

# Lymphofluoroscopy

A valuable tool to monitor decongestive treatment and enhance care

Fluorescent dyes and cameras are effective examination and treatment tools

By JP Belgrado

There has been much discussion regarding the use of ICG fluoroscopy in the management and diagnosis of lymphedema. This short paper will explain reasons for its use and application in clinical practice.

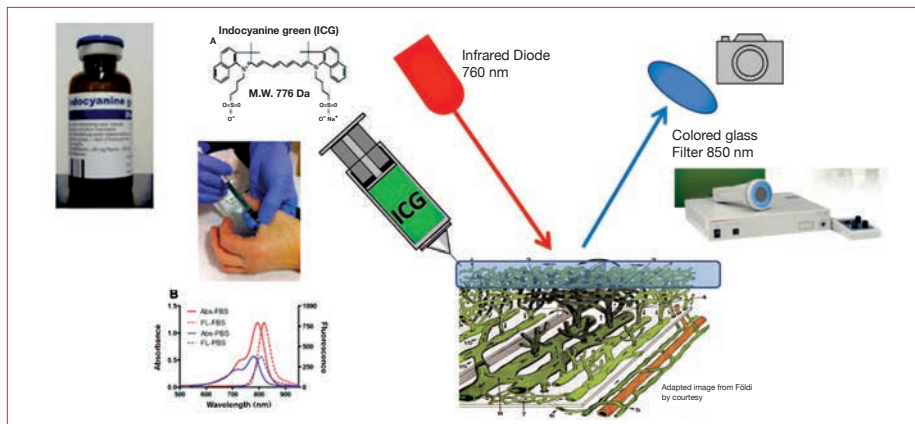
The quest for imaging of the superficial lymphatic network using contrasting products started over 200 years ago. However, due to the specific physiological structure, fragility and size of the lymphatic vessels, researchers have always had difficulty finding a specific tracer that might be sensitive and specific enough for lymphatics and was also minimally invasive, affordable and suitable for in vivo examinations.

Indocyanine Green (ICG) is a well-known fluorescent dye that has been used in angiology, cardiology and hepatology for

many years. More recently, it has been applied to lymphology. This complements the collection of lymphatic imaging tools to study lymphedema and the superficial lymphatic system in humans.

For the first time, ICG Fluoroscopy provides us the ability to visualize the lymphatic system in real time. Through the use of a specific camera equipped with infrared diodes and adapted filters, the lymphatic architecture and propulsion can be seen. In addition, the pathway of the drainage of the lymph or failings of the system can also be recognized.

This report draws on the conclusive experience of over 700 lymphofluoroscopyes, carried out during the examination of primary and secondary lymphedema, as well as on healthy subjects.

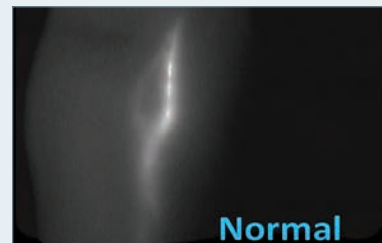
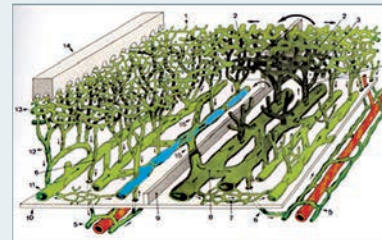
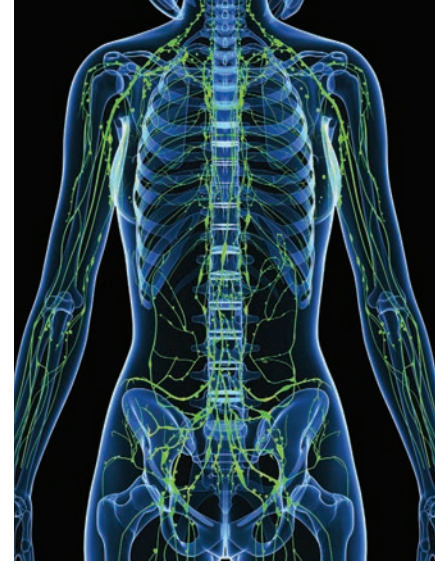


