GEORGIAN MEDICAL NEWS

ISSN 1512-0112

NO 1 (370) Январь 2026

ТБИЛИСИ - NEW YORK

ЕЖЕМЕСЯЧНЫЙ НАУЧНЫЙ ЖУРНАЛ

Медицинские новости Грузии

საქართველოს სამედიცინო სიახლენი

GEORGIAN MEDICAL NEWS

Monthly Georgia-US joint scientific journal published both in electronic and paper formats of the Agency of Medical Information of the Georgian Association of Business Press. Published since 1994. Distributed in NIS, EU and USA.

GMN: Georgian Medical News is peer-reviewed, published monthly journal committed to promoting the science and art of medicine and the betterment of public health, published by the GMN Editorial Board since 1994. GMN carries original scientific articles on medicine, biology and pharmacy, which are of experimental, theoretical and practical character; publishes original research, reviews, commentaries, editorials, essays, medical news, and correspondence in English and Russian.

GMN is indexed in MEDLINE, SCOPUS, PubMed and VINITI Russian Academy of Sciences. The full text content is available through EBSCO databases.

GMN: Медицинские новости Грузии - ежемесячный рецензируемый научный журнал, издаётся Редакционной коллегией с 1994 года на русском и английском языках в целях поддержки медицинской науки и улучшения здравоохранения. В журнале публикуются оригинальные научные статьи в области медицины, биологии и фармации, статьи обзорного характера, научные сообщения, новости медицины и здравоохранения. Журнал индексируется в MEDLINE, отражён в базе данных SCOPUS, PubMed и ВИНИТИ РАН. Полнотекстовые статьи журнала доступны через БД EBSCO.

GMN: Georgian Medical News – საქართველოს სამედიცინო სიახლენი – არის ყოველთვიური სამეცნიერო სამედიცინო რეცენზირებადი ჟურნალი, გამოიცემა 1994 წლიდან, წარმოადგენს სარედაქციო კოლეგიისა და აშშ-ის მეცნიერების, განათლების, ინდუსტრიის, ხელოვნებისა და ბუნებისმეტყველების საერთაშორისო აკადემიის ერთობლივ გამოცემას. GMN-ში რუსულ და ინგლისურ ენებზე ქვეყნდება ექსპერიმენტული, თეორიული და პრაქტიკული ხასიათის ორიგინალური სამეცნიერო სტატიები მედიცინის, ბიოლოგიისა და ფარმაციის სფეროში, მიმოხილვითი ხასიათის სტატიები.

ჟურნალი ინდექსირებულია MEDLINE-ის საერთაშორისო სისტემაში, ასახულია SCOPUS-ის, PubMed-ის და ВИНИТИ РАН-ის მონაცემთა ბაზებში. სტატიების სრული ტექსტი ხელმისაწვდომია EBSCO-ს მონაცემთა ბაზებიდან.

WEBSITE

www.geomednews.com

К СВЕДЕНИЮ АВТОРОВ!

При направлении статьи в редакцию необходимо соблюдать следующие правила:

1. Статья должна быть представлена в двух экземплярах, на русском или английском языках, напечатанная через **полтора интервала на одной стороне стандартного листа с шириной левого поля в три сантиметра**. Используемый компьютерный шрифт для текста на русском и английском языках - **Times New Roman** (**Кириллица**), для текста на грузинском языке следует использовать **AcadNusx.** Размер шрифта - **12**. К рукописи, напечатанной на компьютере, должен быть приложен CD со статьей.

2. Размер статьи должен быть не менее десяти и не более двадцати страниц машинописи, включая указатель литературы и резюме на английском, русском и грузинском языках.

3. В статье должны быть освещены актуальность данного материала, методы и результаты исследования и их обсуждение.

При представлении в печать научных экспериментальных работ авторы должны указывать вид и количество экспериментальных животных, применявшиеся методы обезболивания и усыпления (в ходе острых опытов).

4. К статье должны быть приложены краткое (на полстраницы) резюме на английском, русском и грузинском языках (включающее следующие разделы: цель исследования, материал и методы, результаты и заключение) и список ключевых слов (key words).

5. Таблицы необходимо представлять в печатной форме. Фотокопии не принимаются. **Все цифровые, итоговые и процентные данные в таблицах должны соответствовать таковым в тексте статьи**. Таблицы и графики должны быть озаглавлены.

6. Фотографии должны быть контрастными, фотокопии с рентгенограмм - в позитивном изображении. Рисунки, чертежи и диаграммы следует озаглавить, пронумеровать и вставить в соответствующее место текста **в tiff формате**.

