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Operative Technique

Assessment of Lymphovenous Anastomosis Patency: Technical Highlights

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INTRODUCTION

Breast cancer survivors account for nearly 3 million in the United States and represent 41% of female cancer survivors.[1] Breast cancer survival has increased over the years, reaching 91% at 5 years after diagnosis.[2] Lymphedema surgery is rising worldwide, as breast cancer survival rates increase. The lymphatic system is highly complex, and surgical techniques for correction of lymphedema include microsurgical lymphovenous bypass and lymph node transfer.[3] Several techniques have been proposed to help the surgeon visualize the lymphovenous bypass anastomosis patency (Table 1). Here, we present 2 videos showing these techniques, to verify the patency of a lymphovenous anastomosis intraoperatively.

INDOCYANINE GREEN-ENHANCED PATENCY TEST

Since its introduction by Ogata et al[4] in 2007, the lymphographic method based on fluorometric sensing using indocyanine green (ICG) dye has become the standard for preoperative and intraoperative evaluation of lymphatic circulation and patency.[4,5] The use of this system enables real-time visualization of dynamic lymph flow. ICG is not only a dye marker but also a fluorescent substance.[5] An ICG fluorescence high-sensitivity near-infrared video camera system, the Photodynamic Eye (PDE) (Hamamatsu Photonics, Hamamatsu, Japan), is used to enable detection of sentinel lymph nodes or lymphatic vessels located superficially or deep (2 cm) under the surface of the skin. The optical filtering system of the ICG fluorescence-sensitive camera is optimized to capture the near-infrared light (≈800 nm), enabling noninvasive detection of the fluorescence in deep dermal layers.

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Received for publication October 15, 2019; accepted December 17, 2019.

Plast Reconstr Surg Glob Open 2020;8:e2718; doi: 10.1097/GOX.0000000000002718; Published online 27 March 2020.

Ogata et al[4,5] tested this method in rats and humans to detect lymphatic vessels and their damage, even in a latent stage of radiation-induced lymphostasis. In 2010, Mukenge et al[6] introduced the possibility of using this system to assess the patency of lymphovenous anastomoses at several follow-up visits after lymphovenous microsurgery for treatment of secondary lymphedema in external male genital organs. The authors used PDE lymphography to objectively assess lymphatic structure and progressive improvement of patients' clinical conditions at 3, 6, and 12 months after surgery.[6] ICG fluorescence lymphangiography was performed with a bilateral injection of a bolus of fluorescent ICG, and subcutaneous fluorescence images were collected with the PDE system. The images were analyzed on a personal computer.[6]

In 2016, Maegawa et al[7] sought to determine midterm postoperative patency of lymphovenous side-to-end anastomoses using ICG fluorescence lymphography in human patients. Anastomosis patency was assessed using ICG fluorescence lymphography 6 months or more after surgery. Patency rates were calculated using Kaplan–Meier analysis. They assessed volume reduction on the operated limb and compared this between patients with patent anastomoses and those in whom anastomoses were not clearly patent.

The ICG approach for lymphangiography is efficient and safe method for patency assessment intraoperatively because it is possible to ascertain patency of the anastomosis and assess lymphatic drainage (**see Video 1 [online]**, which displays ICG-enhanced patency test). In this illustrative case, after general anesthesia was induced, 0.05 mL of ICG was injected intradermally using a 30-gauge needle into each web space of the lymphedematous limb. To better visualize the lymphatic vessels during dissection, we also injected intradermally 0.2 mL of isosulfan blue into

Disclosure: *The authors have no financial interest to declare in relation to the content of this article. This study was supported in part by the Plastic Surgery Foundation, the Mayo Clinic Center for Individualized Medicine and the Mayo Clinic Robert D. and Patricia E. Kern Center for the Science of Health Care Delivery.*

Related Digital Media are available in the full-text version of the article on www.PRSGlobalOpen.com.

This work was supported by THE PLASTIC SURGERY FOUNDATION.

Table 1. Evaluation Methods for Lymphovenous Bypass Anastomosis Patency

Authors	Method	Description	Notes
Ogata et al[4,5]	ICG-enhanced patency test (**see Video 1 [online]**, which displays ICG-enhanced patency test)	ICG is used as an optical tracer agent. ICG (0.2 mL) is injected into the web space of the limb(s). An ICG fluorescence high-sensitivity near-infrared video camera system (PDE), in which the optical filtering system is optimized, is used to capture the images. PDE is equipped with a CCD camera as a detector with a 760-nm light-emitting diode and a filter cutting light below 820 nm. The fluorescence images are digitalized for real-time display by using a standard personal computer.	Patients with a history of allergic reaction, especially to iodine, must be excluded.
Yap et al[9]	Blue dye patency test (**see Video 2 [online]**, which displays blue dye patency test)	Blue dye is injected subdermally and is taken up readily by the draining lymphatic channels. The patency of the anastomosis is also demonstrated by the dynamic pumping action of the lymphatics within the vessels.	This technique also helps confirm the success of the lymphovenous anastomosis.