Desmetre, Devoisselle JM, and M.S., Fluorescence properties and metabolic features of indocyanine green (ICG) as related to angiography. *Surv Ophthalmol*, 2000. 45  
Mordon, S., et al., Indocyanine green; physicochemical factors affecting its fluorescence in vivo. *Microvasc Res*, 1998. 55(2):p. 146-52

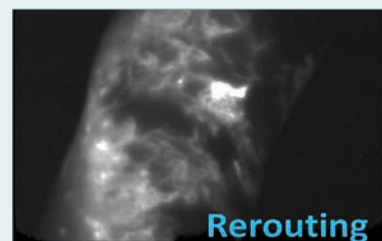
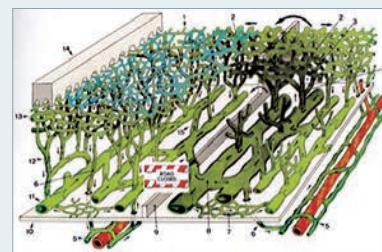


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**Normal**  
Initial lymphatic network is not visible, it drains normally into functional lymphatic collectors which are visible.



**Rerouting**  
When lymphatic collectors are not functioning, lymph moves towards the initial lymphatics enlarging the vessels and making them visible.

**Indocyanine Green (ICG) is a well-known fluorescent dye that has been used in angiology, cardiology and hepatology for many years. More recently, it has been applied to lymphology.**

This minimally invasive examination consists of an intradermal injection of a small volume of highly diluted ICG (0.2mg). This is usually injected in the webbed spaces of the hand or foot depending on the area to be examined. The dye binds with the local lipoproteins (LP), albumin and fluid that are localized in the interstitium (the place the edema is situated) and then reaches the lymphatic circulation.

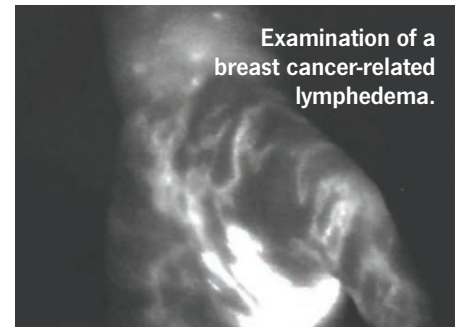
During the examination, a camera is used that emits an infrared light, and this excites the couple ICG-LP. In this condition, ICG-LP,

diluted into the water of the lymph, becomes fluorescent. At this point, the lymphatic network is revealed to the camera. The signal is filtered and amplified and shows dynamic images of the lymphatics on a screen which can be recorded as necessary.

Immediately following the injection, the lymphatic system at the injected area starts to become visible—the lymphangions are able to be seen pumping, and as time progresses, the entire superficial lymphatic network, connected with the injected area and its superficial lymph nodes becomes visible.

The whole topography of the superficial lymphatic network of the injected anatomical region appears as a dynamic route map that provides valuable information to understand the personal situation of each individual. With this knowledge the therapeutic choice can then be customized.

The anatomical regions that are involved in an edema and where the lymph collectors are not functioning are clearly highlighted:



the rerouting of the lymph that flows through the initial lymphatics appears as a very dense, tortuous and small vessel network. Functional vessels appear as straight lines. The efficiency of valves can be tested and the contractility of the lymphangion is perfectly visible. Dedicated software allows for the measurement of the mean velocity of the lymph flow into the lymph collectors (how well the lymphatics are functioning/draining).

When the normal lymphatic pathways do not work, the fluid and macromolecules are redirected to other functional territories to be drained. This specificity is also visible

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during the exam. This provides information to the therapist to change the direction of the manual lymphatic drainage. The image on page 10 (examination of a breast cancer-related lymphedema) shows that fluid on the dorsum of the hand reaches the palm, which is not the usual anatomical pathway.

