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Prevalence of contralateral lymphatic drainage patterns during sentinel lymph node biopsy for truncal melanoma: A retrospective, observational study

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Summary *Background and purpose:* This study aimed to examine the prevalence, patterns, and outcomes of contralateral lymphatic drainage during sentinel lymph node biopsy (SLNB) in patients with truncal melanoma. Understanding this phenomenon is crucial for improving surveillance and management strategies for melanoma patients.
Subjects and methods: This retrospective cohort study analysed 1308 consecutive patients aged 18 years and over who underwent wide local excision (WLE) for truncal melanoma followed by SLNB at The Christie Hospital, Manchester, UK, between October 2006 and November 2024. Exclusions included non-truncal melanoma and cases without lymphoscintigraphy data. SLNB evolved from intradermal injections of blue dye to include radiolabelled Technetium-99m-nano colloid. Contralateral drainage was defined as sentinel lymph nodes draining exclusively to the opposite side of the coronal midline relative to the WLE scar. Data were correlated with imaging results and patient outcomes.
Main findings: Contralateral drainage occurred in 14 patients (1.1%). This subgroup had melanoma thicknesses ranging from 0.80 to 6.40 mm and included 8 males and 6 females (ages 26–72 years). Notably, 10 cases involved posterior torso melanomas, with 6 located on the lower back. Three patients (21.4%) experienced melanoma recurrence during follow-up, all on the ipsilateral side. One patient treated in 2007 died following recurrence, while 2 patients treated in 2018 and 2021 remain alive following immunotherapy.
Conclusions: Contralateral sentinel lymph node drainage, though rare, highlights the need for tailored surveillance strategies for patients with truncal melanoma, particularly those with

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posterior torso lesions. These findings underscore the importance of incorporating this data into patient consent and individualised care plans.

Limited information exists in the literature regarding the lymphatic vessels that drain the skin. Historically, Sappey's research is considered a significant breakthrough in this field. In 1874, he investigated lymphatic drainage by injecting mercury into the interstitial tissues and lymphatic vessels during cadaveric dissection.[1] He ascertained symmetrical lymphatic drainage from the trunk to the ipsilateral side (either right or left), with the highest (axilla) or lowest (groin) lymph node station location defined along a transverse line from the anterior umbilicus to the L2 vertebra posteriorly. These lines, known as 'Sappey's lines', defined 4 zones on the trunk's skin. According to Sappey, lymphatic drainage from these zones would occur to the corresponding axillary or groin lymph nodes.[1] For more than a century, Sappey's theory on the lymphatic vessels that drain the skin was widely accepted. However, the introduction of lymphoscintigraphy (LS) imaging in sentinel lymph node biopsy (SLNB) studies for patients with melanoma revolutionised this hypothesis.[2] This development held particular relevance for melanoma of the torso. Originally, Sappey and later Sugarbaker described Sappey's lines,[3] but modern LS data have revised the traditional understanding of dorsal lymphatic drainage pathways.[4]

A 2010 study using a three-dimensional computer model of skin lymphatic drainage, based on melanoma LS data from 5232 patients, demonstrated that most skin regions exhibit symmetric lymphatic drainage along the coronal midline of the body. However, asymmetry was noted in the lymphatic drainage of the lower anterior torso and posterior torso, alongside the lower posterior neck, posterior legs, and small areas of the anterior forehead.[5] Furthermore, earlier studies examining the distribution of lymph nodes revealed that the right side of the body contains more lymph nodes than the left side, indicating a potential numerical asymmetry in the lymphatic system.[6] A recent observational study on 165 patients with melanoma revealed statistically significant heterogeneous lymph node drainage between the axillary and inguinal nodes in the lumbar region ($p < 0.01$). Additionally, there was significant heterogeneity in lymphatic laterality (homolateral vs. bilateral) in the dorsal subscapularis region ($p < 0.05$).[7]

The existing literature acknowledges that some patients with melanoma show lymphatic drainage to unexpected nodal sites, particularly those with truncal melanoma. However, detailed information on isolated contralateral lymph node drainage in these patients is limited. Thus, the main aim of this study was to examine the prevalence, patterns, and outcomes of contralateral lymphatic drainage during SLNB in patients with truncal melanoma.

