesional injection of 19 MBq of ^{99m}Tc-nanocolloids; yellow arrow: interval lymph node inside the right parotid gland; green arrow: right latero-cervical SLN). Planar imaging detected two areas of radiopharmaceutical uptake on the right side of the neck. SPECT/CT localized them inside the parotid gland and in the latero-cervical level, respectively, providing significant anatomical information for surgical planning

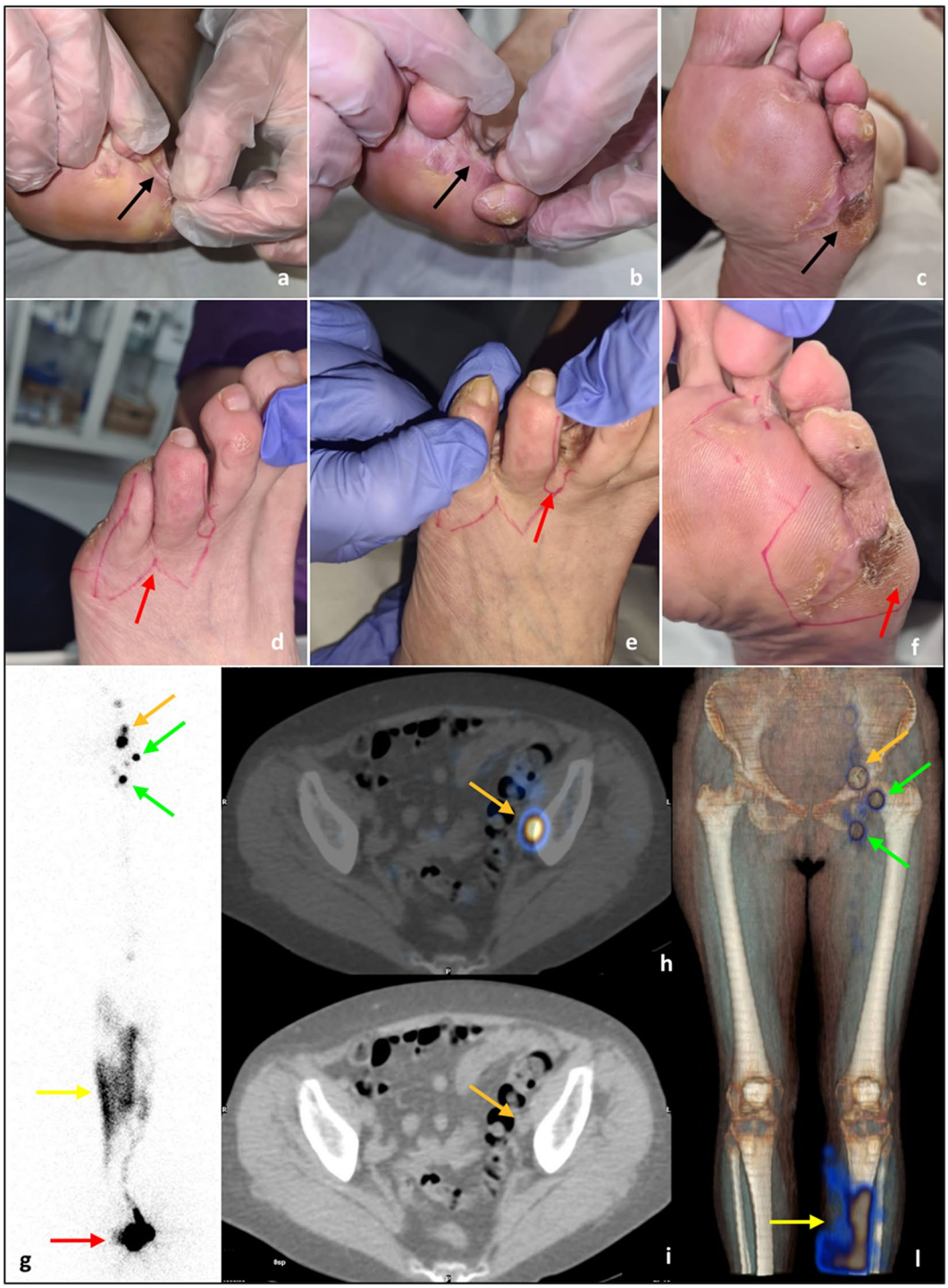


Fig. 5 Lymphoscintigraphy of an 83-year-old female with recurrent acral lentiginous melanoma on the third and fourth interdigital space (**a** and **b**) and lateral surface of the left foot (**c**), behind the skin graft (clinical case #5). **d–f** Intradermal injection sites of ^{99m}TC-nanocolloids: 2 on the dorsum and one on the lateral surface of the left foot (red arrows). **g** Planar lymphoscintigraphy of the lower limbs (anterior view), acquired with dual-head gamma-camera (Optima NM/CT 640, GE, Milwaukee, USA). The image recorded three areas of radiopharmaceutical uptake in the left groin. The image also showed a dermal backflow of the left leg. **h–l** SPECT/CT lymphoscintigraphy (128 × 128 matrix, angle rotation of 180 degrees for each detector, 20 s per view) was acquired 1.5 h after administration: **h** axial fused SPET/CT; **i** axial co-registered CT; **l.** MIP and 3D reconstruction (red arrow: site of radiopharmaceutical injection; green and orange arrows: SLNs in the left inguinal and iliac regions; yellow arrow: dermal of backflow). SPET/CT confirmed multiple areas of uptake, better distinguishing SLNs in the left inguinal and iliac region. The dermal of backflow of the left leg was also confirmed

region-like head–neck district, in which the lymphatic drainage and localization of SLNs represents a challenge due to the complexity of this anatomical area [18].

