PHOTODYNAMIC THERAPY OF BASAL CELL CARCINOMA OF THE FACE H-ZONE

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Abstract

This article reviews clinical experience in treating skin neoplasms using photodynamic therapy with combined ultrasound and fluorescence diagnostics for neoplasms in the nose, lateral face, and adjacent areas. Injectable forms of chlorine-type drugs were used as photosensitizers – photoditazine or photoran at a dose of 0.7 to 2.5 mg per kilogram of patient body weight. The drug was administered intravenously for 30 minutes 2.5-3.0 hours before tumor irradiation. Of 107 observations over a 9-month observation period, one case of marginal tumor recurrence in the treatment area was detected. Thus, the recurrence rate was 0.93%. The results show that three-dimensional tumor visualization for the H-zone with complex noninvasive diagnostics allows achieving high efficiency in photodynamic therapy of non-melanoma tumors of the above anatomical localizations.

Keywords: ultrasound navigation; fluorescence diagnostics; laser spectroscopy; non-melanoma skin tumors, laser spectroscopy, non-invasive monitoring.

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ФОТОДИНАМИЧЕСКАЯ ТЕРАПИЯ БАЗАЛЬНОКЛЕТОЧНОГО РАКА КОЖИ Н-ЗОНЫ ЛИЦА

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Резюме

В данной статье рассмотрен клинический опыт лечения новообразований кожи методом фотодинамической терапии с сочетанной ультразвуковой и флуоресцентной диагностикой для новообразований в зоне носа, боковой поверхности лица и смежных областей. В качестве фотосенсибилизатора применяли инъекционные формы препаратов хлоринового ряда, фотодитазин или фоторан, в дозе от 0,7 до 2,5 мг на килограмм массы тела пациента. Препарат вводили внутривенно в течение 30 мин за 2,5-3,0 ч до начала облучения опухоли. Из 107 наблюдений при сроке наблюдения 9 мес выявлен один случай краевого рецидива опухоли в зоне лечения. Таким образом, частота возникновения рецидивов составила 0,93%. Полученные результаты показывают, что трехмерная визуализация опухоли для Н-зоны с комплексной неинвазивной диагностикой позволяет достичь высокой эффективности при фотодинамической терапии немеланомных опухолей вышеуказанных анатомических локализаций.

Ключевые слова: ультразвуковая навигация; флуоресцентная диагностика; лазерная спектроскопия; немеланомные опухоли кожи, лазерная спектроскопия, неинвазивный мониторинг.

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Introduction

In the Russian Federation, for the period from 2013 to 2023, the crude incidence rate (both sexes) of non-melanoma skin cancers increased from 46.09 to 62.79 cases per 100,000 population. The growth rate for the specified period was 15.44% [1]. For non-melanoma tumors, a wide range of surgical and non-surgical treatment methods are used in accordance with clinical guidelines [2]. Photodynamic therapy (PDT) is one of such methods [2-5]. The desire for uniformity and standardization of clinical treatment protocols are key steps to the implementation of current recommendations for the effective use of PDT in oncology. It is known that up to 90% of all non-melanoma skin cancers are localized on the face [2]. The emerging need for gentle, organ-preserving approaches increases the relevance of PDT in the clinical practice of an oncologist. The key objective of therapy is to achieve a good cosmetic result while maintaining antitumor efficacy. It is also necessary to take into account that critical loss of fluorescent radiation (photobleaching) occurs during photodynamic reactions. The practical significance of fluorescence diagnostics (FD) is due to the ability of a photosensitizer (PS) to selectively accumulate in malignant neoplasms relative to surrounding healthy tissues, creating a fluorescent contrast [6]. High-resolution ultrasound with assessment of tumor microvascularization can be a valuable tool for clarifying neoplasm characteristics such as thickness, contours, echostructure, and prevalence [3].

