

# Video Tutorial for Indocyanine Green Lymphography in Lymphatic Surgery

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## INTRODUCTION

An accurate diagnosis for patients with lymphedema is crucial for treatment and surgical management. Lymphedema can be diagnosed with medical history, a physical exam, limb measurements, and medical imaging.<sup>1,2</sup> There are many methods to evaluate lymphedema such as circumference measurements, volumetry, lymphoscintigraphy (LS), computed tomography, photon emission computed tomography, magnetic resonance imaging (MRI), MRI lymphangiography, and indocyanine green (ICG) lymphography.<sup>3–11</sup> ICG is a fluorescent cyanine dye that remains within the blood and lymphatic vessels due to its high rate of binding to plasma proteins and therefore low extravasation rates. Thus, ICG is ideal for visualizing superficial lymphatic vessels when stimulated with fluorescent and laser light. ICG lymphography has a unique ability in demonstrating the structural disorders of lymph nodes, and it has a high accuracy in evaluating lymphedemas and lymphatic flow disorders.<sup>12</sup> Mihara et al. found that MRI and ICG lymphography were superior to LS or computed tomography for the diagnosis of lymphedema. They suggest dual diagnosis by examination of the lymphatic system using ICG lymphography and evaluation of edema in subcutaneous fat tissue using MRI. Furthermore, Mihara et al. showed that ICG lymphography is superior to LS for diagnostic imaging of early lymphedema of the upper limbs.<sup>13</sup>

ICG lymphography is suitable for preoperative, intraoperative, and postoperative lymphatic flow evaluation.<sup>9</sup>

As a result of this, Yamamoto et al. categorized ICG lymphography patterns into a normal linear pattern and 3 abnormal dermal backflow (DB) patterns.<sup>8–10</sup> Typically, as the severity of lymphedema increases, the findings change from a typical linear pattern to a splash pattern (mild DB), followed by a stardust pattern (moderate DB) and a diffuse pattern (severe DB).<sup>8,10</sup>

Although there are numerous studies on ICG imaging and different spreading patterns of ICG, to our knowledge, there is no published video tutorial on ICG injection and ICG lymphography so far. This video tutorial for ICG lymphography provides an educational tool for young and inexperienced plastic surgeons to learn about the procedure. Additionally, this video tutorial is helpful for experienced plastic surgeons to improve their skill level in the intraoperative use of ICG lymphography for planning and confirmation of supermicrosurgical lymphaticovenous anastomosis (LVA).

## METHODS

In this video tutorial, the procedure of ICG injection and ICG lymphography for clinical evaluation is shown (See Video, [online], which displays the procedure of ICG injection and ICG lymphography for clinical evaluation) For ICG injection, 25 mg of ICG sterile lyophilized powder (Diagnostic Green GmbH) is mixed with 10 mL of distilled water. In this video, 1 mL of ICG solution with a concentration of 2.5 mg ICG is used for injection. For each point of injection, about 50–100 µL is injected to the intradermal layer and in the subcutaneous fat. Injection points can be varied based on lymphedema status. We injected into interdigital space 1–2 toe and 4–5 toe. Kodan forte was used for skin disinfection.

## DISCUSSION

ICG lymphography is a safe, minimally invasive, and simple examination that enables a real-time assessment of lymphatic vessel function and reflects the severity of lymphedema. Characteristic ICG lymphography patterns are consistent with the clinical conditions and can be

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categorized into 4 patterns. These 4 patterns are shown in the video. In the first sequence of the video, we can see a linear pattern as a linear fluorescent image of the lymphatic collectors, which demonstrates a normal lymph flow. In the following sequences, abnormal lymph flows called DB patterns are shown. These patterns change from splash to stardust and finally to diffuse patterns as the severity of the lymphatic disorder increases. These patterns correlate with clinical severity. With this, the lymphedema pathophysiological stage can be evaluated.

Furthermore, several studies demonstrated that ICG lymphography is a useful tool to find lymphatic vessels during LVA.<sup>9,14–16</sup> Yamamoto et al. showed in a considerable number of anastomoses that LVA should not be performed in regions with a diffuse pattern. Thus, the characteristic ICG lymphography patterns could be useful to determine the timing and exact location to perform LVA.<sup>9,14</sup>

**Annotation:** ICG has been approved for use in intravenous applications. Injection of ICG into skin or subcutaneous tissue is an off-label use.

## CONCLUSIONS

This video tutorial demonstrates ICG injection as well as the different ICG lymphography patterns: linear, splash, stardust, and diffuse patterns. Also, the given explanations should clarify the possibilities of ICG lymphography. With the correct interpretation of the ICG patterns, it is possible to not only diagnose lymphedema in general but also to classify it into stages. Furthermore, ICG lymphography is a vital tool for intraoperative use, such as planning the incision for a supermicrosurgical LVA and confirming the patency of an LVA.

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