Fluorescence Angiography in the Assessment of Flap Perfusion and Vitality

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KEYWORDS

• Fluorescence angiography • Pedicle flap • Reconstruction • Free-tissue transfer

KEY POINTS

- Intraoperative Fluorescence angiography is increasingly being adopted by reconstructive surgeons for use in pedicled tissue flaps and microvascular free-tissue transfer procedures.
- The ease of use and the need for minimal amounts of equipment make it advantageous for surgical teams to use intraoperatively.
- At present, the main disadvantage of this technology is its cost; but with time and greater adoption of this technology, the cost will eventually decrease.
- Decreased postoperative complications and reduced need for revision surgery with the use of this technology will play a significant role in decreasing the overall health care costs for these complex reconstructive procedures.

Videos of fluorescence angiography accompany this article at http://www.oralmaxsurgery.theclinics.com/

INTRODUCTION

Pedicled flaps and free-tissue transfers have become invaluable tools for reconstruction of the head and neck region. These methods are used routinely to reconstruct hard and soft tissue defects, but compromised blood supply and subsequent flap failure remains a constant concern for the surgeon, particularly in free-tissue transfer. Early detection of vascular compromise and its prompt correction are thus critical to the success of these procedures.

Many intraoperative and postoperative monitoring devices have been developed to help prevent and identify vessel occlusion, with varying degrees of success. At present, the gold standard in evaluation of microvascular reconstruction remains clinical evaluation of color, turgor, bleeding, and warmth of the exposed soft tissue paddle.[1] Several noninvasive and invasive technologies have been developed to enhance the accuracy of the clinical examination, but none of these devices has been universally adopted. Noninvasive techniques include hand-held Doppler ultrasound, infrared thermography, polarized spectral imaging, and laser Doppler perfusion imaging. Invasive techniques include implantable Doppler probes, microdialysis, and venous pressure measurements with

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indwelling venous catheters. Despite the ingenuity of these novel technologies, clinical flap perfusion evaluation is still based on subjective criteria in both the intraoperative and postoperative periods. During surgery, evaluation of flow through a microvascular anastomosis has previously only been possible with the intraoperative clinical patency test (ie, strip test; **Fig. 1**), which has been reported to have a low sensitivity in the diagnosis of luminal obstruction.[2] Whether it is a pedicled flap or microvascular free-tissue transfer, early detection of vascular compromise with prompt correction still remains crucial to success of the procedure.

The ideal flap evaluation system for head and neck reconstructive surgeons would have a high sensitivity and high specificity for detecting compromised perfusion, and would have a high prognostic value for predicting vascular compromise and overall flap success. This ideal system would have the ability to distinguish between arterial and venous compromise and would also be able to predict future tissue necrosis. The introduction of intraoperative fluorescent angiography approaches the criteria listed earlier with a noninvasive, intraoperative system that is able to visualize blood flow and tissue perfusion.[3] With this system, assessment of anastomosis and vessel patency, along with soft tissue perfusion of the flap, is possible to help predict flap prognosis.

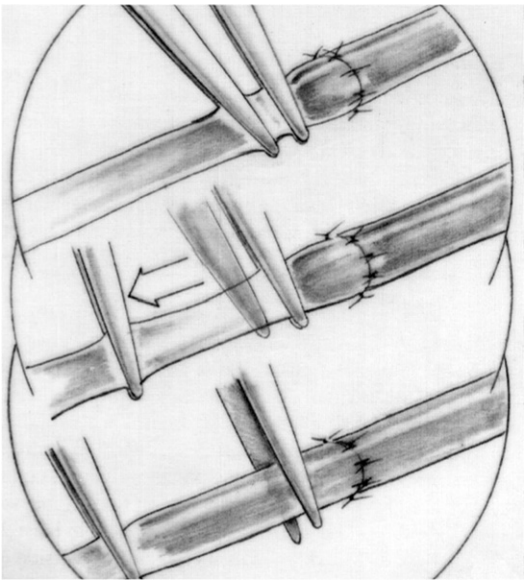

Fig. 1. The clinical patency test (strip test). To evaluate flow through a vessel, the vessel is occluded with 2 microvascular forceps downstream of the anastomosis. The distal forceps is gently moved more downstream while both forceps are still closed. The upstream forceps is then released and a patent anastomosis should allow blood to refill the area between the forceps.

INDOCYANINE GREEN ANGIOGRAPHIC IMAGING SYSTEM

Intraoperative fluorescent angiographic imaging uses the dye indocyanine green (ICG) given intravenously through a peripheral vein. ICG is a water-soluble, tricarbocyanine dye and it has been used for more than 40 years for measuring cardiac output, as a liver function test, and for fluorescent angiography of the ocular choroidea.[4] ICG dye absorbs light in the near-infrared spectral range with a maximum at 805 nm and emits fluorescence with a maximum at 835 nm. These absorption and emission characteristics are optimal in the visualization of deeper structures because the absorption of intrinsic chromophores like hemoglobin and water is low in skin. This property makes skin transparent to ICG's emitted light spectrum and it can therefore be visualized and recorded with a suitable camera. This system uses near-infrared light projected onto the target area, where it penetrates deep into the skin and acts as an excitation light to the ICG dye and induces fluorescence from blood vessels containing dye within the deep dermal plexus and subcutaneous fat, rather than the superficial dermis as when fluorescein is used. Along with the emitted spectrum of light of ICG, this allows deeper vessel imaging than with fluorescein. Detection of blood vessels at a depth of up to 2 cm from the body surface has been shown.[5]

After intravascular injection of ICG, it is bound completely to large plasma proteins, allowing complete intravascular localization of the dye. The binding of the dye to these proteins makes it a suitable tracer for assessing vessel perfusion, because no capillary leakage of the dye occurs.[6] It also has a short half-life of 3 to 4 minutes, which allows sequential monitoring of skin perfusion because previous use does not affect subsequent examinations. ICG dye is efficiently removed from the blood by the liver and excreted into the bile. The incidence of adverse reactions after intravenous injection is low, and it has no effects on blood constituents or on the hemostatic system. Usual doses used for perfusion imaging are in the range of 0.1 to 1 mg/kg; toxicity is not reached when less than 5 mg/kg is used.

There are multiple near-infrared video camera systems that can be used for ICG angiography (ICGA). These systems include the SPY Elite system (LifeCell Corporation), the IC View System, and the PDE system (both from Pulsion Medical Systems and Hamamatsu Photonics). These imaging systems all activate ICG by emitting light at the appropriate wavelength (806 nm), which excites the dye to emit light at ~830 nm. The system uses a camera with appropriate filters to