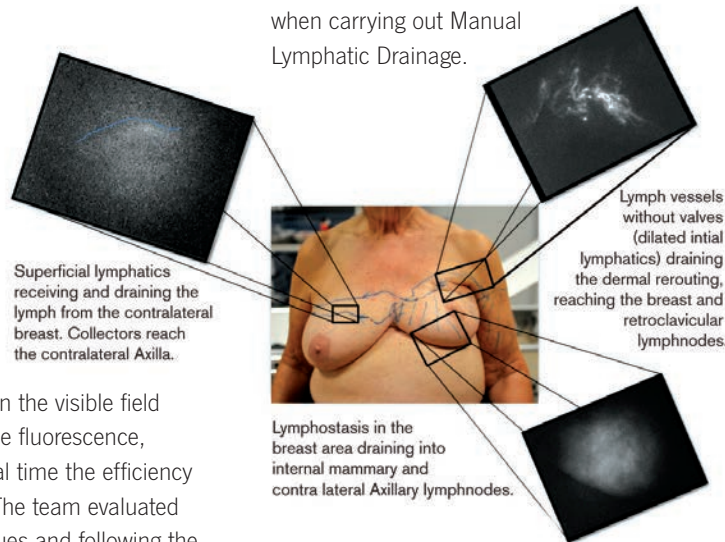
In addition to the functional information, fluoroscopy shows substitution pathways. Substitution pathways are the drainage routes taken by the fluid to drain if another area fails or is blocked. These pathways can be drawn on the patient's skin during the examination to provide details in order to customize the MLD treatment protocol for each individual patient (see photographs).

NIR Fluoroscopy has helped us to optimize manual lymphatic drainage techniques: using a double camera, one in the visible field and the second on the fluorescence, we can observe in real time the efficiency of each manoeuver. The team evaluated existing MLD techniques and following the feedback of fluoroscopy have developed an optimized technique which has demonstrated moving more fluid faster and more effectively. This technique is now being used at the University of Brussels physiotherapy training, and is being rolled out globally through the Lymphoedema Training Academy. After the emptying of the lymph nodes, the technique consists of two main manoeuvres of clearing the lymphatics with the 'flush' manoeuver and filling the collectors with the 'fill' manoeuver. This method of MLD will be known as the 'Fill and Flush' method or Fluoroscopy Guided Manual Lymphatic Drainage (FG-MLD) and has taken many years to refine following the mapping of the lymphatics.

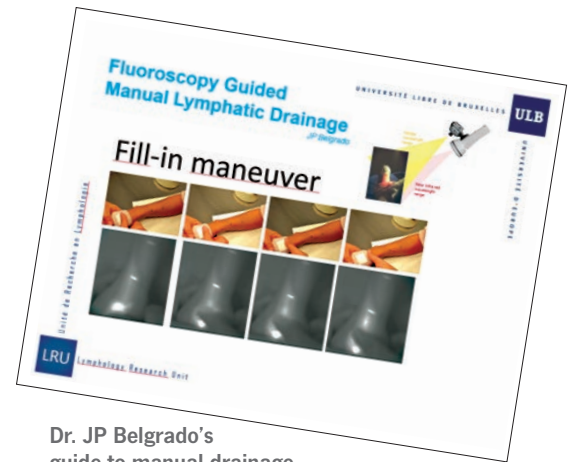
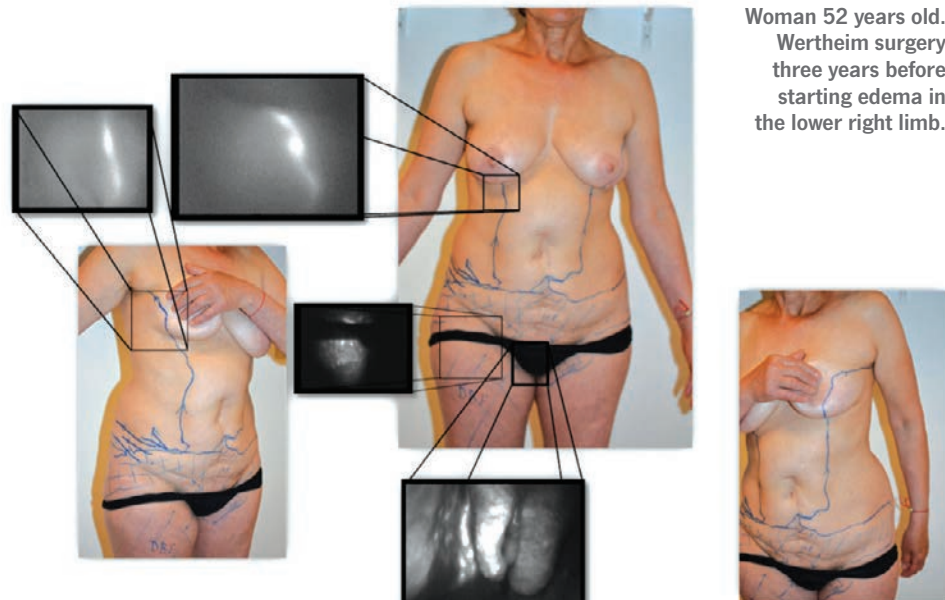
Fluoroscopy has also been used to study intermittent compression therapy, where we performed studies with customized transparent sleeves to allow the flow to be visualized.