В подписях к микрофотографиям следует указывать степень увеличения через окуляр или объектив и метод окраски или импрегнации срезов.

7. Фамилии отечественных авторов приводятся в оригинальной транскрипции.

8. При оформлении и направлении статей в журнал МНГ просим авторов соблюдать правила, изложенные в «Единых требованиях к рукописям, представляемым в биомедицинские журналы», принятых Международным комитетом редакторов медицинских журналов - http://www.spinesurgery.ru/files/publish.pdf и http://www.nlm.nih.gov/bsd/uniform_requirements.html
В конце каждой оригинальной статьи приводится библиографический список. В список литературы включаются все материалы, на которые имеются ссылки в тексте. Список составляется в алфавитном порядке и нумеруется. Литературный источник приводится на языке оригинала. В списке литературы сначала приводятся работы, написанные знаками грузинского алфавита, затем кириллицей и латиницей. Ссылки на цитируемые работы в тексте статьи даются в квадратных скобках в виде номера, соответствующего номеру данной работы в списке литературы. Большинство цитированных источников должны быть за последние 5-7 лет.

9. Для получения права на публикацию статья должна иметь от руководителя работы или учреждения визу и сопроводительное отношение, написанные или напечатанные на бланке и заверенные подписью и печатью.

10. В конце статьи должны быть подписи всех авторов, полностью приведены их фамилии, имена и отчества, указаны служебный и домашний номера телефонов и адреса или иные координаты. Количество авторов (соавторов) не должно превышать пяти человек.

11. Редакция оставляет за собой право сокращать и исправлять статьи. Корректура авторам не высылается, вся работа и сверка проводится по авторскому оригиналу.

12. Недопустимо направление в редакцию работ, представленных к печати в иных издательствах или опубликованных в других изданиях.

При нарушении указанных правил статьи не рассматриваются.

REQUIREMENTS

Please note, materials submitted to the Editorial Office Staff are supposed to meet the following requirements:

1. Articles must be provided with a double copy, in English or Russian languages and typed or compu-ter-printed on a single side of standard typing paper, with the left margin of **3** centimeters width, and **1.5** spacing between the lines, typeface - **Times New Roman** (**Cyrillic**), print size - **12** (referring to Georgian and Russian materials). With computer-printed texts please enclose a CD carrying the same file titled with Latin symbols.

2. Size of the article, including index and resume in English, Russian and Georgian languages must be at least 10 pages and not exceed the limit of 20 pages of typed or computer-printed text.

3. Submitted material must include a coverage of a topical subject, research methods, results, and review.

Authors of the scientific-research works must indicate the number of experimental biological species drawn in, list the employed methods of anesthetization and soporific means used during acute tests.

4. Articles must have a short (half page) abstract in English, Russian and Georgian (including the following sections: aim of study, material and methods, results and conclusions) and a list of key words.

5. Tables must be presented in an original typed or computer-printed form, instead of a photocopied version. **Numbers, totals, percentile data on the tables must coincide with those in the texts of the articles.** Tables and graphs must be headed.

6. Photographs are required to be contrasted and must be submitted with doubles. Please number each photograph with a pencil on its back, indicate author's name, title of the article (short version), and mark out its top and bottom parts. Drawings must be accurate, drafts and diagrams drawn in Indian ink (or black ink). Photocopies of the X-ray photographs must be presented in a positive image in **tiff format**.

Accurately numbered subtitles for each illustration must be listed on a separate sheet of paper. In the subtitles for the microphotographs please indicate the ocular and objective lens magnification power, method of coloring or impregnation of the microscopic sections (preparations).

7. Please indicate last names, first and middle initials of the native authors, present names and initials of the foreign authors in the transcription of the original language, enclose in parenthesis corresponding number under which the author is listed in the reference materials.

8. Please follow guidance offered to authors by The International Committee of Medical Journal Editors guidance in its Uniform Requirements for Manuscripts Submitted to Biomedical Journals publication available online at: http://www.nlm.nih.gov/bsd/uniform_requirements.html
http://www.icmje.org/urm_full.pdf
In GMN style for each work cited in the text, a bibliographic reference is given, and this is located at the end of the article under the title "References". All references cited in the text must be listed. The list of references should be arranged alphabetically and then numbered. References are numbered in the text [numbers in square brackets] and in the reference list and numbers are repeated throughout the text as needed. The bibliographic description is given in the language of publication (citations in Georgian script are followed by Cyrillic and Latin).

9. To obtain the rights of publication articles must be accompanied by a visa from the project instructor or the establishment, where the work has been performed, and a reference letter, both written or typed on a special signed form, certified by a stamp or a seal.

