A Rapid Point-of-care Fluorescence Imaging Device Helps Prevent Graft Rejection Post Modified Radical Mastectomy

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Abstract

Pathogenic bacteria in wounds impede successful skin grafting. However, their detection relies on culture methods, which delay confirmation by several days. Real-time fluorescence imaging detects bacteria, allowing for rapid assessment and documentation. We herein report a post modified radical mastectomy, surgical site infection with multidrug-resistant *Pseudomonas* spp. that underwent repeated antibiotic therapy and debridement and eventually grafting. In this case, a real-time fluorescence imaging device helped prevent graft rejection.

Keywords: Equipment and supplies, machine learning algorithm, mastectomy, modified radical, optical imaging, point-of-care testing

Introduction

The rate of skin graft rejection increases significantly when the wound bed possesses more than 10^5 bacteria/g of tissue.[1] Although different stages of a wound (e.g. slough and granulation tissue) are visible to the naked eye during clinical assessment and provide valuable information about the wound's healing potential, bacteria in wounds are not visible, and their diagnosis (through wound sampling) requires additional time, costs, and can be prone to erroneous results.

Fluorescence imaging has recently emerged as a point-of-care, noninvasive imaging method for visualizing bacteria present in wounds. By visualizing fluorescent signals in real-time, images can reveal not just the presence of bacteria but map them spatially helping the clinician perform targeted sampling, cleaning, and debridement. "Illuminate" is one such device which combines a proprietary machine-learning algorithm with multispectral imaging, to detect and classify gram types of bacteria.[2] We herein report a case where this device helped us prevent graft rejection by finding a small focus of infection that was not being detected by the usual sampling methods.

Case Report

A 52-year-old diabetic female, with no other relevant medical, surgical, family, or psychosocial history, underwent a modified radical mastectomy for the removal of a grade 3 invasive ductal carcinoma of the right breast [Figure 1a and b]. Post mastectomy, the area was prepared for graft placement and a swab sent for culture and sensitivity which reported the growth of a multidrug resistant *Pseudomonas* species, resistant to all beta lactams, aminoglycosides, and carbapenems etc thereby indicating a surgical site infection. However, despite appropriate antibiotic therapy and debridement, repeated sampling demonstrated the continued presence of the bacteria. The patient was treated again with even higher levels of antibiotics, with no success. This delayed the placement of the graft by several weeks and led us to suspect the presence of a small hidden focus of multidrug-resistant bacteria still colonizing the floor or the edge of the wound [Figure 2]. In view of this, the entire wound bed was scanned with Illuminate (after taking informed consent) and a small focus of cyan fluorescence (signifying *Pseudomonas aeruginosa)* was observed in a clean-looking corner of the graft bed, under a skin fold in the lower quadrant [Figure 1c]. Targeted debridement

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of this area led to the complete clearing of the wound bed (as confirmed by a repeat culture sensitivity), enabling graft placement and eventually, a successful uptake [Figure 3].

Discussion

Our case demonstrates that a point-of-care device with the ability to detect and spatially map bacteria in real-time can lead to targeted debridement, enabling successful graft uptake. The device's positive predictive value in visualizing *P. aeruginosa* was also found to be instrumental, as this bacterium is known to have the potential to contaminate skin grafts, resulting in partial or complete graft loss.[3]

Illuminate leverages the autofluorescence property exhibited by pathogens (such as nicotinamide adenine dinucleotide hydrogen [NADH] and flavins) and infectious markers (pyoverdine and porphyrin) present in bacteria and *Fungi*. NADH has a strong emission peak at 470 nm, producing blue fluorescence, while flavin and porphyrin peak at around 525 nm and 620 nm corresponding to green and red fluorescence. Gram-negative organisms have a higher intensity of NADH and flavin than Gram-positive microorganisms, making it possible to differentiate between gram types. *Pseudomonas* spp. possesses pyoverdine, a unique marker having a blue-green color enabling its detection. An image processing and machine learning algorithm processes the spectral images to detect and classify pathogens based on the intensity of autofluorescence variation among these biomarkers. It can see bacterial loads as low as 10^4 CFU/g, allowing for early intervention (Indian patent No. 323440, 2019).[2]

Autofluorescence imaging is rapidly gaining importance in wound care, with studies reporting most devices to have a positive and negative predictive value of over 90%.[4] Autofluorescence wound imaging is simple, does not require training, and gives immediate feedback to the clinician to take necessary therapeutic interventions, leading to increased wound healing rates, decreased rate of graft rejections, and reduced antibiotic usage.[5-8]

