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FLUORESCENCE IMAGING CAPABILITIES IN SECONDARY LYMPHEDEMA FOLLOWING COMPREHENSIVE TREATMENT OF MALIGNANT NEOPLASMS: A CASE SERIES

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ABSTRACT

Background. Secondary upper limb lymphedema is a complication of multimodal treatment for malignant neoplasms associated with damage to the regional lymphatic system. Indocyanine green (ICG) fluorescence lymphography enables real-time visualization of superficial lymphatic vessels and assessment of lymphatic drainage patterns. However, data on fluorescence patterns in secondary lymphedema of different oncological etiologies and their clinical significance remain limited.

Objective. To evaluate the diagnostic potential of ICG fluorescence lymphography for detecting and characterizing lymphatic drainage abnormalities in female patients with secondary upper limb lymphedema following multimodal treatment for malignant neoplasms.

Materials and Methods. A case series of 10 female patients with secondary upper limb lymphedema following treatment for breast cancer (n = 7), melanoma (n = 2), and cutaneous squamous cell carcinoma (n = 1) was analyzed. The duration of lymphedema before examination ranged from 3 months to 2–3 years. All patients underwent ICG fluorescence lymphography.

Results. Fluorescence lymphography revealed four lymphatic drainage patterns: a linear pattern and three types of dermal backflow, namely splash, stardust, and diffuse patterns. The characteristics and extent of fluorescence abnormalities reflected the underlying alterations in lymphatic drainage. Visualization of preserved lymphatic collectors enabled identification of their anatomical location and potential sites for lymphovenous anastomosis.

Conclusion. ICG fluorescence lymphography enabled characterization of lymphatic drainage abnormalities and visualization of preserved superficial lymphatic collectors. The findings demonstrated the potential utility of this technique for assessing lymphatic dysfunction, individualizing treatment strategies, and facilitating preoperative planning of lymphovenous anastomosis.

Keywords: secondary lymphedema; fluorescence lymphography; indocyanine green; breast cancer; lymphatic drainage; dermal backflow; lymphovenous anastomosis.

INTRODUCTION

Secondary upper limb lymphedema is a chronic condition caused by impaired lymphatic transport and the accumulation of interstitial fluid in the tissues. A major cause is injury to the regional lymphatic system during cancer treatment, particularly following lymph node dissection and radiotherapy. As the condition progresses, edema may be accompanied by fibrosis of the skin and subcutaneous tissue, impaired limb function, and reduced quality of life. The extent of these structural changes varies across disease stages, underscoring the importance of timely diagnosis of lymphatic dysfunction [1, 2].

Upper limb lymphedema following breast cancer treatment has been studied most extensively. However, impaired lymphatic drainage can also occur after treatment of other malignancies involving the regional lymph nodes and lymphatic pathways. Clinical assessment of lymphedema includes physical examination, measurement of limb circumference or volume, and evaluation of soft tissue changes. These measures are essential for patient monitoring, but they do not, on their own, identify the location of preserved lymphatic vessels or characterize lymphatic transport [1, 2].

Imaging of the lymphatic system complements clinical assessment and provides information relevant to treatment planning. Available modalities include lymphoscintigraphy, magnetic resonance lymphography, ultrasonography, and fluorescence lymphography using indocyanine green (ICG). These methods differ in imaging depth, the type of information they provide, and their capacity for anatomical mapping. ICG lymphography enables real-time visualization of fluorescent tracer movement through the superficial lymphatic network. Its principal limitation is the inability to fully assess deep lymphatic structures [2, 3].

The clinical value of ICG lymphography in secondary upper limb lymphedema is supported by studies of early lymphatic dysfunction. Mihara et al. showed that, in some patients with early upper limb lymphedema, ICG lymphography detected abnormalities that were not identified by lymphoscintigraphy. The authors also emphasized the value of assessing the lymphatic system alongside changes in subcutaneous adipose tissue [4]. These findings do not establish that ICG lymphography is universally superior to other modalities; the choice of imaging method depends on the diagnostic question and the depth of the structures of interest.

The fluorescence pattern is central to the interpretation of ICG lymphography. A linear pattern indicates visualization of lymphatic collectors. Impaired lymphatic transport may produce dermal backflow patterns, classified as splash, stardust, and diffuse. Yamamoto et al. proposed a staging system for upper limb lymphedema based on the type and extent of these changes [4]. Whereas clinical staging assesses the condition more broadly, fluorescence imaging characterizes the visible

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pattern of superficial lymphatic transport. The two approaches should therefore be considered complementary.