10. Articles must be signed by all of the authors at the end, and they must be provided with a list of full names, office and home phone numbers and addresses or other non-office locations where the authors could be reached. The number of the authors (co-authors) must not exceed the limit of 5 people.

11. Editorial Staff reserves the rights to cut down in size and correct the articles. Proof-sheets are not sent out to the authors. The entire editorial and collation work is performed according to the author's original text.

12. Sending in the works that have already been assigned to the press by other Editorial Staffs or have been printed by other publishers is not permissible.

Articles that Fail to Meet the Aforementioned Requirements are not Assigned to be Reviewed.

ავტორთა საყურადღებოდ!

რედაქციაში სტატიის წარმოდგენისას საჭიროა დავიცვათ შემდეგი წესები:

1. სტატია უნდა წარმოადგინოთ 2 ცალად, რუსულ ან ინგლისურ ენებზე,დაბეჭდილი სტანდარტული ფურცლის 1 გვერდზე, 3 სმ სიგანის მარცხენა ველისა და სტრიქონებს შორის 1,5 ინტერვალის დაცვით. გამოყენებული კომპიუტერული შრიფტი რუსულ და ინგლისურენოვან ტექსტებში - **Times New Roman (Кириллица)**, ხოლო ქართულენოვან ტექსტში საჭიროა გამოვიყენოთ **AcadNusx.** შრიფტის ზომა – 12. სტატიას თან უნდა ახლდეს CD სტატიით.

2. სტატიის მოცულობა არ უნდა შეადგენდეს 10 გვერდზე ნაკლებს და 20 გვერდზე მეტს ლიტერატურის სიის და რეზიუმეების (ინგლისურ, რუსულ და ქართულ ენებზე) ჩათვლით.

3. სტატიაში საჭიროა გაშუქდეს: საკითხის აქტუალობა; კვლევის მიზანი; საკვლევი მასალა და გამოყენებული მეთოდები; მიღებული შედეგები და მათი განსჯა. ექსპერიმენტული ხასიათის სტატიების წარმოდგენისას ავტორებმა უნდა მიუთითონ საექსპერიმენტო ცხოველების სახეობა და რაოდენობა; გაუტკივარებისა და დაძინების მეთოდები (მწვავე ცდების პირობებში).

4. სტატიას თან უნდა ახლდეს რეზიუმე ინგლისურ, რუსულ და ქართულ ენებზე არანაკლებ ნახევარი გვერდის მოცულობისა (სათაურის, ავტორების, დაწესებულების მითითებით და უნდა შეიცავდეს შემდეგ განყოფილებებს: მიზანი, მასალა და მეთოდები, შედეგები და დასკვნები; ტექსტუალური ნაწილი არ უნდა იყოს 15 სტრიქონზე ნაკლები) და საკვანძო სიტყვების ჩამონათვალი (key words).

5. ცხრილები საჭიროა წარმოადგინოთ ნაბეჭდი სახით. ყველა ციფრული, შემაჯამებელი და პროცენტული მონაცემები უნდა შეესაბამებოდეს ტექსტში მოყვანილს.

6. ფოტოსურათები უნდა იყოს კონტრასტული; სურათები, ნახაზები, დიაგრამები - დასათაურებული, დანომრილი და სათანადო ადგილას ჩასმული. რენტგენოგრამების ფოტოასლები წარმოადგინეთ პოზიტიური გამოსახულებით **tiff** ფორმატში. მიკროფოტოსურათების წარწერებში საჭიროა მიუთითოთ ოკულარის ან ობიექტივის საშუალებით გადიდების ხარისხი, ანათალების შეღებვის ან იმპრეგნაციის მეთოდი და აღნიშნოთ სურათის ზედა და ქვედა ნაწილები.

7. სამამულო ავტორების გვარები სტატიაში აღინიშნება ინიციალების თანდართვით, უცხოურისა – უცხოური ტრანსკრიპციით.

8. სტატიას თან უნდა ახლდეს ავტორის მიერ გამოყენებული სამამულო და უცხოური შრომების ბიბლიოგრაფიული სია (ბოლო 5-8 წლის სიღრმით). ანბანური წყობით წარმოდგენილ ბიბლიოგრაფიულ სიაში მიუთითეთ ჯერ სამამულო, შემდეგ უცხოელი ავტორები (გვარი, ინიციალები, სტატიის სათაური, ჟურნალის დასახელება, გამოცემის ადგილი, წელი, ჟურნალის №, პირველი და ბოლო გვერდები). მონოგრაფიის შემთხვევაში მიუთითეთ გამოცემის წელი, ადგილი და გვერდების საერთო რაოდენობა. ტექსტში კვადრატულ ფჩხილებში უნდა მიუთითოთ ავტორის შესაბამისი N ლიტერატურის სიის მიხედვით. მიზანშეწონილია, რომ ციტირებული წყაროების უმეტესი ნაწილი იყოს 5-6 წლის სიღრმის.

