Intraoperative Indocyanine Green Fluorescence Angiography (ICGA) for Evaluation of Tissue Perfusion in Diabetic Limb Salvage Surgery

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Statement of Purpose:

This retrospective case review will exhibit the use of intraoperative microvascular angiography to highlight the benefit of real time tissue perfusion during limb salvage surgery.

Level of evidence: IV

Literature review:

ICGA (indocyanine green angiography) has extensive use in flap evaluation, most notably in breast reconstruction (1). This imaging technology has been increasingly used in evaluation of endovascular intervention (2) and vascular trauma (3). It has also been described in oncological (4) and gastrointestinal surgery (5) to evaluate real-time blood flow to critical structures.


Figure 1


Figure 2


Figure 3


Figure 4

Imaging Technology

The ICGA microvascular imaging modality used for this study is a mobile device that includes a near-infrared laser with associated camera to display real-time perfusion to the tissues up to 5mm of depth from the surface of the skin (6). In order to obtain the images, 3-5 ml of dye is injected intravenously. The dye is water soluble, non-toxic, and binds to plasma proteins rapidly. In this respect, it is metabolized hepatically, avoiding the nephrotoxic effects of contrast dye in conventional imaging used for vascular evaluation in diabetics. Multiple administrations of the dye can be performed during one surgical case. The only major contraindication to the use of the dye is an iodine allergy (6)

Figure 5

Figure 6

Figure 7

Case Study

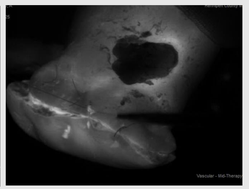
A 73 year old diabetic male with peripheral arterial disease and stage III chronic kidney disease presented with a chronic non-healing wound to his distal right foot (figure 1-2). He underwent standard preoperative vascular assessment that was consistent with ischemia. His preoperative angiography indicated several areas of stenosis and transcutaneous oximetry levels not compatible with healing. After several surgeries for infection control, the patient was still not healed and ICGA indicated poor perfusion to the amputation site (figure 3-4).
Consent was then obtained for lisfranc amputation utilizing intra-operative ICGA.

Technique:
After the amputation was performed and all apparent necrotic tissue and bone was removed (figure 6), the ICGA protocol began. The imaging device was draped using sterile technique and the imaging arm extended into the surgical field. A hyperbaric medicine physician, a hyperbaric technician, and an OR nurse were present to operate the machine. All lights were turned off and 5 ml of the ICG dye was pushed intravenously. The grayscale setting was used, with brighter white indicating good perfusion. After 30 seconds the operative foot began to fluoresce. Good perfusion was noted to the dorsal flap but hypo-fluorescense at the plantar flap indicated non-viable tissue (figure 7).
The lights were then turned on and the plantar flap was remodeled to remove any necrotic or non-viable tissue (figure 8).
The lights were again turned off and a second round of IV contrast was administered. The plantar flap was visualized again with the near-infrared camera and found to fluoresce equally as well as the dorsal flap (figure 9). The edges of the flaps were re-approximated and sutures were placed (figure 10). This is the most challenging aspect of the technique, as suturing is performed in the dark. ICGA was then used to confirm suture tension along the flap without ischemia.
Following closure of the wound, the patient had routine ICGA evaluation at post-op visits to continually evaluate perfusion to the procedure site. He remains healed at 14 months (figure 11-13).

Figure 8

Figure 9

Figure 10



Analysis and discussion

There have been several reported uses of ICGA in foot and ankle surgery for the purpose of evaluating skin perfusion intra-operatively. Minimal research exists regarding ICGA use in diabetic limb salvage surgery. Perry and Armstrong used ICGA to evaluate and debride necrotic tissue in a case of a type I diabetic with a non-healing wound with healing achieved and maintained at 12 month follow up (7). Shannon et al used ICGA to evaluate skin perfusion following ankle fracture open reduction, internal fixation in 30 patients. They were able to determine which suture method was best to obtain healing by monitoring skin perfusion in real-time (8). The limb preservation program at our institution utilizes intra-operative ICGA to firstly evaluate flap perfusion and secondly to determine ideal suture tension. If skin perfusion is adequate, equally important to the perfusion is suturing with enough tension to re-approximate the skin edges without introducing local ischemia. This technique has been used several more times by our institution with similar results. On one occasion, we have used ICGA fluorescence imaging to remove a suture causing local ischemia. This technique is indicated in the high risk, highly motivated patient who is willing to participate in limb salvage.

Figure 11

Figure 12

Figure 13

References

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