Dynamic ICG lymphography provides further information about lymphatic transport. In patients with breast cancer–related arm lymphedema, Yamamoto et al. used dynamic imaging to assess lymphatic transport function [4]. Narushima et al. systematized ICG lymphographic findings in limb lymphedema, supporting more consistent descriptions of pathological fluorescence patterns [6]. Together, these studies support assessment of both the presence of dermal backflow and the distribution of visible lymphatic collectors.

One clinical application of ICG lymphography is lymphatic vessel mapping before microsurgical treatment. When planning lymphovenous anastomosis, it is important to identify the location of potentially suitable lymphatic collectors. Gentileschi et al. investigated preoperative mapping of lymphatic pathways in the affected upper limb using the contralateral unaffected limb for comparison [7]. Woo et al. described variations in the distribution of superficial upper limb lymphatic pathways and their relationship to sites of lymphatic obstruction [8]. A systematic review by van Heumen et al. identified lymphatic vessel imaging as a component of surgical planning for lymphedema [3].

Thus, ICG lymphography is valuable both for detecting pathological fluorescence patterns and for mapping preserved superficial lymphatic collectors. Most primary studies of upper limb lymphedema have involved patients treated for breast cancer [4–6]. Examining cases of lymphedema following treatment for malignancies of different origins may further characterize the observed patterns of lymphatic dysfunction and the potential role of imaging in treatment planning.

Objective: To assess the ability of indocyanine green fluorescence lymphography to detect and characterize impaired lymphatic drainage in patients with secondary upper limb lymphedema following multimodal treatment for malignancy.

MATERIALS AND METHODS

Study design and patient characteristics. A prospective descriptive case series was conducted between January and August 2026. The study included 10 women with secondary upper limb lymphedema following multimodal treatment for malignancy. Seven patients had a history of breast cancer, two had upper limb melanoma, and one had cutaneous squamous cell carcinoma of the upper limb. Depending on the underlying malignancy and clinical circumstances, prior anticancer treatment comprised various combinations of surgery, regional lymph node dissection, radiotherapy, and systemic therapy.

At the time of assessment, two patients had stage I lymphedema, three had stage II, and five had stage III. The interval from the onset of lymphedema to fluorescence lymphography ranged from 3 months to approximately 2–3 years.

Clinical assessment and calculated limb volume. To assess the severity of lymphedema, the circumferences of the affected and contralateral upper limbs were measured at successive levels 4 cm apart. The volume of the measured limb segment was calculated using the truncated-cone method: the portion between each pair of adjacent measurement levels was treated as a separate truncated cone, and the resulting volumes were summed.

The volume of each segment was calculated using the following formula:

In the formula, is the distance between adjacent measurement levels (4 cm), and and are the limb circumferences at those levels (cm). The total calculated volume of the measured limb segment was obtained by summing the volumes of all segments:

where is the number of measurement levels. Values for the affected and contralateral limbs were compared. The contralateral limb served as a reference for comparison but was not assumed to be unaffected.

Fluorescence lymphography technique. All patients underwent fluorescence lymphography with indocyanine green (ICG). The study used ICG supplied by Aurolab Veerapanjan (Madurai, Tamil Nadu, India) and the SPY-PHI fluorescence imaging system (Novadaq Technologies Inc., Canada). Images were recorded using equipment from AVerMedia Technologies Inc. (Taiwan).

ICG solution was injected intradermally at three or four sites on the affected upper limb, with 0.1 mL administered at each site. The total injected volume was 0.3–0.4 mL, depending on the number of injection sites. Near-infrared fluorescence imaging of the superficial lymphatic network was then performed.

The assessment included the direction and pattern of fluorescence propagation, the location of visible superficial lymphatic collectors, the presence of dermal backflow, and the extent of pathological fluorescence changes. When preserved lymphatic collectors were identified, their anatomical locations were documented for potential use in subsequent preoperative mapping.

Classification of fluorescence patterns. Four patterns were used to describe the ICG lymphographic findings: *linear*, *splash*, *stardust*, and *diffuse*.

The linear pattern was defined by relatively narrow, elongated fluorescent pathways corresponding to superficial lymphatic collectors. The splash pattern was characterized by localized, irregular spread of fluorescence within the superficial lymphatic network. The stardust pattern was defined by multiple small, discrete areas of fluorescence. The diffuse pattern was characterized by extensive confluent tissue fluorescence, against which individual lymphatic collectors could be difficult to distinguish.

