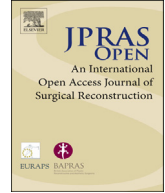




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Case Report

Is non-invasive indocyanine-green angiography a useful adjunct for the debridement of infected sternal wounds?

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ABSTRACT

Laser-assisted indocyanine-green imaging (ICG) has a wide range of surgical applications, and has been used in reconstructive surgery to aid in assessing the viability of free tissue transfers and to help predict poor tissue perfusion. However, its indications for use is limited to assessing free flap tissue perfusion, coronary artery perfusion during coronary artery bypass (CABG), and tissue perfusion in diabetic foot ulcers, to name a few. This system has been proven to be a safe, reliable adjunctive modality to assess microvascular compromise or poor perfusion peri-operatively, which could minimize skin necrosis and other post-operative complications (Further et al., 2013).¹ The ability to objectively assess tissue perfusion has led to improved post-operative outcomes in breast, abdominal wall, colorectal, and cardiac surgery. To date, no studies have reviewed the use of ICG in delineating devitalized bone during sternal wound debridement after cardiac surgery. At our institution, we have encountered a cohort of patients with post-cardiac surgery sternal wound infections who have required debridement of infected and devitalized bone. We propose that SPY technology aids in delineating this devitalized bone, and may aid in the timing muscle flap coverage. In this paper, we will demonstrate two cases of patients who had post-operative sternal wound infections after undergoing cardiac surgery for which ICG was used to demarcate

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debridement zones and subsequent flap coverage. In these cases, ICG allowed for efficient and reliable intraoperative evaluation of bony perfusion and has aided in early adequate debridement and flap coverage.

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Introduction

Sternal wound infection after cardiac surgery is relatively rare occurring in up to 4% of patients undergoing median sternotomy.² Risk factors for sternal wound infection include patient specific factors—such as age, diabetes, and obesity—as well as operative factors, such as harvesting of an internal mammary artery, early re-operation for bleeding, and the use of vasopressors.² In early review papers, mortality was quoted to be as high as 50% due to mediastinitis and septic shock, however, after the advent of radical debridement followed by muscle flap coverage, mortality has dropped to less than 10%.³

Laser-assisted indocyanine-green imaging has several useful applications, ranging from assessing microvasculature in diabetic foot ulcers to evaluating bone perfusion during vascularized bone flaps.^{1,4,5} Indocyanine green (ICG) has been shown to be most useful in evaluating skin and soft tissue viability,^{6–8} however, research has also proved its efficacy in evaluating bone perfusion. In one study, Nguyen et al. used ICG to study vascularized osteomyocutaneous free flaps in pigs. Here, the authors concluded that ICG was able to provide an accurate, intra-operative assessment of bone perfusion.⁵

Indocyanine-green angiography has also proved useful in abdominal wall reconstruction. In one study, patients underwent concomitant abdominal wall reconstruction and panniculectomy. The amount of resection was guided by ICG angiography versus standard operative technique. Patients who underwent ICG angiography demonstrated less complications with a 20% reduction in the amount of wound healing complications.⁸ Other institutions have used the technology to help assess viability of tissue pre-operatively and intra-operatively to aid in operative planning.^{6,9}

In our literature review, we did not find any studies centered on using ICG for sternal wound debridement after cardiac surgery. The debridement of the bony sternum can prove problematic due to compromise of sternal stability, as well the possibility of injuring underlying vascular grafts. Given the segmental blood supply to the sternum from perforating branches of the internal mammary artery (IMA) and collaterals from intercostal arteries, we hypothesize that ICG angiography would be useful in identifying segments of the sternum without adequate bony and tissue perfusion. Objective assessment of bone may be instrumental in guiding the extent of sternal debridement and optimal timing of flap coverage.

Case presentations

Case 1

In our first case, an 82-year-old male with multiple medical comorbid conditions—including hyperlipidemia, congestive heart failure, and prior myocardial infarction—underwent a coronary artery bypass (CABG) with left internal mammary artery (LIMA) and saphenous vein graft. He had a prolonged hospitalization prior to his initial discharge. Following this, he was re-admitted with purulent drainage from his sternotomy wound. He was initially taken to the operating room for sternal debridement, where he was found to have significant soft tissue necrosis. He was treated with negative pressure wound therapy for one week, and then returned to the operating room for further debridement. During the second operation, ICG angiography was performed, which demonstrated that a significant portion of his left sternum was not viable and was resected ([Video S1](#)). In this video, we

clearly demonstrate perfusion of the right half of the sternum from the intact right internal mammary artery and simultaneously decreased perfusion in the left portion of the sternum. The patient underwent bilateral pectoralis major advancement flap coverage in the same procedure, and had no post-operative wound complications.

Case 2

In the second case, a 67-year-old male with history of diabetes, hyperlipidemia, and inflammatory lung disease presented with a chronic wound in the lower portion of his incision after undergoing a CABG and double-lung transplant. He initially developed a sternal wound infection two months after CABG and double-lung transplant. At that time, he underwent sternal debridement with removal of wires. Three weeks later, he underwent bilateral pectoralis advancement flaps and was subsequently discharged. He then presented three months later with a chronic non-healing wound in the lower portion of the incision then had been managed as an outpatient with negative pressure wound therapy (NPWT). He was taken to the operating room and underwent debridement of the chronic wound, as well as ICG angiography and NPWT (Video S2). During ICG angiography, a portion of the bony sternum showed no perfusion with ICG administration, and displayed no bleeding with debridement. In this case, ICG angiography was helpful in finding ischemic bony sternum, which was likely, the cause of his chronic wound.

Discussion

Laser-assisted ICG imaging has been documented in literature to accurately predict tissue necrosis and has been widely used for various plastic surgery cases, including immediate breast reconstruction after mastectomy.¹⁰ The technology allowed poorly perfused skin to be identified and removed, and also allowed for the assessment of the patency of vascular anastomosis with small percentages of adverse reactions.^{10,11} A prospective study evaluating 62 breast reconstructions demonstrated that ICG angiography has a sensitivity of 83% and specificity of 97% in predicting flap necrosis for breast reconstruction, where false-positive test results were observed to be higher in patients who had injections of epinephrine and who smoked.¹² Laser-assisted ICG angiography has also been shown to be cost effective for patients secondary to lower wound complications and reoperations.^{10,11}

Laser-assisted ICG angiography has been clearly demonstrated to assist in the assessment of skin and muscle flaps. In this paper, we demonstrate the use of laser-assisted ICG angiography in the evaluation of the viability of bone. This information was clinically relevant in the decision-making process of the timing of pectoralis major muscle flap in one instance, and in evaluating a chronic non-healing wound in another. Laser-assisted ICG angiography provides objective data in evaluating sternal wounds which, in the future, may prove to reduce the time for debridement to muscle flap coverage.

Conflict of interest

None.

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None.

Appendix A. Supplementary data

Supplementary data related to this article can be found at <https://doi.org/10.1016/j.jpra.2017.12.002>.

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