Methods

Setting

Where applicable, this study was conducted and reported in accordance with the Strengthening the Reporting of Observational Studies in Epidemiology checklist. A list of all patients aged 18 years and over who underwent wide local excision (WLE) for truncal melanoma followed by SLNB after LS imaging ± single-photon emission computed tomography (SPECT-CT) scan was collated from the Nuclear Physics department at a single centre: The Christie Hospital, Manchester, UK, between October 2006 and November 2024. The Christie Hospital is a tertiary oncology centre located in northwest England and serves a catchment area of 3.2 million across Greater Manchester and Cheshire. It is a national specialist, with around 15% of patients referred from other parts of the country. We collected data for each patient by analysing LS imaging ± SPECT-CT scan reports. In cases where these reports were unavailable, relevant information was obtained by reviewing medical illustration data recorded in the patient's clinical notes. Patients demonstrating contralateral lymphatic drainage were followed up either until the present time or until the time of death.

Patients included

Patients, both male and female, aged 18 years and over who underwent cutaneous WLE for trunkal melanoma followed by SLNB at The Christie Hospital in Manchester, UK, from October 2006 to November 2024.

Patients excluded

Patients who had cutaneous WLE for melanoma but without available LS, and patients who had non-truncal melanoma or melanoma with a central truncal scar. Also, patients who had skin cancer other than melanoma.

Outcome

The study aimed to determine the prevalence of contralateral sentinel node drainage in truncal melanoma. Additionally, the study aimed to assess the frequency of contralateral sentinel node. The study also evaluated mortality, additional treatment, and disease recurrence. We classified the anatomical location of truncal melanoma using Sappey's line.

Intervention

Initially, the SLNB procedure involved injecting vital blue dye intradermally. Over time, it evolved to include additional injections of radiolabelled colloid at the site of the primary cutaneous melanoma. LS was conducted using Technetium-99m-nano colloid, ranging from 13 to 71.2 MBq, either on the same day or the day before surgery. The colloid was injected in 4 deposits of 0.1 mL each around the surgical scar. Dynamic images of the anatomical region and adjacent lymphatic basins were taken over 5 min, followed by anterior, lateral, and oblique projections for another 5 min each using a dual-detector gamma camera. In cases requiring further clarification, SPECT-CT imaging was used. All images were reviewed by medical personnel.

Statistical methods

Raw data on the distribution of SLN drainage patterns were collected and presented as absolute figures. Patients with missing data, central scar, or non-truncal WLE were excluded from the study.

Results

This retrospective observational study analysed data from a cohort comprising 1335 patients with cutaneous truncal c melanoma. Twenty-seven patients with a central scar were excluded from the analysis, resulting in a final study population of 1308 patients. The cutaneous WLE scar site of primary melanomas for each patient was individually evaluated through medical photography and subsequently correlated with the lymphatic region of the SLN, which was identified using LS or SPECT-CT scan. Contralateral drainage was defined as SLNs draining exclusively to the opposite side of the coronal midline relative to the site of the WLE scar.

Among the cohort, 14 patients exhibited contralateral SLN drainage relative to the primary melanoma site, constituting 1.1% of the patient population (Table 1). Melanoma thickness in this subgroup varied from 0.80 to 6.40 mm. This group comprised 8 males and 6 females, with ages at diagnosis ranging from 26 to 72 years. All participants were of White British ethnicity. Notably, 10 of these patients had their primary melanoma located on the posterior torso, with 6 cases specifically on the lower back (Table 2). Furthermore, 3 out of 4 patients with melanoma on the left lower back demonstrated SLN drainage to the right groin, along with other contralateral regions. Six patients experienced contralateral drainage to the left axilla, with 4 of these originating from a primary melanoma on the right upper back.

Three patients with contralateral lymph node drainage experienced melanoma recurrence during follow-up, representing 21.4% of this subgroup. One patient, diagnosed and treated with WLE and SLNB in 2007, had a recurrence the same year. This patient received Dacarbazine in 2007, developed further metastases, and ultimately died. In contrast, the other 2 patients, treated with WLE and SLNB in 2018 and 2021 and given immunotherapy, are alive. Interestingly, all 3 patients experienced melanoma recurrence on the ipsilateral side of their primary melanoma, despite initial contralateral drainage.