The linear pattern was assessed separately from the three dermal backflow patterns. When multiple patterns were present in the same limb, their combination, anatomical location, and extent were documented.

Data documentation and analysis. Clinical findings, calculated limb volumes, and fluorescence imaging results were analyzed descriptively in relation to oncological history and the stage and duration of lymphedema. Individual patient characteristics, examination chronology, ICG injection volumes and sites, and observed fluorescence patterns were summarized in Table 1 of the Results section. Images illustrating the linear pattern and the three dermal backflow patterns were selected for presentation. Informed consent for publication of the clinical cases and images was obtained from the patients.

ICG lymphography was performed for diagnostic purposes, including characterization of lymphatic dysfunction

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and identification of potential sites for lymphovenous anastomosis. No lymphovenous anastomoses were performed in this case series.

RESULTS

The study included 10 women with secondary upper limb lymphedema following multimodal treatment for malignancy. The underlying malignancy was breast cancer in seven patients (70%), upper limb melanoma in two (20%), and cutaneous squamous cell carcinoma of the upper limb in one (10%). At the time of ICG lymphography, two patients (20%) had stage I lymphedema, three (30%) had stage II, and five (50%) had stage III. The duration of lymphedema before assessment ranged from 3 months to approximately 2–3 years.

Fluorescence lymphography revealed variation in superficial lymphatic drainage. The images differed in the length of visible lymphatic collectors, the configuration of the fluorescence signal, and the extent of dermal backflow. Four lymphographic patterns were observed in this case series: *linear*, *splash*, *stardust*, and *diffuse*.

Individual Case Characteristics

Limb volumetry demonstrated an increased calculated volume of the affected upper limb compared with the contralateral limb in all patients. The relative interlimb volume difference ranged from 10.0% to 55.0%. The smallest differences were observed in patients with stage I lymphedema (10.0% and 12.0%), whereas patients with stage III disease showed differences ranging from 45.0% to 55.0%. Individual volumetric measurements are presented in Table 1.

Fluorescence Pattern Characteristics

Table 1. Patient characteristics and ICG lymphography findings.

Patient	Month of assessment	Oncological diagnosis	ICD-10 code	Lymphedema stage	Affected limb, cm³	Contralateral limb, cm³	Difference, %	Fluorescence findings in the available images
1	January 2026	Breast cancer	C50.2	II	3125	2500	25.0	Predominant fluorescence in the hand
2	February 2026	Breast cancer	C50.1	III	4205	2900	45.0	Extensive, heterogeneous fluorescence in the hand and forearm
3	March 2026	Breast cancer	C50.4	II	3456	2700	28.0	Extensive fluorescence in the forearm
4	April 2026	Breast cancer	C50.4	I	2640	2400	10.0	Fluorescence in the hand with separate proximal fluorescent areas
5	May 2026	Breast cancer	C50.3	II	3458	2600	33.0	Intense fluorescence in the hand with separate areas of fluorescence proximally
6	June 2026	Breast cancer	C50.4	I	2800	2500	12.0	Localized, heterogeneous fluorescence in the hand
7	July 2026	Breast cancer	C50.2	III	4200	2800	50.0	An elongated linear fluorescent pathway; another image shows broader, heterogeneous fluorescence
8	July 2026	Upper limb melanoma	C43.6	III	3915	2700	45.0	Extensive, heterogeneous fluorescence in the upper arm
9	August 2026	Upper limb melanoma	C43.6	III	4650	3000	55.0	ICG pattern not available for image-based reassessment
10	August 2026	Cutaneous squamous cell carcinoma of the upper limb	C44.6	III	4060	2800	45.0	ICG pattern not available for image-based reassessment

Linear Pattern

The linear pattern was characterized by elongated fluorescent structures corresponding to superficial lymphatic collectors. Their location and direction enabled individual lymphatic drainage pathways to be traced within the examined limb. An example of a linear fluorescent pathway is shown in the image of patient 7 (Figure 1). The visible collectors could be anatomically localized for potential use in subsequent preoperative mapping.

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Figure 1. Linear pattern on upper limb ICG lymphography, showing an elongated superficial lymphatic collector. Patient 7. Source: Images obtained by the authors.

