Tattoo Ink Fluorescence Interfering with Axillary Reverse Mapping Using ICG in Breast Conservation Surgery

Aishwarya Vijay, MD, MBA[1,2], Bethany Andrew[1], Jamie Anderson, MD[1,2], Dominika Dziadecki, MD[3], Mary Legenza, MD, FACS[3], Diane Krutzler-Berry, MD, FACS[3]

[1]Joan C. Edwards School of Medicine, Marshall University, Huntington, WV, [2]Department of Surgery, Marshall University, Huntington, WV, [3]Departments of Surgery and Oncology, Marshall University, Huntington, WV

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INTRODUCTION

- **Breast cancer-related lymphedema (BCRL)**
  - Affects approximately 1 in 5 women
  - Associated with significant morbidity
- **Sentinel lymph node biopsy (SLNB)** using lymphatic mapping is associated with risk
  - Current gold standard: dual mapping with blue dye (BD) and radioisotope (RI), 98.8% yield
- **Axillary reverse mapping (ARM)**
  - Used to reduce BCRL incidence
  - BD
    - Allergic/anaphylactic risk, skin necrosis; lower varied yield alone
  - RI (^{99m}Tc)
    - Increased cost, radiation exposure, limited supply; lower varied yield alone
- Fluorescent indocyanine green (ICG) for ARM following SLNB
  - Promising alternative; 97-98% yield alone
  - Combining with other methods increases success rate of identifying lymph nodes, reported up to 100%
  - Has not been adopted as the standard-of-care

CASE PRESENTATION

- 55-year-old nulliparous postmenopausal female
  - Last screening mammogram: 3 years prior
  - Menarche Age: 14, Menopause Age : 49
  - Multiple bilateral upper extremity tattoos present
- Screening mammogram
  - Mass with calcifications in the upper outer quadrant of the right breast, BI-RADS 4
- In-office ultrasound: 1.2 x 1.1 x 0.7 cm mass with calcifications at the 10 o'clock position, 5 cm from the nipple
- Ultrasound-guided biopsy with pathology: Grade 1 right-breast invasive ductal carcinoma and Grade 1 ductal carcinoma in situ
  - ER/PR positive, HER2 negative, genetic testing: negative
- Lumpectomy and SLNB were performed
- Prior to the first incision, ^{99m}Tc was injected at the edge of the areola while ICG was injected in the upper arm
- A handheld near-infrared fluorescence camera was used to visualize ICG transit through the lymphatic vessels

OUTCOME



Figure 1: Right tattoo ink-stained sentinel lymph node number 1 with false positive NIRF-ICG lymphangiography.

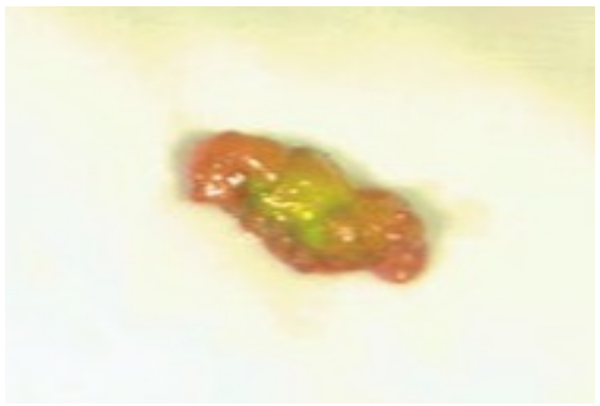


Figure 2: Right tattoo ink-stained sentinel lymph node number 2 with false positive NIRF-ICG lymphangiography.

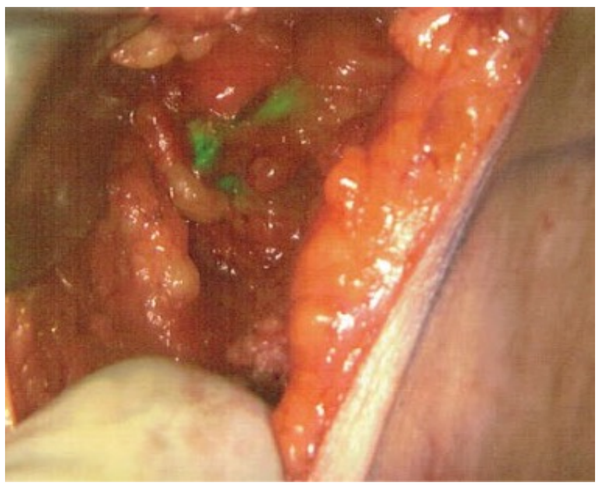


Figure 3: Right tattoo ink-stained sentinel lymph node numbers 1 and 2 with false positive NIRF-ICG lymphangiography.

Green fluorescence (Fig. 1) was observed in regions where tattoo ink and lymphatics were overlapping. Areas of tattoo-ink-stained lymph node (TISLN) were the only regions to exhibit fluorescence (Fig. 1, 2, 3). Scanning of external, non-lymphatic regions with tattoo ink revealed no fluorescence.

DISCUSSION

- Tattoo pigmentation can interfere with differentiating blue-dyed lymph nodes from TISLN during SLNB
- Complicates intraoperative differentiation between nodes draining the arm lymphatics and those stained by ink
- May lead to over-excision of axillary nodes, under-staging of cancer due to misidentification, or increase the risk of lymphedema
- Black tattoo ink contains nanoparticles, polycyclic aromatic hydrocarbons (PAH), and carbon black
  - Carbon black is a hydrophobic matrix that binds PAH
- ICG intensity increases in certain environments
  - Bound to plasma proteins (lipophilic environment)
- Literature suggests that lipid-bound ICG utilizes the hydrophobic suspension in black tattoo ink to bind to and travel to the lymph node, potentially contributing to the false-positive node findings in this patient

CONCLUSION

- TISLN have been indicated in the literature as interfering with SLNB, which may influence the accuracy of lymphatic mapping and surgical outcomes
- This case highlights a unique interaction between ICG and tattoo ink, suggesting that lipid-bound ICG utilizes the hydrophobic suspension in black tattoo ink to bind to the lymph node, which we propose led to the false-positive node fluorescence in this patient
- There is a need to expand current understanding of tattoo ink interference in breast cancer surgery guided by ICG fluorescence
- This underscores the importance of recognizing tattoo pigmentation's impact on lymphatic mapping during breast cancer surgery, warranting further exploration of the biochemical interactions between ICG and tattoo ink to refine surgical approaches and improve patient outcomes in the context of BCRL prevention