Table 1 The distribution of sentinel lymph node drainage pattern in patients.

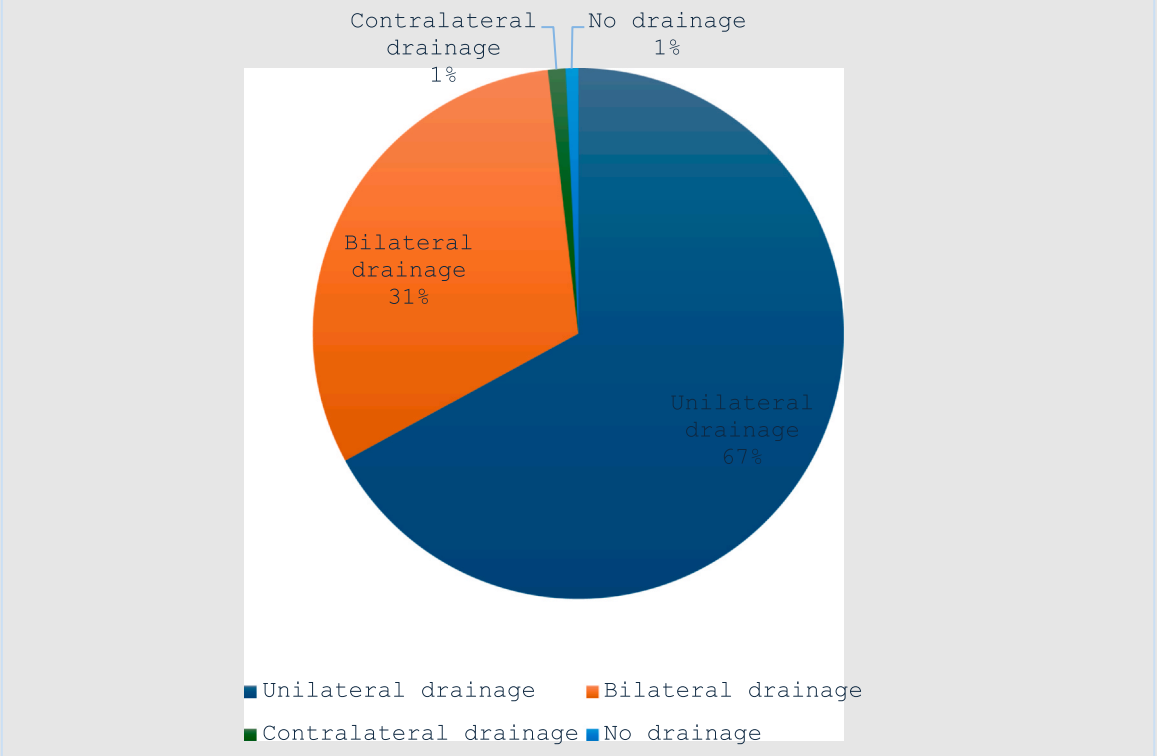

Table 2 The location of primary melanoma scar according to Sappey's line in patients with contralateral sentinel lymph node drainage.

Location of primary melanoma scar	Number of patients, n (%)
Left lower back	4 (28.6)
Left lower abdomen	1 (7.1)
Right lower back	2 (14.3)
Right upper back	4 (28.6)
Right upper chest	1 (7.1)
Right upper abdomen	2 (14.3)

Discussion

Our research identified a significant incidence of contralateral SLN drainage in cases of primary melanoma situated on the posterior torso. The recurrence rate of melanoma in all cases with contralateral SLN drainage was 21.4%, with all recurrences occurring on the ipsilateral side relative to the primary melanoma. Consequently, primary melanoma of the posterior torso presents a high-risk factor for contralateral SLN drainage, necessitating close monitoring for recurrence and subsequent disease progression.

