Real-Time Autofluorescence Imaging to Diagnose LVAD Driveline Infections

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A 64-year-old man experienced a driveline infection that was treated with serial debridements and antibiotics. When the wound clinically appeared ready for closure, a handheld fluorescence imaging device still revealed a margin of red fluorescence around the wound edges consistent with a subclinical infection. Therefore, a wider margin was made and additional specimens for wound culture were taken, which demonstrated a vancomycin-resistant enterococcal infection. The autofluorescence signals of common bacteria can be detected with a fluorescence camera in subclinical wound infections without clinical signs. Here we describe the first use of this technology to diagnose ventricular assist device driveline infections after left ventricular assist device implantation.

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Driveline infections are the most common infections associated with the left ventricular device (LVAD) and are one of the leading causes for hospital readmissions after device implantation. Treatment with aggressive antibiotic therapy may select for a secondary superinfection. Moreover, secondary infections may not be readily apparent and cannot always be detected by clinical signs and symptoms, especially while the patient is receiving suppressive therapy for the initial pathogen. However, many skin bacteria can be detected on the basis of their autofluorescence. Therefore, we sought to use a portable fluorescence imaging device to guide surgical decision making. This article reports our experience using the handheld noninvasive real-time fluorescence imaging device MolecuLight (MolecuLight iX, Toronto, Canada) to diagnose cutaneous driveline infections and guide their effective treatment.

A 64-year-old man presented with orthopnea, paroxysmal nocturnal dyspnea, peripheral edema, and productive cough with frothy white sputum. His medical history was significant for viral cardiomyopathy, coronary artery disease treated with multiple stent placements, atrial fibrillation treated with Coumadin, and recurrent heart failure. He received a diagnosis of stage IV advanced heart failure and was given a continuous dobutamine drip. His workup revealed elevated right heart pressures and a left ventricular ejection fraction of 36%. He was treated with a HeartWare LVAD through a left thoracotomy as a bridge to transplantation. The LVAD was placed into the apex, and the outflow graft was anastamosed to the aorta. The driveline was tunneled laterally to the midabdominal rectus through a counter-incision 2 cm below the right midclavicular line, then exited at a premarked position at the right anterior flank of the patient.

The postoperative course was complicated by a driveline counterincision site infection with wound cultures positive for *Corneybacterium* species. The patient was treated with serial debridements, vancomycin irrigations, and intravenous meropenem. Eleven days after the first driveline debridement, the patient was scheduled for a rectus abdominus myocutaneous flap closure over the counterincision site. When the wound visually appeared ready for closure and the patient had been treated with antibiotics for 11 days, before excision of the wound margins, we used the MolecuLight fluorescence imaging device intraoperatively to examine the wound. We noticed a 1-cm margin of red fluorescence around the wound edges (Fig 1). The MolecuLight's fluorescence can detect the presence and distribution of many gram-positive bacteria in real time. This prompted us to take specimens for an additional wound culture. We also took an additional margin beyond the visualized fluorescence. The wound cultures grew out vancomycin-resistant *Enterococcus* (VRE) species, and the patient was subsequently treated with an 8-day course of linezolid. The patient was discharged 2 days after the wound closure and has been well during follow-up after 10 months.

Comment

Most driveline infections are associated with skin flora. *Staphylococcus aureus*, *Streptococcus epidermidis*, *Corneybacterium* species, and *Enterococcus* species represent the most common gram-positive cocci, and *Pseudomonas* species constitute the most common gram-negative pathogen isolated in driveline infections [1]. Polymicrobial infections are also common and likely occur as a result of a superinfection while a patient is receiving suppressive therapy for the initial pathogen [2]. VRE infections of driveline wounds are associated with the aggressive treatment of suspected driveline infections with vancomycin. They are also associated with longer hospital stays and higher mortality [3]. Inasmuch as skin flora are the causative agent of most driveline infections, we sought to use a new fluorescent camera technology that is routinely used by podiatrists to guide debridement and wound care for cutaneous foot ulcers.

The MolecuLight is a handheld fluorescent camera that can detect bacterial colonization in real time based on the

