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# Distal- to- proximal sequential ICG injection technique (DOPSIT) for lymphatic vessels mapping

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## Abstract

Supermicrosurgical lymphaticovenular anastomosis (LVA) is the most sought-after procedure among lymphedema patients. However, the same enthusiasm is currently not shared among lymphedema surgeons due to the lackluster results of LVA. The common unfavorable experience with this famed procedure is at least partially caused by the difficulty in finding the lymph vessels. We share our time-tested indocyanine green-based lymph vessel mapping technique, which has helped us establish LVA as our procedure for all fluid-predominant lymphedema.

**Keywords:** ICG lymphography, ICG flow, linear patterns, lymphatic mapping, multipoint injection, multilevel injection, advanced lymphedema

## INTRODUCTION

With recent technical breakthroughs, supermicrosurgical lymphaticovenular anastomosis (LVA) is no longer limited to early lymphedema[1-4]. However, performing LVA in late disease is frequently challenging due to difficult lymphographic identification of the functioning lymph vessels. Classically, indocyanine green (ICG) lymphographic mapping is performed with 2 to 3 injections of the fluorophore in hands and feet. The "linear" patterns observed immediately post-injection are identified as targets for LVA. In late

lymphedema, lymphatic stasis and unfavorable pressure gradients may prevent visualization of healthy lymph vessels even when they are present. Based on our observation, the classic ICG injection technique has resulted in many patients being unnecessarily declared as poor LVA candidates, due to the scant visualization of lymph vessels. In this article, we share our ICG lymphographic mapping technique[5], which is time-tested and has helped us achieve successful LVA reconstruction in many difficult cases.

## TECHNIQUE

The procedure begins with intradermal injection of two to three dorsal web spaces of the ipsilateral hand/feet using 0.1 cc of 0.25% indocyanine green per injection point. This is followed by a gentle massage at the injected sites for 2 minutes. A near-infrared, fluorescence camera system is then used for visualizing the real-time spread of ICG. The course of the identified lymphatic vessels is then marked on the skin. Another row of ICG injections is given at the ankle/wrist level and the resultant change in lymphatic patterns is marked. This process is repeated at 15 cm (10 cm in upper limb) intervals along the extremity till the popliteal fossa/ cubital fossa is reached. Each level includes a row of multiple injection points, 3 to 4 cm apart, along the anterior and medial part of the limb circumference. The lymphatics pattern generated from these different injection levels is marked with different colors in Figure 1 to distinguish their origins. This distal-to-proximal sequential ICG injection technique (DOPSIT) is demonstrated step by step in Supplementary Video.

## DISCUSSION

In our lymphedema clinic, we most commonly hear from our patients, "I want LVA. I don't want any other surgery!" The popularity of LVA stems from its capability to treat a bothersome, disabling condition with minimal invasiveness. Indeed, in comparison to vascularized lymph node/vessel transfers (VLNT/VLVT), LVA is conceptually benign and is free of the risk of causing donor-site lymphedema[3]. Interestingly, LVA's popularity among patients is not replicated among surgeons. In North America, VLNT remains the most commonly offered/performed lymphedema reconstruction. Why?

Many factors go into successful and efficacious LVA, including but not limited to patient selection, preoperative optimization, proficiency in supermicrosurgery, number of anastomoses, choice of anastomotic configuration, and postoperative care[6,7]. Among these, the ability to identify all available lymph vessels is crucial. After all, without the "L", there would be no LVA. LVA has been our go-to technique for all cases of fluid-predominant lymphedema. After overcoming our learning curve, we have found LVA to be technically straightforward, effective, and gratifying for both the patient and the surgeon. One of the keys to our procedural success is the ICG lymphographic mapping using DOPSIT. This technique allows us to identify more viable lymph vessels than achievable with the classic injection technique, leading to the creation of more functioning lymphatic drainage pathways in both upper and lower limbs.

In severe disease, unfavorable lymphatic pressure gradients can be such that, despite the use of DOPSIT, no lymph vessels are detectable. In this challenging scenario, the lymph vessels can usually be found by making incisions over veins mapped using an infrared vein finder. This technical trick takes advantage of the anatomic fact that superficial lymphatic anatomy loosely approximates that of superficial venous anatomy. In the unfortunate scenario of failure to image both the lymph vessels and the superficial veins, the lymph vessels can still be uncovered with the so-called "blind/anatomic" approach, based on a detailed knowledge of the superficial lymphatic system - how the lymph vessels are distinctly clustered in certain anatomic segments[5,8].