Typically, drainage from truncal melanomas occurs to the axillary or groin lymph nodes. Recent research has indicated that patients with truncal melanoma showing multiple lymphatic drainage sites, as opposed to a single basin, have a higher risk of lymph node metastases and a poorer prognosis, even in the absence of pathological lymph node involvement.[8,9] Conversely, McHugh et al.[10] found that among 98 of 423 (23.2%) patients with primary truncal melanoma undergoing sentinel biopsy to multiple lymphatic basins, multiple drainage is not an independent risk factor for nodal metastasis and lacks prognostic significance. They suggested considering multiple drainages only from a physiological perspective, implying that SLN might be unnecessary in these cases.[10] Minimal data exist on contralateral drainage as a prognostic marker in patients with melanoma.

The majority of patients in our cohort with contralateral drainage had their melanoma in the posterior torso, notably the lower back. A collaborative study in New Zealand and Australia, involving 5232 patients,[11] yielded comparable findings. Reynolds et al.[11] used an online software tool to compare lymphatic drainage in the midline and lower back. The results indicated significant variability in drainage routes: left axilla (71.4%), right axilla (52.4%), intercostal (4.8%), paravertebral (4.8%), retroperitoneal (4.8%), left groin (66.7%), right groin (23.8%), and interval node (9.5%). Furthermore, another prospective study on 90 consecutive patients with melanoma highlighted several key findings regarding lymphatic drainage patterns in the trunk.[12] It was observed that drainage pathways could exhibit contralateral routes in the medial trunk regions, with a potential for retrograde lymphatic flow. Medial areas were noted for bilateral drainage patterns, particularly towards axillary regions above the L1 level. Furthermore, posterior trunk areas demonstrated greater variability in drainage sites compared with anterior regions. Asymmetric lymphatic drainage patterns in melanoma, as previously noted by Leong et al.[13] and highlighted by Marone et al.,[14] indicate that melanoma located within 2.5 cm of the midline or the Sappey line may exhibit drainage to unilateral or bilateral sites, which is not deemed discordant.

Studies analysing the numerical distribution of lymph nodes have revealed more axillary nodes on the left side of the body. These lymph nodes are smaller than those on the right side.[15,16] This asymmetry may explain our data showing 6 patients with contralateral drainage to the left axilla, 4 of whom had primary melanoma on the right posterior back. Furthermore, a multi-centre study indicated left-sided lateralisation in patients with cutaneous melanoma, potentially due to variations in sun exposure, melanocyte distribution asymmetry, or characteristics established during embryological development.[17]

Several hypotheses have been proposed to account for these lymphatic drainage asymmetries, including the embryological development of the lymphatic system. It is established that the lymphatic system begins to form at 5 weeks gestation, concurrently with the vascular system.[18] The development of lymphatic capillaries parallels that of blood vessels, and major lymphatic channels typically follow the course of primary veins.[4] While the major veins in the limbs, head, and neck regions display topological symmetry, the asymmetrical positioning of the heart may predispose the lymphatic vessels within the torso to exhibit an asymmetrical distribution. In particular, the asymmetry can be attributed to anatomical variabilities in the lymphatic network situated amidst the posterior trunk muscles and subscapular arteries.[19-21]

The extensive participation of patients in this study at The Christie Hospital, a regional melanoma centre, has significantly contributed to our understanding of the relationship between contralateral SLN drainage and melanoma of the posterior torso. However, it is important to note that the data may not represent the global population. Additionally, this study is limited by the absence of standardised measurements for quantifying the distance of melanoma scars from the midline and assessing the size of the melanoma scar, thus impeding further subgroup analysis.

Conclusion

Our study identifies a significant correlation between contralateral sentinel lymph node drainage and primary melanoma of the posterior torso. Importantly, the 21.4% recurrence rate, exclusively on the ipsilateral side, underscores the critical need for rigorous surveillance to detect recurrence and monitor disease progression. These results emphasise the need for tailored surveillance strategies to manage the heightened risks associated with melanomas in this anatomical region. Furthermore, it is crucial to integrate updated data into patient consent processes for SLNB, ensuring informed decision-making and personalised care strategies.

Ethical approval

Not required.

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Conflicts of interest

None declared.

Declaration of Generative AI and AI-assisted technologies in the writing process

During the preparation of this work, the authors used ChatGPT (Version 1.2024.348) to improve language and readability. After using this tool/service, the authors reviewed and edited the content as needed and took full responsibility for the content of the publication.

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