Combining therapeutic and diagnostic capabilities into a single technology will help personalize the selection of energy parameters for laser exposure and monitor PDT in real time.

Materials and methods

A total of 107 cases of clinical observations of ultrasound-guided PDT of epithelial malignant tumors in patients of both sexes and different age groups with basal cell skin cancer were selected for participation in the study. They underwent inpatient treatment in the fluorescence diagnostics and photodynamic therapy room from November 2023 to March 2024. During the ultrasound-guided PDT procedure, injectable forms of chlorine photosensitizers – photoditazine or photoran were used at a dosage of 0.7 to 2.5 mg per kilogram of patient body weight. The drug was administered intravenously for 30 minutes 2.5-3.0 hours before the start of tumor irradiation. The average age of patients was 73 years. The tumors were divided into comparable groups based on indicators regarding high-risk zones of recurrence, ultrasound characteristics, local fluorescence data, and laser exposure parameters. During PDT, high-resolution ultrasound examination was performed on an expert-class Philips Epic 7 device using MFI technology. At the next stage, FD was performed in the blue and red spectrum ranges in real time using PDT apparatus "Harmony" and UFF630/675-01 (video LED phototherapeutic fluorescence devices), as well as a LESA-01 laser fiber-optic spectrometer. For the laser irradiation session, a Lakhta-Milon model 662–2.8 device (OOO Kvalitek, MILON laser LLC group of companies, St. Petersburg, Russia, registration certificate of the Federal Service for Supervision of Health, Safety and Social Development No. FS 02262003/2932-06) with a wavelength of 662 nm was used. Light was delivered to the tumor using a certified light guide with macrolenses (manufactured by OOO Polironik, Moscow, Russia). The light dose and power density were 100-250 J/cm^2. All PDT and FD procedures were performed in specially equipped rooms in accordance with the requirements of the "Sanitary Norms and Rules for the Installation and Operation of Lasers" No. 5804-91. Further clinical observations were carried out 3, 6 and 9 months after PDT under ultrasound navigation in an outpatient care center.

Results

In a retrospective study, cases of non-melanoma skin cancer were analyzed in a group of patients with tumors located in the H-zone of the face. With respect to the anatomical areas, the neoplasms were divided into three groups: group 1 – nasal zone (n=44), group 2 – lateral face surface zone (n=33) and group 3 – adjacent localization zone (n=30). All patients from the studied groups underwent expert-class ultrasound examination with an assessment of the ultrasound characteristics of thickness and prevalence (Fig. 1).

The diagnostic results showed that the thickness of the formations in the nasal area averaged 2.1 mm (minimum 1.5 mm, maximum 3 mm). As for the prevalence of neoplasms in this area, the average value was 9 mm, with a minimum value of 6.38 mm and a maximum value of 12.25 mm. In the area of the lateral surface of the face and adjacent localizations, the thickness of the neoplasms was slightly smaller, averaging 1.8 mm (with a minimum thickness of 1.35 mm and a maximum of 2.6 mm). The prevalence rates in these areas were 9.7–10 mm (minimum 7.5 mm, maximum 13 mm) (Table 1).

After ultrasound navigation, local fluorescence imaging was performed in the blue and red spectral ranges. During local fluorescence spectroscopy (HeNe laser, 632.8 nm), the degree of PS accumulation was assessed using calculations of the fluorescence contrast "tumor/healthy tissue" based on average fluorescence intensity values (Fig. 2).