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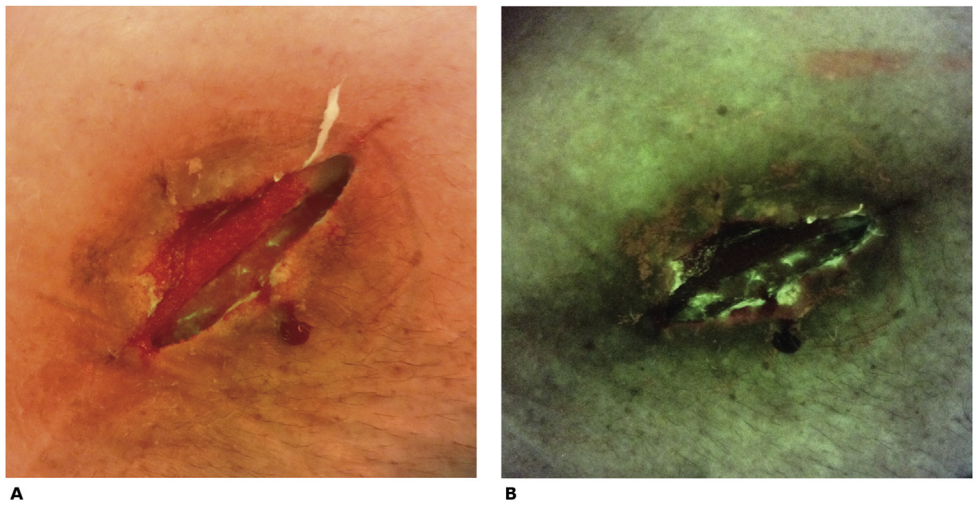

Fig 1. (A) White light and (B) fluorescent images of the counterincision infection site 11 days after antibiotic treatment for the original Corneybacterium infection before myocutaneous flap closure. The red fluorescence in the wound periphery indicates possible gram-positive infection.

principle of autofluorescence. With the use of an excitation wavelength of 405 nm and an emission wavelength of 525 nm, autofluorecence signals of common skin bacteria can be detected and viewed in real time and stored on the internal hard drive. Red fluorescence on a faint green background of fluorescence is indicative of gram-positive bacteria, while a strong bluish-green fluorescence is indicative of *Pseudomonas* infection [4]. This quick, safe, and noninvasive technology was developed and validated to guide wound debridement and to identify areas of high bacterial load for culture in foot ulcers that may not be visually apparent under white light (Fig 2).

Subclinical bacterial loads cannot always be detected by visible clinical signs and symptoms. Moreover, heavy use of broad-spectrum antibiotic agents may select for drug-resistant bacteria. For these reasons, we believe that fluorescence imaging is valuable before myocutaneous closure of an infected driveline site. In this case report, the information provided by the MolecuLight device in the operating room changed our surgical management of the wound. First, the excision margin was increased. Second, a specimen for culture was taken, and the culture detected subclinical VRE, allowing for prompt antibiotic treatment after the myocutaneous flap. In summary,

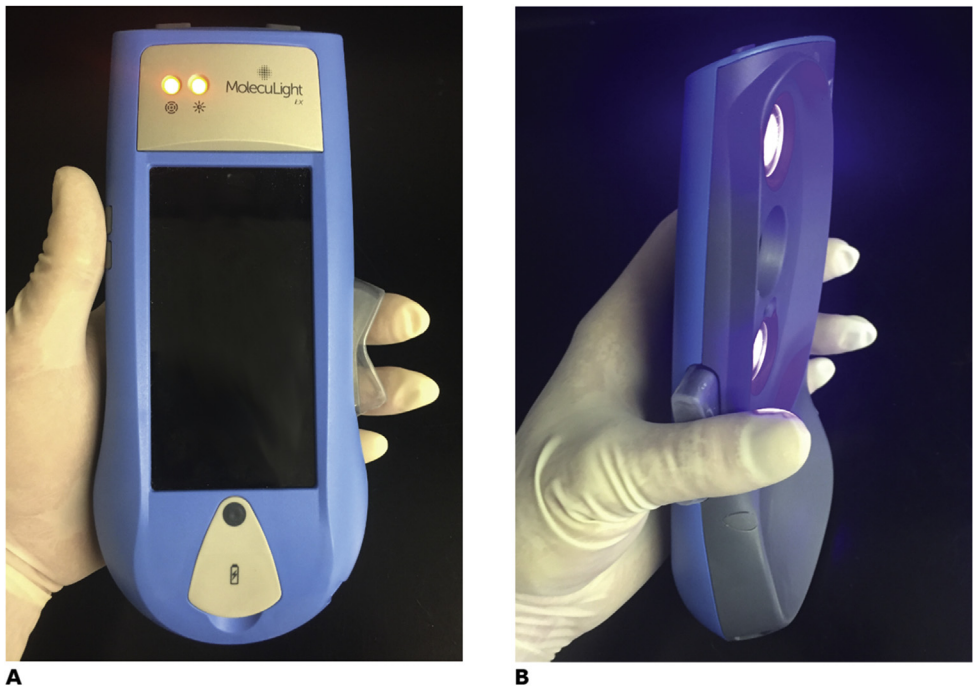

Fig 2. Handheld Moleculight device. (A) Front with real-time liquid crystal display. (B) Back with dual-excitation light-emitting diode array and iris.

intraoperative fluorescence imaging of high-risk driveline sites and possible contaminated mediastinal wounds may be a useful real-time surgical tool to guide better surgical management.

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