Frequently, the lymphatic drainage of the head–neck district does not follow the standard drainage pathways. In this setting, lymphoscintigraphy also plays a key role in the identification of the so-called interval nodes (i.e., those located between the primary tumor and a regional drainage basin and/or aberrant nodes) [19, 20]. Although the incidence of these nodes is relatively low in both malignant melanoma and non-melanoma skin cancer patients, interval SLNs may present metastatic deposits in a significant percentage of cases, and therefore, their identification is necessary [21, 22]. Interval SLNs may coexist with SLNs in nodal basins: in this case, all "hot spots" should be removed [23].

Finally, preoperative lymphoscintigraphy is an image mapping of both lymph node basins and flow, able to provide information about the functional status of the lymphatic system. Lymphoscintigraphic visual assessment has been reported to have a high diagnostic performance, with a minimally invasive technique and discomfort [24]. This technique reveals the major lymph vessels and demonstrates the absence or delayed lymph flow and reflux zones (backflow). The presence, grade and type of pattern of dermal backflow may also be used to predict the risk of developing clinically evident lymphedema, as demonstrated in our clinical case 5 [25, 26].

Conclusion

Lymphatic mapping, using preoperative lymphoscintigraphy with ^{99m}Tc-labelled radiocolloids and intraoperative detection of sentinel lymph node, remains the most comprehensive imaging method for an accurate staging in patients with several solid cancers. A lymphoscintigraphic study, completed with hybrid SPET/CT imaging, is highly recommended, because it provides the opportunity for the evaluation of regional lymph node basins, even in case of additional or unexpected SLNs, with high diagnostic performance.

Funding Open access funding provided by Università degli Studi di Bari Aldo Moro within the CRUI-CARE Agreement.

Data availability The data that support the findings of this study are not openly available due to reasons of sensitivity and are available from the corresponding author upon reasonable request.

Declarations

Conflict of interest All the authors (Francesca Iuele, Cristina Ferrari, Paolo Mammucci, Dino Rubini, Giusi Pisano, Luca Zagaria and Giuseppe Rubini) declare nothing to disclose and did not receive any funding.

Human and animal rights All patients gave their informed consent for the scientific use of medical data.