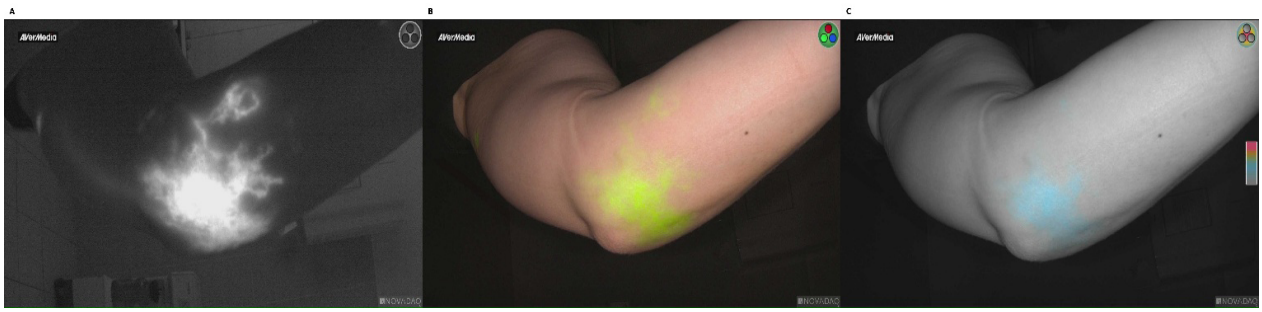


Figure 2. Splash pattern on ICG lymphography: localized, irregular spread of the fluorescence signal within the superficial lymphatic network. Source: Images obtained by the authors.



Figure 3. Stardust pattern: multiple small, discrete areas of fluorescence consistent with dermal backflow. Source: Images obtained by the authors.



Figure 4. Patient 8, Diffuse pattern: extensive, confluent fluorescence in the upper limb tissues, with individual lymphatic collectors difficult to distinguish. Source: Images obtained by the authors.

The *splash* pattern was characterized by localized, irregular spread of the fluorescence signal beyond a clearly delineated linear lymphatic collector. This appearance corresponded to limited areas of dermal backflow and differed from the linear pattern in its less organized fluorescence configuration.

The *stardust* pattern was characterized by multiple small, spatially separate areas of fluorescence. Compared with the splash pattern, the fluorescence signal was more fragmented, appearing as discrete punctate foci within the affected tissues.

The *diffuse* pattern was characterized by extensive, confluent tissue fluorescence. Within these areas, individual linear lymphatic collectors were difficult to distinguish. Extensive heterogeneous fluorescence was observed, in particular,

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in the images of patient 8.

Interpretation of Individual Lymphographic Findings

Different fluorescence patterns could occur within the same limb. Interpretation therefore required assessment of each pattern's anatomical location and extent, as well as its type. ICG lymphography enabled lymphatic dysfunction to be described in individual visible regions of the superficial lymphatic network rather than assigning a single overall fluorescence pattern to the entire limb.

The findings were used to identify visible superficial lymphatic collectors and potential sites for subsequent surgical mapping. No patient in this case series underwent lymphovenous anastomosis; assessment of outcomes after surgical treatment of lymphedema was therefore outside the scope of this study.

DISCUSSION

This case series demonstrates variation in the fluorescence appearance of the superficial lymphatic network in women with secondary upper limb lymphedema following multimodal treatment for malignancy. ICG lymphography showed both elongated linear lymphatic pathways and areas of abnormal fluorescence spread corresponding to different dermal backflow patterns. These observations are consistent with the view that the clinical severity of edema and the spatial characteristics of the superficial lymphatic network reflect complementary aspects of lymphatic dysfunction [2, 4, 6].

Yamamoto et al. proposed a system for assessing upper limb lymphedema using ICG lymphographic patterns, distinguishing a linear pattern from three dermal backflow patterns: *splash*, *stardust*, and *diffuse* [4]. Narushima et al. subsequently described changes in lymphographic appearance with the progression of obstructive lymphedema, from a linear pattern to localized, punctate, and then extensive dermal backflow [6]. This classification provides a consistent terminology for describing images. However, a clinical stage should not be assigned on the basis of a single fluorescence image alone. Interpretation should account for the location and extent of abnormalities, the coexistence of multiple patterns within a limb, and the findings of clinical examination [4, 6].

Eight of the 10 patients in this series had stage II or III lymphedema. Nevertheless, an elongated linear fluorescent pathway was visible in one of the presented images. This finding has practical relevance: even in patients with marked clinical manifestations, treating the entire limb as a uniform area of lymphatic impairment may overlook spatial variation in superficial lymphatic drainage. Identifying visible collectors may support subsequent anatomical mapping. A linear pattern alone, however, does not establish that a vessel has sufficient transport function or is suitable for lymphovenous anastomosis.