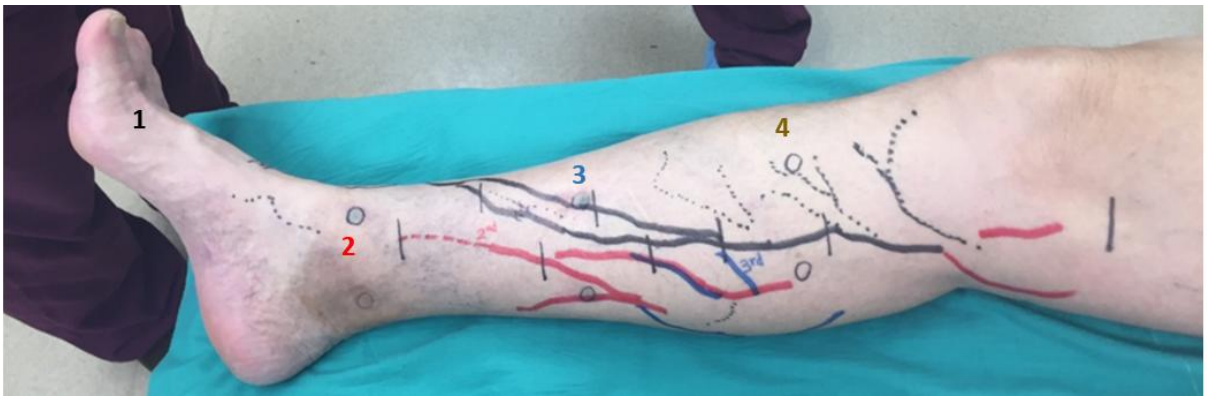


**Figure 1.** ICG lymphography-mapped lymphatics are shown in the lower extremity after sequential rows of injections (circles) were given on the anterior and medial surfaces. The injection row levels have been numbered from distal to proximal. The pattern in black originated from row 1 (webspace level), and the pattern in red originated from row 2 (ankle level). Part of the ICG injected at row 2 entered the same channel highlighted by the row 1 injection and lengthened it further proximally. The pattern arising from row 3 (distal calf) injection is marked with blue lines and is seen overlapping partially with the level 1 and level 2 patterns. The highest level of injection points at 4 (proximal leg) did not show any further linear patterns, and since this was close to the popliteal fossa, no further injections were necessary.

In patients with advanced lymphedema, the dermal backflow results from reflux of lymph/ICG from collectors into the precollectors (valved) and lymph capillaries (valveless). This reflux may not be apparent immediately after injection, but the poor flow gradient hinders the forward flow of ICG injected distal to such zones. This will be seen as interrupted linear pattern in ICG lymphography. To allow ICG to re-enter the lymphatic channels and resume antegrade flow, it is injected anatomically proximal to such an area of linear pattern interruption [Figure 2][9].

In keeping with the lymphosome theory, multiple, distal-level injection techniques have been described by some authors to include more lymhosomes[8,10-12]. However, within the length of a given lymphosome, there can be segments of unfavorable flow. Our technique allows the inclusion of all relevant lymphosomes as well as overcomes barriers to ICG antegrade flow within a lymphosome by injecting both distal and proximal to it.

## CONCLUSION

The described distal- to- proximal sequential ICG injection technique (DOPSIT) enhances the intraoperative lymphatic mapping capability of ICG lymphography and facilitates successful LVA.

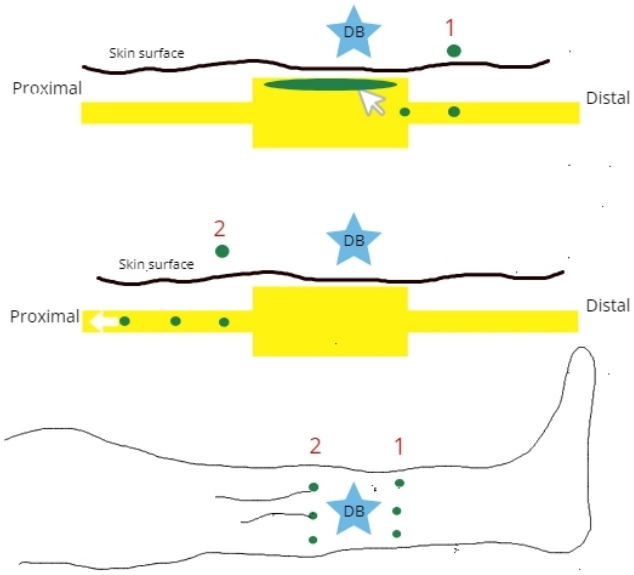


**Figure 2.** An illustration of a leg and its sagittal cross section showing the difference in the flow of injected ICG at levels 1 and 2, which are respectively distal and proximal to dermal backflow (DB)/zone on unfavorable pressure gradient. The green dots depict the ICG and the white arrows show the direction of ICG flow. A single collector channel in yellow is shown in each image for simplification, with widened central part representing the zone of unfavorable pressure gradient. Injection at level 2 bypasses this zone and ICG resumes antegrade flow.

## DECLARATIONS

### Authors' contributions

Created the technique and conceptualized this article: Chen WF
Designed the article and figures: Pandey SK

### Availability of data and materials

Not applicable.

### Financial support and sponsorship

None.

### Conflicts of interest

All authors declared that there are no conflicts of interest.

### Ethical approval and consent to participate

Not applicable.

### Consent for publication

Not applicable.

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