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The use of a microscope with near-infrared imaging function in indocyanine green lymphography and lymphaticovenous anastomosis☆

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Summary *Background:* Indocyanine green (ICG) lymphography has become an important investigation in lymphaticovenous anastomosis (LVA). Near-infrared (NIR) imaging systems are available in the market for the production of ICG lymphography. These machines, however, may be difficult to obtain owing to their costs. In our institute, these NIR imaging devices are not available. Alternatively, microscopy with NIR imaging function was used for LVA. The experiences of the production of ICG lymphography with an NIR microscope are described.
Methods: For the production of preoperative ICG lymphography, ICG solution was injected subdermally to the web spaces of the lymphoedema limb. The NIR mode of the microscope was used for the lymphatic mapping. Black and white images and videos of the ICG lymphography were then produced. Intra-operatively, the NIR function was used for the localisation of lymphatic vessels and confirmation of the patency of the LVA.
Results: Between February 2013 and May 2013, 24 ICG lymphographies were performed in 20 female patients as a preoperative investigation for LVA. All four ICG lymphography patterns (linear, splash, stardust and diffuse patterns) were demonstrated.
Conclusions: In institutes where NIR imaging devices are not available, we believe that a microscope with an NIR imaging function is a reasonable alternative for the production of ICG lymphography.

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Lymphaticovenous anastomosis (LVA) is an established treatment for early stage lymphoedema. The success of LVA mainly depends on the availability of functional lymphatic vessels, their accurate localisation and the expertise of making anastomoses between submillimetre lymphatic vessels and veins.

The skill of anastomosing submillimetre vessels can be mastered through practice in an animal model. The amount of functional lymphatic vessels remaining in the lymphoedema limb for anastomosis is mainly determined by the stage of the lymphoedema. Generally, the earlier is the stage of lymphoedema, the more functional lymphatic vessels remain in the limb.

In the authors' opinion, the most unpredictable factor in the success of LVA is the localisation of lymphatic vessels. A great amount of the operation time is usually spent in searching for lymphatic vessels. Further, it is also not uncommon that lymphatic vessels could not be found in the operation field. The uncertainty in localising lymphatic vessels can be reduced if lymphatic mapping can be performed accurately before operation.

Owing to poor image resolution, conventional lymphatic imaging studies (e.g., lymphoscintigraphy and lipiodol lymphangiography) give no information on the location of lymphatic vessels. In the recent 10 years, indocyanine green (ICG) lymphography has been studied extensively as a novel imaging modality for modern lymphoedema surgery. Since the lymphatic vessels can be localised accurately with this study, ICG lymphography has quickly become an important investigation for LVA.

Due to the increasing demand for ICG lymphography, several near-infrared (NIR) imaging systems which are designed specifically for ICG lymphography have been brought to the market. However, these systems may not be readily available in every centre owing to their costs and lack of Food and Drug Administration (FDA) approval.

The above-mentioned NIR imaging systems are not available in our centre. A microscope with NIR imaging function was used preoperatively to produce lymphatic mapping and intra-operatively for LVA. Our experiences of using an NIR microscope for LVA are described in the following case series.

Methods

In our division, ICG lymphography was performed as a preoperative investigation for all lymphoedema patients who wished to undergo LVA.

For upper limb cases, 0.2 ml of 0.5% ICG solution (Diagnogreen, Daiichi Pharmaceutical, Tokyo, Japan) was injected subdermally to the second and third web spaces of the hand and the medial and lateral sides of the volar surface of the wrist. For lower limb cases, the ICG solution was injected to the first and third web spaces of the foot and the medial and lateral sides of the Achilles tendon. The injection was performed 60 min before the lymphangiography. The patients were instructed to massage the injection sites to help the dispersion of the dye.

A microscope with an NIR imaging function (Leica FL800, Leica Microsystems (Schweiz) AG, Germany) was used for lymphatic mapping. The procedure was performed in the operation theatre. Similar to ordinary microsurgery, the focus was placed over the concerned limb. The whole width of the limb was completely captured inside the microscope video monitor. The NIR function was then switched on and ICG lymphography was performed. The intensity of the light source was set to around 50—60%; this helped the production of better quality black and white images/videos of the lymphography.

After ICG lymphography, LVA was suggested only to the patients with favourable ICG patterns: linear and splash patterns.

Patients

Between February 2013 and May 2013, 20 patients received ICG lymphography as a preoperative investigation for LVA. Their mean age was 59 years (range = 38—78 years). All were females who developed lymphoedema secondary to cancer and its treatment, that is, breast cancer and gynaecological cancer. The mean duration from the onset of lymphoedema to the ICG lymphangiography was 8.1 years (range = 1—16 years).

There were 16 patients with unilateral lymphoedema and four patients with bilateral lymphoedema. Of the four patients with bilateral lymphoedema, one patient had bilateral upper limb lymphoedema and three had bilateral lower limb lymphoedema. A total of 24 limbs were studied, which included 12 upper limbs and 12 lower limbs.

The International Society of Lymphology's (ISL) staging system was adopted in this study.[1] For the 12 upper limb cases, 10 were ISL stage II and two were ISL late stage II. For the 12 lower limb cases, two were ISL stage I, seven were ISL stage II and three were ISL late stage II. None of the patients received surgical treatment for lymphoedema before the ICG imaging study.

Results

A total of 24 ICG lymphographies were performed. For the description of the ICG lymphography patterns, we adopted the ICG staging system published by Yamamoto et al. The patterns include one linear pattern and three dermal backflow patterns, that is, splash, stardust and diffuse patterns, in the order of the advancing stages of lymphoedema.[2]

In this study, all four patterns of ICG lymphography were demonstrated (Figure 1). In 21 limbs, more than one ICG pattern was observed, while a pure diffuse pattern was observed in three limbs. The earlier stage of ICG pattern almost always occurred at the more distal part of the limb. When moving proximally in the limb, the ICG pattern progressed to more advanced stages.

The linear pattern was identified in four limbs, the splash pattern in 10 limbs, the stardust pattern in 18 limbs and the diffuse pattern in 20 limbs. There were 13 limbs showing linear or splash patterns in the ICG images, including six upper limbs and seven lower limbs. For the six upper limb cases, the visualised lymphatic vessels were found at the dorsal surface of the hand, the radial side of the volar surface of wrist extending to the distal forearm. We observed that scattered short lymphatic vessels were usually present at the volar surface of the elbow even in the background of a dermal backflow pattern (Figure 2). For the seven lower limb