Mihara et al. demonstrated the value of ICG lymphography in the early stages of lymphatic dysfunction [3]. In their study population of patients with early upper limb lymphedema, the method detected changes in the superficial lymphatic network and offered diagnostic advantages over lymphoscintigraphy under the protocol used. These findings support incorporating lymphatic drainage imaging into the assessment of patients with suspected early lymphedema. They do not imply that ICG lymphography can replace other imaging modalities in every clinical setting [2, 3].

A key advantage of ICG lymphography is its ability to assess tracer movement dynamically. Yamamoto et al. described the use of dynamic ICG lymphography in breast cancer–related upper limb lymphedema [5]. Unlike assessment of a single image, sequential imaging enables the direction of fluorescence propagation to be tracked and the characteristics of visible lymphatic pathways to be assessed more precisely. Future development of the present study will therefore require standardized image acquisition times and analysis of the original video recordings in addition to still images [5].

A distinctive feature of this case series is the heterogeneity of the patients' oncological histories. In addition to women treated for breast cancer, the series includes patients with lymphedema following treatment for melanoma and cutaneous squamous cell carcinoma of the upper limb. Differences in primary tumor location, the extent of surgery, and combinations of anticancer treatments may be associated with different mechanisms of impaired lymphatic drainage. However, the small number of cases and the absence of comparable subgroups preclude assessment of associations between malignancy type, prior treatment, and specific ICG lymphographic patterns. These findings should be interpreted as a description of the range of lymphographic appearances in a clinically heterogeneous group, rather than as a comparison across oncological diagnoses.

Combining fluorescence imaging with clinical examination and calculated limb volume is an important aspect of comprehensive lymphedema assessment. Measuring limb circumference and calculating volume using the sum-of-truncated-cones method provides a quantitative estimate of edema within the examined segment. ICG lymphography provides spatial information about visible superficial lymphatic collectors and areas of dermal backflow. Reviews of lymphatic imaging methods emphasize that the choice of examination depends on the diagnostic question: limb volume measurement, superficial vessel imaging, and assessment of deeper structures address different aspects of the condition [1, 2]. In the present series, the quantitative relationship between calculated limb volume and the extent of individual fluorescence patterns was not assessed.

Potential Applications of ICG Lymphography in Lymphedema Care in the Republic of Kazakhstan

In the Republic of Kazakhstan, the findings of this study are relevant primarily to the development of a coordinated clinical pathway for patients with lymphedema following anticancer treatment. Such a pathway could include detection of swelling during oncological follow-up, clinical staging, quantitative assessment of limb volume, specialized imaging of lymphatic drainage, and assessment of indications for further conservative or surgical treatment. Within this pathway, ICG lymphography could help characterize the anatomy and function of the superficial lymphatic network, extending assessment beyond the overall severity of swelling to individual lymphatic pathways [1, 2].

One potential application in specialized care in Kazakhstan is preoperative mapping before lymphovenous anastomosis. In their systematic review, van Heumen et al. examined

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lymphatic vessel imaging in the context of planning lymphatic surgery [1]. Gentileschi et al. described mapping lymphatic pathways in an affected upper limb before lymphatic supermicrosurgery, using the distribution of pathways in the contralateral limb as a reference [7]. Woo et al. demonstrated variation in superficial upper limb lymphatic pathways and differences in the distribution of lymphatic obstruction according to their anatomical location [8]. Together, these studies illustrate the value of patient-specific imaging when planning an intervention [1, 7, 8].

The method may also support intraoperative navigation. In a multicenter, single-arm study of ICG fluorescence lymphography in secondary lymphedema, lymphatic vessels suitable for anastomosis were identified in 97.7% of 263 incisions whose locations had been determined using ICG lymphography. The method was reported to be useful for confirming anastomotic patency in 95.1% of cases [9]. These figures describe the findings and conditions of that study; they do not predict outcomes for patients in the present series or for healthcare institutions in Kazakhstan. Nevertheless, the study shows that ICG imaging can contribute at several stages of surgical treatment, from locating lymphatic vessels to assessing the newly established drainage pathway intraoperatively [9].

In a systematic review of secondary upper limb lymphedema, Qian et al. examined ICG lymphography as a tool for diagnosis and for guiding treatment interventions [10]. Developing this area of care in Kazakhstan may benefit from standardized pattern descriptions, a reproducible mapping protocol, and prospective data documenting which lymphographic findings informed treatment decisions and what clinical outcomes followed. The use of ICG lymphography should not, however, automatically broaden indications for surgery. Decisions about surgical treatment require a comprehensive assessment of the patient, the available technical resources, and the intended goal of the intervention [1, 2, 10].