9. სტატიას თან უნდა ახლდეს: ა) დაწესებულების ან სამეცნიერო ხელმძღვანელის წარდგინება, დამოწმებული ხელმოწერითა და ბეჭდით; ბ) დარგის სპეციალისტის დამოწმებული რეცენზია, რომელშიც მითითებული იქნება საკითხის აქტუალობა, მასალის საკმაობა, მეთოდის სანდოობა, შედეგების სამეცნიერო-პრაქტიკული მნიშვნელობა.

10. სტატიის ბოლოს საჭიროა ყველა ავტორის ხელმოწერა, რომელთა რაოდენობა არ უნდა აღემატებოდეს 5-ს.

11. რედაქცია იტოვებს უფლებას შეასწოროს სტატია. ტექსტზე მუშაობა და შეჯერება ხდება საავტორო ორიგინალის მიხედვით.

12. დაუშვებელია რედაქციაში ისეთი სტატიის წარდგენა, რომელიც დასაბეჭდად წარდგენილი იყო სხვა რედაქციაში ან გამოქვეყნებული იყო სხვა გამოცემებში.

აღნიშნული წესების დარღვევის შემთხვევაში სტატიები არ განიხილება.

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Содержание:

GEORGIAN MEDICAL NEWS
No 1 (370) 2026

ARM-ICG IN THE PREVENTION OF LYMPHEDEMA AFTER SURGICAL TREATMENT OF BREAST CANCER

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Abstract.

Objective: To evaluate the effectiveness of *Axillary Reverse Mapping* (ARM) using indocyanine green (ICG) during axillary lymph node dissection (ALND) in breast cancer (BC) patients, aimed at preventing postoperative upper limb lymphedema.

Materials and Methods: A prospective study included 128 female patients with invasive breast cancer who underwent surgical treatment at the University Hospital of Odesa National Medical University. The control groups underwent sentinel lymph node biopsy (SLNB) or standard ALND, whereas the study group underwent ARM-ICG with intraoperative visualization of upper limb lymphatic pathways. Lymphedema was assessed at 1, 3, 6, and 12 months postoperatively.

Results: ARM-ICG provided clear visualization of lymphatic collectors in 94% of cases and reduced the rate of postoperative lymphedema to 5%, which was significantly lower than after conventional ALND (42.9%, $p < 0.001$). In the SLNB-only group, lymphedema occurred in 9.4% of patients. The use of ARM-ICG did not compromise oncologic radicality or increase the risk of residual disease.

Conclusions: The application of ARM-ICG in surgical management of breast cancer effectively decreases the risk of postoperative lymphedema by preserving upper extremity lymphatic drainage without loss of oncologic control. The technique demonstrates high clinical relevance and may be recommended for routine inclusion in the comprehensive treatment of breast cancer patients.

Key words. Breast cancer, ARM-ICG, axillary reverse mapping, lymphedema, axillary lymph node dissection, sentinel lymph node biopsy, prevention of postoperative complications.

Introduction.

Breast cancer remains the most common oncological disease among women in Ukraine. Each year, approximately 14–18 thousand new cases are diagnosed nationwide, although the COVID-19 pandemic and wartime disruptions have significantly affected reporting accuracy of new diagnoses [1]. It should be noted that the majority of early-stage cases (about 60–70%) are not accompanied by metastasis to axillary lymph nodes, making such patients potential candidates for *sentinel lymph node biopsy* (SLNB) and therefore suitable for preservation of arm lymphatic drainage [2,3]. Today, SLNB has become the standard approach for patients with clinically node-negative disease [4,5]. This method allows for omission of axillary lymph node dissection (ALND) in node-negative cases and, in certain clinical contexts, even in patients with one or two positive nodes when breast-conserving or radical mastectomy is followed by adjuvant radiotherapy to the axilla. The risk of lymphostasis with this strategy rarely exceeds 5% [6]. However, ALND remains essential for achieving local control in patients with clinically node-positive disease or those with a high tumor burden [7]. In such cases, radical axillary surgery minimizes the risk of recurrence but leads to partial or complete disruption of upper extremity lymphatic drainage in approximately 18–30% of patients [8]. A major advancement in modern breast cancer management is the introduction of *neoadjuvant chemotherapy* (NAC) [9,10]. NAC can achieve complete pathological response in a considerable proportion of patients, especially in HER2-positive and triple-negative subtypes [11,12]. This response allows for surgical de-escalation and consequently reduces the risk of secondary lymphedema — one of the most frequent and debilitating postoperative complications. A promising preventive strategy is *Axillary Reverse Mapping* (ARM) [13], which enables intraoperative identification and preservation of lymphatic channels that drain the upper extremity during ALND, without compromising oncologic radicality. ARM is particularly beneficial in node-negative cases; in node-positive cases, traditional ALND remains preferred because preservation of ARM-identified collectors may carry a residual metastatic risk. Nevertheless, in patients achieving nodal pathologic response after NAC, ARM may combine oncologic safety with lymphedema prevention [13]. Therefore, the integration of neoadjuvant therapy, sentinel node biopsy, and ARM techniques in breast cancer surgery may reduce postoperative complications without compromising therapeutic efficacy. The aim of the study was to evaluate the possibility of preserving upper limb lymphatic drainage when using axillary reverse mapping with indocyanine green (ARM-ICG) in patients with breast cancer and to compare the incidence of postoperative lymphedema with that in patients who underwent sentinel lymph node biopsy (SLNB) and with traditional axillary lymphadenectomy.