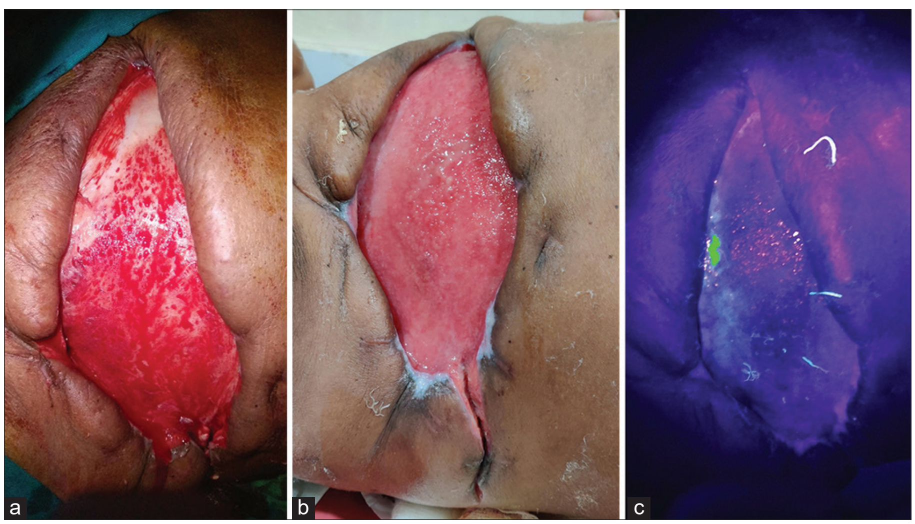

Figure 1: (a and b) Showing wound post radical Mastectomy. (c) showing wound when scanned by "Illuminate"

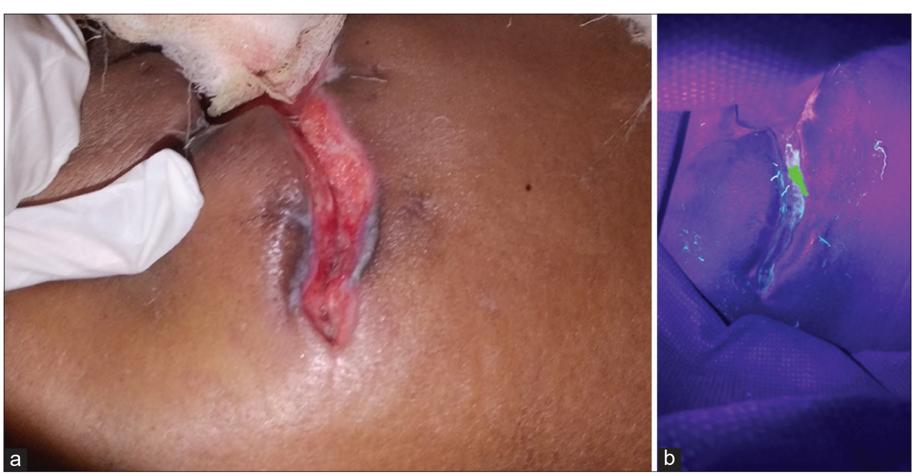

Figure 2: (a) Showing a small area as floor of the wound. (b) showing the presence of a small hidden cyan under a skin fold in the lower quadrant

Figure 3: Showing final graft uptake

However, technology limitations exist in detecting deep-seated bacterial infections and differentiating pathogenic from commensal bacteria. An approximation of bacterial load is possible, but their accurate determination still requires tissue culture.[9] Therefore, this device does not replace the gold standard methods for bacterial detection but acts as an adjunct, helping provide real-time feedback to the clinician.

In summary, incorporating bacterial fluorescence imaging into routine wound care can result in more specific debridement, avoiding the unaffected tissue and leading to an improvement in the chances of graft uptake.

Research quality and ethics statement

The authors followed applicable EQUATOR Network (https://www.equator-network.org/) guidelines, notably the CARE guideline, during the conduct of this report.

Declaration of patient consent

The authors certify that they have obtained all appropriate patient consent forms. In the form, the patient has given her consent for her images and other clinical information to be reported in the journal. The patient understands that her name and initials will not be published and due efforts will be made to conceal her identity, but anonymity cannot be guaranteed.

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Nil.

Conflicts of interest

There are no conflicts of interest.

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