PDT in combination with ultrasound diagnosis and FD demonstrated high efficiency in dynamic observation of 107 cases of skin neoplasms for 9 months after therapy. The observation periods for patients from the specified groups were divided into time periods in accordance with the schedule. The first period was from 1 week to 3 months, the

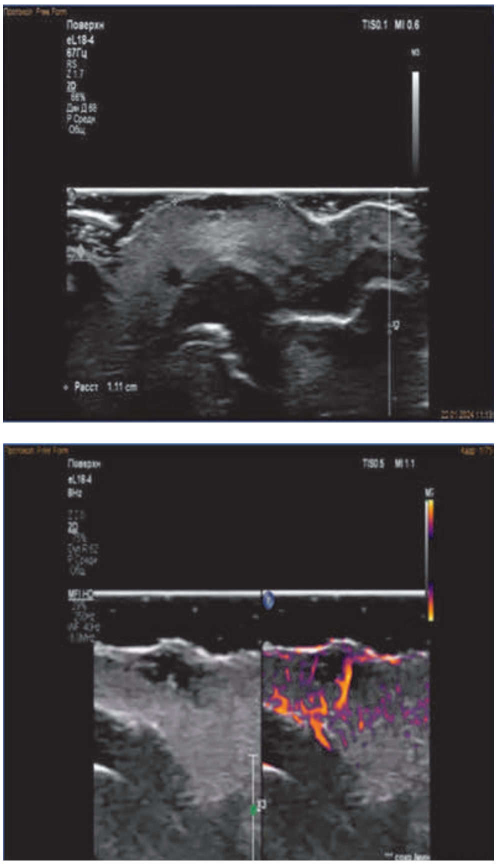

Рис. 1. Пример ультразвукового исследование высокого разрешения на аппарате экспертного класса Philips Epic 7 с использованием технологии MFI перед ФДТ: a – внутрикожное гипоэхогенное неоднородное с неровными нечеткими контурами образование, горизонтальными размерами (протяженность) не менее 11 мм; b – толщина образования 2,8 мм, активный центральный и периферический сосудистый рисунок.
Fig. 1. Example of high-resolution ultrasound examination on the Philips Epic 7 expert class device using MFI technology before PDT: a – intradermal hypoechogenic inhomogeneous formation with uneven fuzzy contours; horizontal dimensions (extent) not less than 11 mm; b – thickness of the formation 2.8 mm, active central and peripheral vascular pattern.