Materials and Methods.

Study Design and Patient Characteristics: A prospective single-center study was conducted to evaluate the efficacy of indocyanine green (ICG)-guided *Axillary Reverse Mapping* (ARM) for intraoperative identification of upper limb lymphatic pathways aiming to prevent postoperative lymphedema in patients undergoing mastectomy with axillary lymph node dissection.

A total of 128 female patients with primary invasive breast cancer were enrolled, all treated at the surgical department of the University Clinic (Center for Reconstructive and Restorative Medicine) of Odesa National Medical University. Patient ages ranged from 31 to 72 years (mean age 52.4 ± 8.1 years). Prior to therapy, all patients underwent comprehensive clinical and diagnostic evaluation, including physical examination, mammography or breast and axillary ultrasonography. When lymph node involvement was suspected, ultrasound-guided fine-needle aspiration biopsy (US-FNAB) was performed. Nodes with cytologically confirmed metastases were preoperatively marked prior to the initiation of neoadjuvant chemotherapy for selective dissection at a later stage. Subjective symptoms (feelings of heaviness, tension, discomfort in the upper limb) were assessed by a standardized questionnaire during a follow-up visit 12 months after surgery.

Distribution by Molecular Subtypes:

Molecular Subtype	%	Number of Patients
Luminal A	38	49
Luminal B ($HER2^+$)	14	18
Luminal B ($HER2^-$)	19	24
Non-luminal ($HER2^+$)	15	19
Triple-negative	14	18
Total	**100**	**128**

Clinical Group Classification: Based on the clinical status of axillary lymph nodes and prior therapy, patients were divided into three groups:

- **Control Group I (57%, n = 53):** patients with clinically negative

axillary lymph nodes who underwent sentinel lymph node biopsy only, without neoadjuvant chemotherapy.

- **Control Group II (12%, n = 35):** patients with N2–N3 lymphadenopathy who underwent full axillary lymph node dissection after NAC without ARM, due to high residual metastatic risk.
- **Study Group (31%, n = 40):** patients with N1 disease who had metastatic nodes pre-marked before NAC and subsequently underwent selective axillary dissection with preservation of identified lymphatic pathways, provided a complete pathological response was achieved.

The study group was formed for the purpose of comparison with control group 1, since both groups used limited axillary intervention, which allowed to evaluate the effect of ARM-ICG on preservation of lymphatic drainage of the upper limb without confounding related to the extent of lymphoedema.

Control group 2 was considered as a reference group with an expected high incidence of lymphedema after complete axillary lymphoedema.

ARM-ICG Technique: On the day of surgery, two consecutive injections of indocyanine green (ICG) were administered under local anesthesia:

1. **Periareolar injection** — into the tumor quadrant to visualize lymphatic drainage of the breast and sentinel nodes (SLN).
2. **Subcutaneous injection** — into the middle section of the medial upper arm to visualize lymphatic drainage of the upper extremity (ARM).

Visualization was performed using a near-infrared (NIR) camera system (excitation 750–810 nm, emission 830–840 nm) 5–10 minutes post-injection. ARM signal fluorescence persisted for 30–45 minutes, providing an optimal operating window for dissection.

A light green or mixed fluorescent signal corresponded to breast sentinel nodes, while a bright green signal indicated lymphatic collectors of the upper extremity.

Surgical Technique: In the study group, all ARM nodes identified by ICG were subjected to intraoperative visual and palpatory assessment. In cases where the ARM node anatomically coincided with the lymphatic collectors of the breast (crossover) or had macroscopic signs of possible tumor lesion, a decision was made to remove it with subsequent histological examination. In the absence of such signs, the ARM nodes were preserved.