The effects of multicomponent bandages have been studied using lymphofluoroscopy. The tracer's progression is observed and

recorded during the drainage from differing therapies. It is possible with this technique to observe the effects of diverse physical treatments such as different manual lymphatic drainage methods, intermittent compression therapy, multicomponent bandages or effect from wearing garments. More recently, fluoroscopy helped us to define the occlusion pressure of superficial lymphatics, which is a slightly higher pressure than previously believed. It provides evidence that leads us to understand that we can use more pressure when carrying out Manual Lymphatic Drainage.



The use of fluoroscopy imaging is changing the focus of lymphedema management and offering improved care pathways. This basic outline of its uses demonstrates the major advantage of this imaging technique



Dr. JP Belgrado's guide to manual drainage.

is the possibility to observe, in real-time, fluid movements from the interstitial space to the lymphatics; lymph propagation velocity, contraction rate, kinesiology of the lymphangions and mapping of substitution pathways. It allows for the detection of subclinical lymphedema.

In lymphedema, "ectopic" lymph nodes, which are not described in the literature, can be highlighted giving valuable data to optimize the treatment protocol.

Lymph nodes share the drainage of different anatomical territories. When the pressure increases in a lymph node, because it cannot drain itself to the consecutive lymph node (adenectomy or lymphatic impairment of the downstream network), and because one of afferent lymph collectors continues to pump

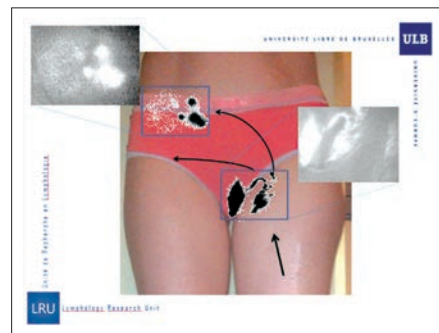


**NIRF to improve the knowledge about intermittent Compression Therapy related to lymphatic system and develop new concepts.**

lymph into it, the lymph is “rerouted” to one or more of its afferent lymph collectors instead of to the efferent lymph collector. The reflux of lymph coming from the lower limb into the collectors that drain the labia majora is one example of this characteristic. Lympho fluoroscopy allows us to identify that reflux before the labia start to swell, then possibly to surgically clip the collectors, impeding the reflux. We perform this simple surgery in our lymphology clinic with encouraging results (top right picture).

In addition, in the operating room, lymphofluoroscopy used pre-operatively protects the lymphatic vessels and nodes during surgery by identifying them more clearly.

In conclusion, patients, surgeons and therapists are finding possibilities in this emerging tool to expand their visual spectrum in the field of near infrared. Improving knowledge in lymphology, mapping of the superficial lymphatics provides a view of the individual pathways used and therefore can lead to improvements



**Near Infrared Fluorescence Imaging showing the superficial substitution lymphatic pathways after the intradermal injection of the ICG.**

in application of MLD. It may prevent secondary lymphedema in high-risk patients, by helping surgeons to easily find and protect the lymph nodes and lymph collectors that drain the limb. **LP**

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**Editor’s Note:**

Fluoroscopy at the moment is a research tool and not used in regular practice in Canada.



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