References

1. Ferrucci M, Franceschini G, Douek M (2018) New techniques for sentinel node biopsy in breast cancer. Transl Cancer Res 7(Suppl 3):S405–S417. https://doi.org/10.21037/tcr.2018.02.0
2. Ahmed M, Purushotham AD, Douek M (2014) Novel techniques for sentinel lymph node biopsy in breast cancer: a systematic review. Lancet Oncol 15:e351. https://doi.org/10.1016/S1470-2045(13)70590-4
3. Giammarile F, Schilling C, Gnanasegaran G et al (2019) The EANM practical guidelines for sentinel lymph node localisation in oral cavity squamous cell carcinoma. Eur J Nuclear Med Mol Imaging 46(3):623–637. https://doi.org/10.1007/s00259-018-4235-5
4. Collarino A, Vidal-Sicart S, Perotti G, Valdés Olmos RA (2016) The sentinel node approach in gynaecological malignancies. Clin Transl Imaging 4(5):411–420. https://doi.org/10.1007/s40336-016-0187-6
5. NCCN Clinical Practice Guidelines in Oncology (NCCN Guidelines®) (2022) Melanoma: Cutaneous. Version 1.2023-December 22 https://www.nccn.org/guidelines/guidelines-detail?category=1&id=1492
6. Vural GU, Şahiner I, Demirtaş S, Efetürk H, Demirel BB (2015) Sentinel lymph node detection in contralateral axilla at initial presentation of a breast cancer patient: case report. Mol Imaging Radionucl Ther 24(2):90–93. https://doi.org/10.4274/mirt.91300
7. Goyal A, Newcombe RG, Mansel RE, Chetty U, Ell P, Fallowfield L, Kissin M, Sibbering M (2005) Role of routine preoperative lymphoscintigraphy in sentinel node biopsy for breast cancer. Eur J Cancer 41:238–243. https://doi.org/10.1016/j.ejca.2004.05.008
8. Ahmed M, Baker R, Rubio IT (2016) Meta-analysis of aberrant lymphatic drainage in recurrent breast cancer. Br J Surg 103(12):1579–1588. https://doi.org/10.1002/bjs.10289
9. Amin MB, Greene FL, Edge SB, et al (2017) The eighth edition AJCC cancer staging manual: continuing to build a bridge from a population-based to a more "personalized" approach to cancer staging. CA Cancer J Clin 67:93–99. https://doi.org/10.3322/caac.21388
10. Magnoni F, Colleoni M, Mattar D, Corso G, Bagnardi V, Frassoni S et al (2020) Contralateral axillary lymph node metastases from