After developing the axillary space, intraoperative identification of breast and upper-limb lymphatic pathways was performed under ICG fluorescence guidance. Lymphatic collectors not intersecting with breast drainage pathways were preserved. If a collector crossed or passed through a metastatic node, it was resected to maintain oncologic radicality.

- Patients without clinical lymph node involvement underwent SLNB only.
- Patients with N1 disease and complete pathological response after NAC underwent selective axillary dissection with preservation of limb lymphatic drainage.
- In patients with residual nodal metastasis, full ALND was performed without lymphatic preservation.

Lymphedema Assessment: Upper extremity circumference was measured preoperatively and at 1, 3, 6, and 12 months after surgery.

Lymphedema was defined as a >2 cm circumference difference or >10% volume increase compared with the contralateral arm. Subjective symptoms, such as heaviness, tightness, and paresthesia, were also recorded.

Statistical Analysis: Data analysis was performed using *Statistica 13.3* and *SPSS v.26*. Categorical variables were compared using Pearson's χ^2 test, and correlations were analyzed by Spearman's method. Differences were considered statistically significant at $p < 0.05$.

Results.

Morphological Characteristics of Tumors: Among the 128 included patients, invasive ductal carcinoma accounted for 87% of cases, invasive lobular carcinoma for 9%, and other histologic variants (medullary, micropapillary, metaplastic carcinoma) for 4%. Most tumors were grade II (G2) — 68%, followed by G1 (14%) and G3 (18%).

Lymphovascular invasion was detected in 52% of cases and correlated with the frequency of axillary lymph node metastasis ($r = 0.46$; $p < 0.01$).

The molecular profile was largely dominated by luminal subtypes (71%), with Luminal A being the most prevalent (38%). Triple-negative and non-luminal HER2-positive subtypes accounted for 14% and 15%, respectively, both associated with more aggressive tumor behavior and higher rates of regional metastases (N1–N3).

Visualization of Lymphatic Pathways Using ARM-ICG: Intraoperative mapping with indocyanine green (ICG) provided clear visualization of upper-extremity lymphatic collectors in 94% of patients in the study group (n = 40).

The mean time to fluorescence visualization was 6.8 ± 1.9 minutes, and the ARM signal remained stable for 30–45 minutes, offering an optimal window for selective dissection.

ARM collectors were most frequently located medial to the thoracodorsal nerve (73%) and lateral to the pectoral nerve (24%), defining reproducible "safe zones" for lymphatic preservation during ALND.

In 3% of cases, fluorescence could not be visualized due to anatomical variation or technical error during the mapping procedure.

Frequency of Axillary Lymph Node Involvement:

In **Control Group I** (SLNB only, without NAC), metastatic involvement was found in 3 patients (5.6%), who consequently underwent targeted node excision and received systemic chemotherapy.

In **Control Group II**, all 35 patients received several cycles of neoadjuvant polychemotherapy. Eleven patients (31%) showed minimal or no response to treatment, while 24 patients (69%) demonstrated partial regression; complete clinical response was not achieved in this group. All subsequently underwent full ALND followed by systemic therapy continuation.

In the **Study Group**, after NAC completion, complete clinical response in the axilla was documented in 37 patients (92.5%). These patients underwent ARM-ICG-assisted selective axillary dissection to identify and preserve lymphatic pathways draining the upper extremity.

In the study group (n = 40), ARM-ICG allowed the identification of lymphatic collectors of the upper limb in 100% of cases. In 2 (5.0%) patients, an anatomical crossover of the lymphatic pathways of the upper limb and the breast was detected. In these cases, the ARM nodes were resected for oncological reasons. According to the results of the final histological examination, no metastatic lesion was detected in the resected ARM nodes. In the remaining 38 (95.0%) patients, the ARM nodes were preserved, and no signs of tumor lesion were recorded.

In the study group, standard axillary lymphadenectomy within levels I–II was performed after neoadjuvant chemotherapy in accordance with current oncosurgical recommendations.

A special feature of the intervention was the use of axillary reverse mapping technology using indocyanine green (ARM-ICG), which allowed intraoperative identification of the lymphatic collectors of the upper limb and, in the absence of their involvement in the tumor process, to preserve them. No purposeful reduction in the volume of dissection or exclusion of anatomical zones of the axillary area was performed. The average number of removed axillary lymph nodes in the study group did not differ statistically significantly from the control group II ($p > 0.05$), which indicates a comparable volume of surgical intervention.