CCD, charge-coupled device.

each web space, as well an additional 0.1 mL 4 minutes before the specific site dissection, 2–3 cm distal to the incision. An end-to-side anastomosis between the previously mapped lymphatic vessel and adjacent vein was conducted under microscopic magnification using 11-0 nylon suture and 50-μm needle. Future applications of ICG are currently being studied. For instance, Najjar et al[8] assessed the lymphatic drainage pattern to evaluate the reestablishment of lymphatic drainage in the transplanted nodes of rats by injecting fluorescent ICG and detecting the uptake using a PDE infrared camera.

BLUE DYE PATENCY TEST

Blue dyes, such as methylene blue and isosulfan blue, can be used to better visualize and assist with microsurgical dissection. Blue dye is a substance readily excreted, and the real-time visualization of the lymph flow improves visualization of functional lymph vessels during surgery.[9] However, rare allergic adverse reactions (0.2%–2.7%) from rash to anaphylaxis and cardiovascular collapse and death as well as skin necrosis might appear and should be considered at the moment of the procedure.[10–12] Use of the highly lymphotrophic methylene blue staining of the lymphatic vessels for lymphangiography has the advantage of an intense optical visualization of lymph flow and sensitive detection of leakages.[13] Blue dye staining during lymphovenous anastomosis is a simple and effective method for mapping suitable subdermal lymphatics, allowing for speedier dissection of the lymphatic vessels.[9]

However, if the blue dye is not used during dissection, then the detection of patency of an anastomosis can be readily assessed with its injection, which helps to confirm success of the lymphovenous anastomosis.[13] Patency is proved directly by observation of blue dye transit through the anastomosis (**see Video 2 [online]**, which displays blue dye patency test). In this case, 0.2 mL of blue dye was injected intradermally 2.5 cm distal to the incision located 1 cm distal to the wrist crease on the volar aspect of the forearm. An end-to-end anastomosis between the lymphatic vessel and adjacent vein was conducted under microscopic magnification using 11-0 nylon suture.

CONCLUSIONS

Even though blue dye does not depend on a specific video camera system, such as the PDE, to evaluate the lymph flow between vessels, both ICG-enhanced and blue dye patency tests are helpful for evaluating patency of lymphovenous bypass anastomosis due to their simplicity, accuracy, reproducibility, and safety.

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REFERENCES

1. Ganz PA, Goodwin PJ. Breast cancer survivorship: where are we today? *Adv Exp Med Biol.* 2015;862:1–8.
2. American Cancer Society. *Breast Cancer Facts & Figures 2019-2020.* https://www.cancer.org/content/dam/cancer-org/research/cancer-facts-and-statistics/breast-cancer-facts-and-figures/breast-cancer-facts-and-figures-2019-2020.pdf. Accessed September 01, 2019.
3. Granzow JW. Lymphedema surgery: the current state of the art. *Clin Exp Metastasis.* 2018;35:553–558.
4. Ogata F, Azuma R, Kikuchi M, et al. Novel lymphography using indocyanine green dye for near-infrared fluorescence labeling. *Ann Plast Surg.* 2007;58:652–655.
5. Ogata F, Narushima M, Mihara M, et al. Intraoperative lymphography using indocyanine green dye for near-infrared fluorescence labeling in lymphedema. *Ann Plast Surg.* 2007;59:180–184.
6. Mukenge SM, Catena M, Negrini D, et al. Assessment and follow-up of patency after lymphovenous microsurgery for treatment of secondary lymphedema in external male genital organs. *Eur Urol.* 2011;60:1114–1119.
7. Maegawa J, Yabuki Y, Tomoeda H, et al. Outcomes of lymphaticovenous side-to-end anastomosis in peripheral lymphedema. *J Vasc Surg.* 2012;55:753–760.
8. Najjar M, Lopez MM Jr, Ballestin A, et al. Reestablishment of lymphatic drainage after vascularized lymph node transfer in a rat model. *Plast Reconstr Surg.* 2018;142:503e–508e.
9. Yap YL, Lim J, Shim TW, et al. Patent blue dye in lymphaticovenular anastomosis. *Ann Acad Med Singapore.* 2009;38:704–706.
10. Mansouri R, Chicken DW, Keshtgar MR. Allergic reactions to patent blue dye. *Surg Oncol.* 2006;15:58.
11. Woltsche-Kahr I, Komericki P, Kränke B, et al. Anaphylactic shock following peritumoral injection of patent blue in sentinel lymph node biopsy procedure. *Eur J Surg Oncol.* 2000;26:313–314.
12. Lee JH, Chang CH, Park CH, et al. Methylene blue dye-induced skin necrosis in immediate breast reconstruction: evaluation and management. *Arch Plast Surg.* 2014;41:258–263.
13. Wallmichrath J, Baumeister RG, Deglmann CJ, et al. Technique and proof of patency of microsurgical lympho-lymphonodular anastomoses: a study in the rat model. *Microsurgery.* 2009;29:303–309.