A further area for investigation is a standardized follow-up protocol for patients after anticancer treatment. Such a program would need to define the patient groups to be monitored, the timing of clinical assessments, indications for ICG lymphography, and referral criteria for a specialized center. This is particularly relevant when interpreting early lymphographic changes: an imaging finding should be considered in its clinical context and should not automatically be treated as an indication for an invasive procedure. Published findings on early diagnosis and dynamic imaging provide a basis for developing such a protocol, but its effectiveness in Kazakhstan would require independent evaluation [3, 5].

This series of 10 cases may serve as an initial contribution to a local evidence base on ICG lymphography in secondary upper limb lymphedema. A subsequent study should use a standardized protocol for ICG injection and image acquisition, document patterns by anatomical region, perform standardized limb volumetry, record prior anticancer treatments, and follow patients over time. If a microsurgical program is developed, a separate objective would be to compare preoperative lymphographic findings with intraoperative observations and treatment outcomes. Such systematic data collection would allow the clinical applicability of the method in Kazakhstan to be assessed directly.

ICG lymphography is not itself a treatment for lymphedema. Its role is to characterize lymphatic dysfunction and provide information that may inform subsequent management and procedural planning. No lymphovenous anastomoses were performed in this series. The findings therefore cannot establish the effectiveness of surgical treatment, a postoperative reduction in limb volume, or an improvement in quality of life attributable to the use of ICG.

The limitations of this study include its small sample size, descriptive design, heterogeneous oncological histories and prior treatments, and the lack of quantitative assessment of dermal backflow extent or analysis of its relationship with limb volume. No surgical interventions were performed, and long-term treatment outcomes were not assessed. Accordingly, the findings describe the diagnostic and potential mapping capabilities of ICG lymphography but do not establish an effect on treatment outcomes.

This case series illustrates how ICG lymphography can characterize superficial lymphatic drainage in individual patients with secondary upper limb lymphedema. In Kazakhstan, further development of this approach may provide a diagnostic basis for more structured follow-up after anticancer treatment, specialized lymphatic mapping, and subsequent investigation of microsurgical treatment for lymphedema.

CONCLUSION

This case series of 10 patients demonstrates the ability of indocyanine green (ICG) fluorescence lymphography to assess superficial lymphatic drainage in women with secondary upper limb lymphedema following multimodal treatment for malignancy. The method visualized linear lymphatic pathways and several dermal backflow patterns, revealing spatial variation in lymphatic dysfunction.

ICG lymphography complements clinical staging and calculated limb volumetry by providing information on the location of visible superficial lymphatic collectors and the extent of pathological fluorescence changes. These findings may inform individualized further assessment and potential preoperative mapping when lymphatic microsurgery is being considered.

In the Republic of Kazakhstan, further development of ICG lymphography may improve specialized care for patients with lymphedema after anticancer treatment by helping characterize lymphatic impairment and inform treatment planning. Future studies should standardize imaging protocols, examine associations between ICG patterns and clinical and volumetric measures, and evaluate the role of lymphographic findings in microsurgical planning and treatment outcomes.

The small size of this series and the absence of surgical interventions preclude conclusions about the effect of ICG lymphography on treatment effectiveness. These findings should be regarded as preliminary clinical experience that provides a basis for further prospective research.

Author contributions

Conceptualization — A.K. Makishev, Y.B. Gazizova; Methodology and study design — Y.B. Gazizova, U.Y. Kairov; Investigation and data collection — Y.B. Gazizova, A.M. Kukanova;

Analysis and interpretation of results — Y.B. Gazizova;

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CONFLICT OF INTEREST

The authors declare no conflict of interest.

REFERENCES

1. van Heumen S., Riksen J.J.M., Bramer W.M., van Soest G., Vasilic D. Imaging of the Lymphatic Vessels for Surgical Planning: A Systematic Review // Annals of Surgical Oncology. — 2023. — Vol. 30, № 1. — P. 462–479. DOI: 10.1245/s10434-022-12552-7 . PMID: 36171528 .

2. Nagy B.I., Mohos B., Tzou C.-H.J. Imaging Modalities for Evaluating Lymphedema // Medicina. — 2023. — Vol. 59, № 11. — Article 2016. DOI: 10.3390/medicina59112016 . PMID: 38004065 .