Within the 12-month observation period, no locoregional recurrences or distant metastases were recorded in any of the groups; at the same time, the duration of observation does not allow drawing definitive conclusions about the long-term oncological safety of the applied technique.

Frequency and degree of postoperative lymphedema:

The assessment of the presence and degree of postoperative lymphedema was performed 12 months after surgery. The incidence of this complication differed significantly between clinical groups ($p < 0.01$), indicating the influence of both the volume of axillary intervention and the surgical tactics used.

In control group I (n = 53), where only sentinel lymph node biopsy was performed without neoadjuvant therapy, lymphedema was registered in 5 (9.4%) patients. In most cases, it corresponded to grade I severity - 4 (7.5%), while grade II was noted in only one patient (1.9%).

In control group II (n = 35), after neoadjuvant chemotherapy, a partial clinical effect was observed in 70% of patients, while in 30% there was no response to treatment, which necessitated the performance of a complete axillary lymphadenectomy. In this group, the frequency of lymphedema was the highest and amounted to 15 (42.9%) cases, with a predominance of grade II severity — 11 (31.4%). Grade I was recorded in 3 (8.6%) patients, grade III — in one (2.9%).

In the study group (n = 40), where after neoadjuvant therapy in 92% of patients a complete clinical and morphological response was achieved, the use of ARM-ICG allowed intraoperative identification and preservation of the main lymphatic pathways of the upper limb. Lymphedema was detected in only 2 (5.0%) patients, and in both cases it corresponded to grade I severity and was not accompanied by pronounced functional disorders.

Group	n	Grade I	Grade II	Grade III	Total (%)
Control I	53	4 (7.5%)	1 (1.9%)	—	5 (9.4%)
Control II	35	3 (8.6%)	11 (31.4%)	1 (2.9%)	15 (42.9%)
Study	40	2 (5%)	—	—	2 (5%)

Subjective symptoms characteristic of lymphedema were significantly more frequently recorded in patients of control group II. A feeling of heaviness or tension in the upper limb was noted by 13 (37.1%) patients of this group, which correlated with the presence of objectively confirmed edema. In control group I, such complaints were recorded in 4 (7.5%) patients, while in the study group - only in 2 (5.0%) cases, which corresponded to minimal changes in limb circumference. Thus, subjective symptoms were consistent with the data of objective measurements and reflected the real functional impact of lymphedema.

Comparative analysis showed that the incidence of postoperative lymphedema in the ARM-ICG group was statistically significantly lower compared to control group II (5.0% vs. 42.9%; $p < 0.01$). At the same time, when compared with control group I, where sentinel lymph node biopsy was used, no significant differences were found (5.0% vs. 9.4%; $p > 0.05$).

Thus, the use of ARM-ICG is associated with a low incidence of postoperative lymphedema, comparable to rates after limited axillary interventions and significantly lower than after traditional axillary lymphadenectomy, which confirms the feasibility of using this technology in selected categories of patients.

Postoperative Complications: The most frequent early postoperative complications were seroma formation and mild lymphedema, correlated with the extent of surgical dissection and reconstructive technique used.

In Group I, seroma occurred in 8 patients (26.7%); in Group II — in 11 (36.7%); and in the ARM-ICG group (with reconstructive flap use) — only in 3 (10%).

These results indicate that use of reconstructive flap techniques significantly reduces seroma formation by improving local tissue perfusion and eliminating postoperative dead space.

The highest lymphedema incidence was observed in Group II, where treatment included both ALND and radiotherapy. Conversely, incorporation of ARM-ICG and reconstructive surgery notably decreased both incidence and severity of this complication.

Overall, the highest complication rate occurred among patients who underwent standard ALND following systemic therapy. The combination of ARM-ICG and reconstructive techniques significantly improved postoperative outcomes by lowering both seroma and lymphedema rates.

Discussion.

Lymphedema of the upper limb remains one of the most common and clinically significant complications of surgical treatment of breast cancer. Its development is due not only to the mechanical removal of regional lymphatic collectors, but also to a complex of pathophysiological changes, including cicatricial-fibrotic transformation of tissues in the intervention area, damage to small lymphatic vessels, compression of preserved lymphatic pathways, and impaired microcirculation. The combined effect of these factors leads to progressive impairment of lymphatic outflow and the formation of chronic edema [2,3,7].

The results of the study indicate that the frequency and degree of postoperative lymphedema are determined primarily by the volume of axillary surgical intervention and the degree of damage to lymphatic structures. Thus, in control group II, where a significant part of the patients underwent complete axillary lymphadenectomy after neoadjuvant chemotherapy, lymphedema was recorded in 42.9% of cases with a predominance of clinically significant forms of grade II–III. In contrast, in control group I, where the scope of intervention was limited to sentinel lymph node biopsy, the frequency of lymphedema was significantly lower (9.4%) and was characterized by only mild manifestations.