breast carcinoma: is it time to review TNM cancer staging? Ann Surg Oncol 27(11):4488–4499. https://doi.org/10.1245/s10434-020-08605-4
11. Herrera-Martínez Y, Acevedo-Bañeza I, De-Bonilla-Damiá A, Fernández-Rodríguez P, Sousa JM, Jiménez-Hoyuela García JM (2021) Contralateral axillary lymph node metastasis in a patient with relapsed breast cancer: locoregional event or distant metastasis disease? Oncol Res Treat 44:128–131. https://doi.org/10.1159/000513661
12. Assarian AA, Elahi A (2016) Contralateral axillary lymph node metastasis in breast cancer, an unusual clinical scenario: a case report and review of the literature. Arch Breast Cancer 3(3):97–101. Available from: www.archbreastcancer.com/index.php/abc/article/view/86. https://doi.org/10.19187/abc.20163397-101. Accessed 19 Jan 2023
13. Maaskant-Braat AJ, Voogd AC, Roumen RM, Nieuwenhuijzen GA (2013) Repeat sentinel node biopsy in patients with locally recurrent breast cancer: a systematic review and meta-analysis of the literature. Breast Cancer Res Treat 138(1):13–20. https://doi.org/10.1007/s10549-013-2409-1
14. Folli S, Falco G, Mingozzi M, Buggi F, Curcio A, Ferrari G, Taffurelli M, Regolo L, Nanni O (2016) Repeat sentinel lymph node biopsy in patients with ipsilateral recurrent breast cancer after breast-conserving therapy and negative sentinel lymph node biopsy: a prospective study. Minerva Chir 71(2):73–79 (**Epub 2015 Jul 17**)
15. Tokmak H, Kaban K, Muslumanoglu M, Demirel M, Aktan S (2014) Management of sentinel node re-mapping in patients who have second or recurrent breast cancer and had previous axillary procedures. World J Surg Oncol 12:205. https://doi.org/10.1186/1477-7819-12-205
16. Klapdor R, Länger F, Gratz KF, Hillemanns P, Hertel H (2015) SPECT/CT for SLN dissection in vulvar cancer: improved SLN detection and dissection by preoperative three-dimensional anatomical localization. Gynecol Oncol 138(3):590–596. https://doi.org/10.1016/j.ygyno.2015.06.011
17. Collarino A, Fuoco V, Garganese G, Pereira Arias-Bouda LM, Perotti G, Manca G, Vidal-Sicart S, Giammarile F, De Geus-Oei LF, Scambia G, Giordano A, Valdés-Olmos RA, Maccauro M (2020) Lymphoscintigraphy and sentinel lymph node biopsy in vulvar carcinoma: update from a European expert panel. Eur J Nucl Med Mol Imaging 47:1261–1274. https://doi.org/10.1007/s00259-019-04650-8
18. Chakera AH, Hesse B (2009) EANM-EORTC general recommendations for sentinel node diagnostics in melanoma. Eur J Nucl Med Mol Imaging 36:1713–1742. https://doi.org/10.1007/s00259-009-1228-4
19. Willis AI, Ridge JA (2007) Discordant lymphatic drainage patterns revealed by serial lymphoscintigraphy in cutaneous head and neck malignancies. Head Neck 29:979–985. https://doi.org/10.1002/hed.20631
20. Lavelli V, Ferrari C, Santo G, Altini C, Ballini A, Sardaro A, Fanelli M, Pisani AR, Nappi AG, Giudice G, Rubini G (2020) The lymphoscintigraphic study of unpredictable head and neck cutaneous melanoma lymphatic drainage. Biomedicines 8(4):70. https://doi.org/10.3390/biomedicines8040070
21. Vidal-Sicart S, Pons F, Fuertes S, Vilalta A, Rull R, Puig S, Palou JM, Ortega M, Castel T (2004) Is the identification of in-transit sentinel lymph nodes in malignant melanoma patients really necessary? Eur J Nucl Med Mol Imaging 31(7):945–949. https://doi.org/10.1007/s00259-004-1485-1
22. Matthey-Giè ML, Boubaker A, Letovanec I, Demartines N, Matter M (2013) Sentinel lymph node biopsy in nonmelanoma skin cancer patients. J Skin Cancer 2013:267474. https://doi.org/10.1155/2013/267474
23. McMasters KM, Chao C, Wong SL, Wrightson WR, Ross MI, Reintgen DS, Noyes RD, Cerrito PB, Edwards MJ (2002) Sunbelt Melanoma Trial Group. Interval sentinel lymph nodes in melanoma. Arch Surg 137(5):543–547. https://doi.org/10.1001/archsurg.137.5.543
24. Vidal-Sicart S, Valdés Olmos R (2016) Using lymphoscintigraphy as a prognostic tool in patients with cancer. Res Rep Nuclear Med 6:1–17. https://doi.org/10.2147/RRNM.S64945
25. Kwon HR, Hwang JH, Mun GH, Hyun SH, Moon SH, Lee KH, Choi JY (2021) Predictive role of lymphoscintigraphy undergoing lymphovenous anastomosis in patients with lower extremity lymphedema: a preliminary study. BMC Med Imaging 21:188. https://doi.org/10.1186/s12880-021-00713-1
26. Rubini G, Altini C, Iuele F, Ferrari C (2022) Lymphoscintigraphy and lymphedema. In: Signore A (eds) Nuclear medicine and molecular imaging, Elsevier, pp. 546–554, ISBN 9780128229804, https://doi.org/10.1016/B978-0-12-822960-6.00048-X