3. Mihara M., Hara H., Araki J. et al. Indocyanine Green (ICG) Lymphography Is Superior to Lymphoscintigraphy for Diagnostic Imaging of Early Lymphedema of the Upper Limbs // PLOS ONE. — 2012. — Vol. 7, № 6. — Article e38182. DOI: 10.1371/journal.pone.0038182 . PMID: 22675520 .

4. Yamamoto T., Yamamoto N., Doi K. et al. Indocyanine Green-Enhanced Lymphography for Upper Extremity Lymphedema: A Novel Severity Staging System Using Dermal Backflow Patterns // Plastic and Reconstructive Surgery. — 2011. — Vol. 128, № 4. — P. 941–947. DOI: 10.1097/PRS.0b013e3182268cd9 . PMID: 21681123 .

5. Yamamoto T., Narushima M., Yoshimatsu H. et al. Dynamic Indocyanine Green (ICG) Lymphography for Breast Cancer-Related Arm Lymphedema // Annals of Plastic Surgery. — 2014. — Vol. 73, № 6. — P. 706–709. DOI: 10.1097/SAP.0b013e318285875f . PMID: 24322632 .

6. Narushima M., Yamamoto T., Ogata F. et al. Indocyanine Green Lymphography Findings in Limb Lymphedema // Journal of Reconstructive Microsurgery. — 2016. — Vol. 32, № 1. — P. 72–79. DOI: 10.1055/s-0035-1564608 . PMID: 26422172 .

7. Gentileschi S., Servillo M., Albanese R. et al. Lymphatic Mapping of the Upper Limb with Lymphedema Before Lymphatic Supermicrosurgery by Mirroring of the Healthy Limb // Microsurgery. — 2017. — Vol. 37, № 8. — P. 881–889. DOI: 10.1002/micr.30247 . PMID: 28952193 .

8. Woo K.-J., Lee M.K., Seong I.H., Park J.-W. Classification of Superficial Lymphatic Pathways in the Upper Extremity and Incidence of Lymphatic Obstruction According to the Lymphatic Pathways in Patients with Unilateral Upper Extremity Lymphedema // Journal of Plastic, Reconstructive & Aesthetic Surgery. — 2022. — Vol. 75, № 7. — P. 2143–2152. DOI: 10.1016/j.bjps.2022.02.049 . PMID: 35346607 .

9. A phase III, multicenter, single-arm study to assess the utility of indocyanine green fluorescent lymphography in the treatment of secondary lymphedema // Journal of Vascular Surgery: Venous and Lymphatic Disorders. — 2022. — Vol. 10, № 3. — P. 728–737.e3. DOI: 10.1016/j.jvsv.2021.09.006 .

10. Qian Y., Yao Z., Wang C. et al. Application of indocyanine green lymphography in the diagnosis and treatment of secondary upper extremity lymphedema: a systematic review // Journal of Plastic Surgery and Hand Surgery. — 2025. — Vol. 60. — P. 171–179. DOI: 10.2340/jphs.v60.44582 .

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ВОЗМОЖНОСТИ ФЛУОРЕСЦЕНТНОЙ ВИЗУАЛИЗАЦИИ ПРИ ВТОРИЧНОЙ ЛИМФЕДЕМЕ ПОСЛЕ КОМПЛЕКСНОГО ЛЕЧЕНИЯ ЗЛОКАЧЕСТВЕННЫХ НОВООБРАЗОВАНИЙ: СЕРИЯ КЛИНИЧЕСКИХ СЛУЧАЕВ

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АННОТАЦИЯ

Актуальность. Вторичная лимфедема верхних конечностей является одним из осложнений комплексного лечения злокачественных новообразований, сопровождающихся повреждением регионарной лимфатической системы. Флуоресцентная лимфография с применением индоцианина зелёного (ICG) позволяет в реальном времени визуализировать поверхностные лимфатические сосуды и оценивать особенности лимфатического оттока. Однако данные о характере флуоресцентных изменений при вторичной лимфедеме различной онкологической этиологии и их клиническом значении остаются ограниченными.

Цель исследования. Оценить возможности ICG-лимфографии в выявлении и характеристике нарушений лимфатического оттока у пациенток с вторичной лимфедемой верхних конечностей после комплексного лечения злокачественных новообразований.

Материалы и методы. Проведён анализ серии клинических случаев 10 пациенток с вторичной лимфедемой верхних конечностей после лечения рака молочной железы (n=7), меланомы (n=2) и плоскоклеточного рака кожи (n=1). Длительность лимфедемы до обследования варьировала от 3 месяцев до 2–3 лет. Всем пациенткам выполнена флуоресцентная лимфография с применением ICG.