In the study group, the use of ARM-ICG was associated with the lowest frequency of postoperative lymphedema — 5%, and in all cases, it corresponded to grade I severity. It is important to emphasize that these indicators were comparable to the results after sentinel lymph node biopsy and significantly better than after traditional axillary lymphadenectomy. This demonstrates the potential of ARM-ICG as a tool for preserving lymphatic pathways in selected patient categories, especially in conditions of limited axillary intervention.

Special clinical attention is deserved by observations in patients in whom zones of anatomical “crossing” of lymphatic collectors of the upper limb and breast were detected during ARM-ICG. It was among this subgroup that both cases of lymphedema were registered, which emphasizes the anatomical vulnerability of the areas of intersection of lymphatic pathways and the critical role of their intraoperative visualization. At the same time, even in these patients, clinical manifestations of edema were minimal, which may be associated with partial preservation of peripheral lymphatic vessels, formation of collateral drainage and less traumatic nature of the ARM technique compared to classical lymphodissection.

It is important to emphasize that the decrease in the incidence of postoperative lymphedema in the ARM-ICG group was not a consequence of a decrease in the volume of axillary dissection. Interventions were performed within the standard anatomical limits of levels I–II, similarly to the control group II. The difference was solely in the possibility of intraoperative identification and preservation of the lymphatic collectors of the upper limb, which probably caused the preventive effect on the development of lymphedema.

The detection of cases of anatomical crossing of the lymphatic collectors of the upper limb and the breast is of fundamental clinical importance. It was in these two patients, where the ARM nodes were resected through the crossover, that lymphedema developed in the postoperative period. This confirms that it is not the fact of using ARM itself, but the

impossibility of preserving the lymphatic pathways of the limb in conditions of anatomical overlap that limits the preventive potential of the technique. At the same time, even in such cases, lymphedema was only minimal, which indicates partial preservation of lymphatic drainage.

The results obtained should be interpreted taking into account the limited duration of observation. The absence of locoregional recurrences in the short term may indicate the preservation of surgical radicality of the intervention, but does not provide a basis for definitive conclusions about the oncological safety of ARM-ICG in the long term.

It cannot be completely ruled out that the lower incidence of lymphedema in the study group is partly due to the lower tumor burden after neoadjuvant therapy and, accordingly, the potentially less traumatic course of axillary dissection. At the same time, even under these conditions, the use of ARM-ICG allowed visualization and preservation of the lymphatic collectors of the upper limb, which, in our opinion, played an independent role in reducing the risk of lymphedema.

Statistical Analysis and Comparative Outcomes: Intergroup comparison of lymphedema rates was performed using Pearson's chi-square and Fisher's exact tests.

Pairwise comparison of lymphedema incidence between the experimental group and control group 1 revealed no statistically significant differences (5.0% vs. 9.4%; $\chi^2 = 0.16$; $p = 0.68$; Fisher's exact test $p = 0.70$). At the same time, the incidence of lymphedema in control group 2 was significantly higher compared to the experimental group (42.9% vs. 5.0%; $\chi^2 = 13.18$; $p < 0.001$; Fisher's $p = 0.0002$). After Bonferroni correction ($\alpha = 0.025$), the difference remained statistically significant.

These results demonstrate that ARM-ICG substantially reduces postoperative lymphedema risk compared with conventional ALND, reaching rates similar to those of SLNB alone. This supports the high preventive value and oncologic safety of the ARM-ICG technique in surgical breast cancer management.

Conclusion.

1. The incidence and severity of postoperative upper-limb lymphedema directly depend on the extent of surgery and the degree of anatomical disruption of lymphatic collectors.
2. Among patients who underwent sentinel lymph node biopsy (SLNB) only, lymphedema occurred in 9.4% of cases and was limited to mild grades of severity.
3. Complete axillary lymph node dissection (ALND) significantly increased lymphedema incidence (42.9%), predominantly grade II, underscoring the clinical importance of surgical extent and postoperative scarring in the axilla.
4. The use of ARM-ICG allows for preservation of upper-limb lymphatic pathways, reducing lymphedema incidence to 5%, with only mild manifestations even when partial crossing of breast and arm lymphatic collectors occurred.
5. Statistical analysis confirmed a significant reduction in postoperative lymphedema risk using ARM-ICG compared with traditional ALND ($p < 0.001$), demonstrating the high preventive efficacy of this technique in maintaining lymphatic drainage without compromising oncologic radicality.

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