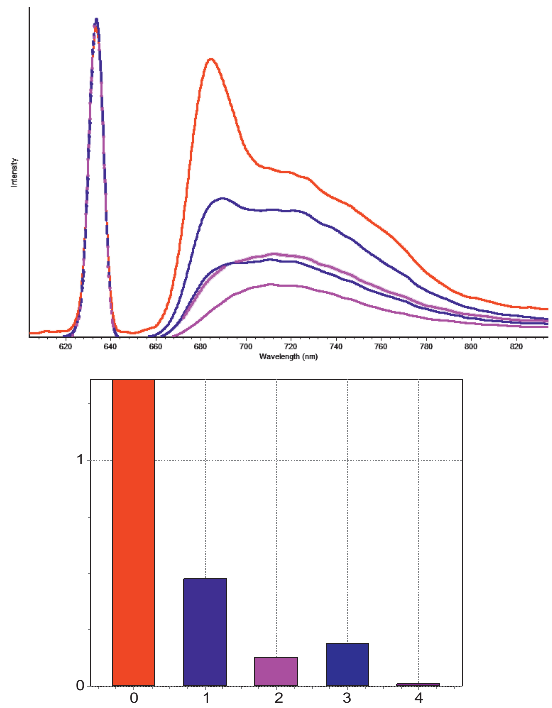

Рис. 2. Спектры флуоресценции и соответствующие им гистограммы, характеризующие интенсивность флюоресценции (возбуждение HeNe-лазер, 632,8 нм): 1 – (красный) – флуоресценция опухоли через 3 часа после введения ФС; 2 – (синий) – флуоресценция опухоли после первого этапа облучения (100 Дж/см²); 3 – (розовый) – флуоресценция опухоли после второго этапа облучения (50 Дж/см²); 4 – (темно-синий) – флуоресценция нормальной кожи пациента (контроль 1); 5 – (фиолетовый) – флуоресценция кожи врача (контроль 2).
Фотосенсибилизатор: фотолон, доза 2,0 мг/кг веса. Флуоресцентная контрастность ~6 . Облучение 662 нм, 250 мВт/см².
Fig. 2. Fluorescence spectra and their corresponding histograms characterising fluorescence intensity (HeNe-laser excitation, 632.8 nm): 1 – (red) – tumour fluorescence 3 hours after PS injection; 2 – (blue) – tumour fluorescence after the first stage of irradiation (100 J/cm²); 3 – (pink) – tumour fluorescence after the second stage of irradiation (50 J/cm²); 4 – (dark blue) – fluorescence of the patient's normal skin (control 1); 5 – (violet) – fluorescence of the doctor's skin (control 2).
Photosensitiser: fotolon, dose 2.0 mg/kg weight. Fluorescence contrast ~6 . Irradiation at 662 nm, 250 mW/cm².

Таблица 1.
Характеристики опухолей (толщина и распространенность) и площади лазерного воздействия в зависимости от локализации опухоли

Table 1.
Tumor characteristics (thickness and extent) and laser treatment areas depending on tumor location

Группа Group	n	Толщина образования, мм Formation thickness, mm		Размеры (протяженность), мм Dimensions (length), mm		Общая площадь лазерного воздействия Total laser treatment area	
		Me	$Q_1 - Q_3$	Me	$Q_1 - Q_3$	Me	$Q_1 - Q_3$
Область боковой поверхности лица Lateral facial surface area	33	1,8	1,35 – 2,60	9,7	7,50 – 13,00	3	3 – 5
Область носа Nasal region	44	2,1	1,51 – 3,00	9	6,38 – 12,25	3	3– 5
Область смежных локализаций Area of related localisations	30	1,8	1,32 – 2,50	10	7,70 – 12,00	3	3 – 5

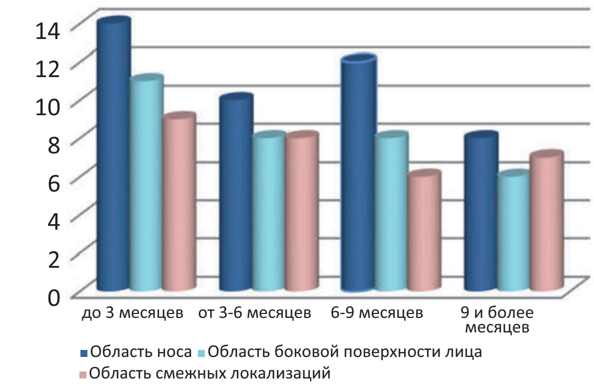

Рис. 3. **Распределение новообразований кожи для исследуемых групп согласно графику динамического наблюдения.**
Fig. 3. **Distribution of skin neoplasms for the studied groups according to the dynamic observation schedule.**

second – from 3 to 6 months, the third – from 6 to 9 months, and the fourth – from 9 months and more (Fig. 3).

All patients underwent regular monitoring, which allowed for timely detection of relapse and provision of the necessary subsequent treatment. Of the 107 observations, 106 cases of relapse-free observation and one case of marginal tumor relapse in the treatment area 9 months after PDT were identified. Thus, the relapse rate was 0.93%. Registration of one relapse of the disease (0.93%) during the specified observation period indicates the high therapeutic efficiency of PDT.

Fig. 4 shows an example of the result obtained 9 months after PDT under ultrasound navigation of a skin neoplasm on the bridge of the nose.

Рис. 4. **Результат лечения пациента через 9 мес после ФДТ под УЗ-навигацией новообразования кожи спинки носа. Фотосенсибилизатор: фотолон, доза 2,0 мг/кг веса. Облучение 662 нм, 250 мВт/см^2.**
Fig. 4. **Patient's treatment result 9 months after PDT under ultrasound guidance of dorsal nasal skin neoplasm. Photosensitiser: Fotolon, dose 2.0 mg/kg body weight. Irradiation at 662 nm, 250 mW/cm^2.**

Conclusion

The study confirmed that PDT is a highly effective method for treating basal cell skin cancer, including tumor foci localized on the skin of the H-zone of the face. At the same time, three-dimensional visualization of the tumor for the H-zone with complex non-invasive diagnostics had an advantage in PDT of non-melanoma tumors of the above anatomical localizations.