Результаты. При флуоресцентной лимфографии выявлены четыре паттерна лимфатического оттока: линейный (linear) и три варианта дермального обратного тока — «брызги» (splash), «звёздчатая пыль» (stardust) и диффузный (diffuse). Характер и распространённость флуоресцентных изменений отражали особенности нарушения лимфатического дренажа. Визуализация сохранившихся лимфатических коллекторов позволила определить их анатомическое расположение и потенциальные участки для формирования лимфовенозных анастомозов.

Заключение. ICG-лимфография позволила оценить характер нарушений лимфатического оттока и визуализировать сохранившиеся поверхностные лимфатические коллекторы. Полученные данные продемонстрировали возможности метода для оценки лимфатической дисфункции, индивидуализации лечебной тактики и предоперационного планирования лимфовенозного анастомозирования.

Ключевые слова: вторичная лимфедема; флуоресцентная лимфография; индоцианин зелёный; рак молочной железы; лимфатический отток; дермальный обратный ток; лимфовенозное анастомозирование.

ҚАТЕРЛІ ІСІКТЕРДІ КЕШЕНДІ ЕМДЕУДЕН КЕЙІН ЕКІНШІЛІК ЛИМФЕДЕМАДА ФЛУОРЕСЦЕНТТІ БЕЙНЕЛЕУ МҮМКІНДІКТЕРІ: КЛИНИКАЛЫҚ ЖАҒДАЙЛАР СЕРИЯСЫ

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АҢДАТПА

Өзектілігі: Жоғарғы аяқ-қолдардың екіншілік лимфедемасы өңірлік лимфа жүйесінің зақымдануымен байланысты қатерлі ісіктерді кешенді емдеудің асқынуларының бірі болып табылады. Индоцианин жасылын (ICG) қолдану арқылы жүргізілетін флуоресценттік лимфография беткей лимфа тамырларын нақты уақыт режимінде визуализациялауға және лимфа ағысының ерекшеліктерін бағалауға мүмкіндік береді. Алайда әртүрлі онкологиялық этиологиялы екіншілік лимфедема кезіндегі флуоресценттік өзгерістердің сипаты мен олардың клиникалық маңызы туралы деректер әлі де шектеулі.

Зерттеудің мақсаты: Қатерлі ісіктерді кешенді емдеуден кейін жоғарғы аяқ-қолдардың екіншілік лимфедемасы дамыған пациент әйелдерде лимфа ағысының бұзылыстарын анықтау және сипаттау үшін ICG-лимфографияның диагностикалық мүмкіндіктерін бағалау.

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Материалдар мен әдістер. Сүт безі обырын (n = 7), меланоманы (n = 2) және терінің жалпақ жасушалы обырын (n = 1) емдеуден кейін жоғарғы аяқ-қолдардың екіншілік лимфедемасы дамыған 10 пациент әйелдің клиникалық жағдайлар сериясына талдау жүргізілді. Зерттеуге дейінгі лимфедеманың ұзақтығы 3 айдан 2–3 жылға дейін өзгерді. Барлық пациенттерге индоцианин жасылын қолдану арқылы флуоресценттік лимфография жүргізілді.

Нәтижелері: Флуоресценттік лимфография барысында лимфа ағысының төрт паттерні анықталды: сызықтық (linear) паттерн және дермалық кері ағыстың үш түрі — «шашырау» (splash), «жұлдызды шаң» (stardust) және диффузды (diffuse) паттерндер. Флуоресценттік өзгерістердің сипаты мен таралу дәрежесі лимфалық дренаж бұзылыстарының ерекшеліктерін көрсетті. Сақталған лимфалық коллекторларды визуализациялау олардың анатомиялық орналасуын және лимфовеноздық анастомоздар қалыптастыруға ықтимал аймақтарды анықтауға мүмкіндік берді.

Қорытынды: ICG-лимфография лимфа ағысы бұзылыстарының сипатын бағалауға және сақталған беткей лимфалық коллекторларды визуализациялауға мүмкіндік берді. Алынған нәтижелер бұл әдістің лимфа жүйесі дисфункциясын бағалауда, емдеу тактикасын жекелендіруде және лимфовеноздық анастомоздау операциясын жоспарлауда қолдану мүмкіндіктерін көрсетті.

Түйін сөздер: екіншілік лимфедема; флуоресценттік лимфография; индоцианин жасылы; сүт безі обыры; лимфа ағысы; дермалық кері ағыс; лимфовеноздық анастомоздау.