REFERENCES

1. The state of oncological care for the Russian population in 2023. Edited by Kaprina A.D., Starinsky V.V., Shakhzadova A.O. Malignant neoplasms in Russia in 2023 (morbidity and mortality) – Moscow: P.A. Herzen Moscow Medical Research Institute – branch of the Federal State Budgetary Institution «NMITS of Radiology» of the Ministry of Health of the Russian Federation. Moscow, 2024, pp.14.
2. Basal cell carcinoma of the skin. Clinical recommendations. Association of Oncologists of Russia. Association of Melanoma Specialists. All-Russian public organization «Russian Society of Clinical Oncology». All-Russian public organization «Association of Ophthalmologists». Russian Federation 2024 (Russia), pp. 26-47.
3. Kapinus V.N., Kaplan M.A., Sokol N.I. Predictors of recurrence of basal cell carcinoma of the skin after photodynamic therapy with photolon photosensitizer. *Laser medicine,* 2019, pp. 28-37.
4. Filonenko E.V., Ivanova-Radkevich V.I. Fluorescence diagnostics in non-melanocytic skin tumors. *Biomedical Photonics*, 2022, pp. 32-40.
5. Kapinus V.N., Kaplan M.A., Yaroslavtseva-Isaeva E.V. [et al.] Photodynamic therapy as a treatment option for skin cancer that has developed on scars. *Laser medicine*, 2020, Vol. 24(4), pp. 54-61.
6. Khoruzhaya S.S., Vasiliev A.Yu., Semin V.E., Nechaev V.A. High – resolution ultrasound examination during photodynamic therapy of basal cell carcinoma of the head and neck. *Radiology – practice*, 2025, pp.12-26.

ЛИТЕРАТУРА

1. Состояние онкологической помощи населению России в 2023 году. Под ред. А.Д. Каприна, В.В. Старинского, А.О. Шахзадовой. Злокачественные новообразования в России в 2023 году (заболеваемость и смертность) – М.: МНИОИ им. П.А. Герцена – филиал ФГБУ «НМИЦ радиологии» Минздрава России. Москва. – 2024. – С.14.
2. Базальноклеточный рак кожи. Клинические рекомендации. Ассоциация онкологов России. Ассоциация специалистов по проблемам меланомы. Общероссийская общественная организация «Российское общество клинической онкологии». Общероссийская общественная организация «Ассоциация врачей-офтальмологов». РФ 2024 г. (Россия). – С. 26-47.
3. Капинус В.Н., Каплан М.А., Сокол Н.И. Предикторы рецидивов базальноклеточного рака кожи после проведения фотодинамической терапии с фотосенсибилизатором фотолон // Лазерная медицина. – 2019. – С. 28-37.
4. Филоненко Е.В., Иванова-Радкевич В.И. Флуоресцентная диагностика при немеланоцитарных опухолях кожи // Biomedical Photonics. – 2022 г. – С. 32-40.
5. Капинус В.Н., Каплан М.А., Ярославцева-Исаева Е.В. [и др.] Фотодинамическая терапия как вариант лечения рака кожи, развившегося на рубцах // Лазерная медицина. – 2020. – Т. 24, № 4. – С. 54-61.
6. Хоружая С.С., Васильев А.Ю., Семин В.Е., Нечаев В.А. Ультразвуковое исследование высокого разрешения при проведении фотодинамической терапии базальноклеточного рака головы и шеи // Радиология — практика. – 2025 г. – С.12-26.