

Surgical component of lateral and central breast cancer treatment

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Abstract

Aim. To improve the results of the surgical component in the treatment of a nodular form of breast cancer with lateral and central localization by analyzing hemoglobin oxygen saturation of arterial blood in the foci of breast cancer, regional lymph nodes and resection line of the breast.

Methods. The study involved 175 patients with a nodular form of breast cancer with lateral and central localization (T2–3N1–2M0), including 86 in the main group and 89 in the comparison group. In the main group, hemoglobin oxygen saturation in arterial blood of the foci of breast cancer, parenchyma, pectoral muscles and regional lymph nodes was examined for spread of cancer during surgery for nodular breast cancer by using a device developed by us (patent RU 2581266). This examination was not performed in the comparison group. Histopathological examination of resection specimens revealed confirmation of the main foci of breast cancer and the presence of metastases in the regional lymph nodes and pectoral muscles of the breast. Statistical analysis of the data was performed by using the Statistica 10 software. The arithmetic mean, the standard error of the mean and the standard deviation were calculated for the quantitative indicators.

Results. In the main group, 86 patients had no recurrence and metastases in the follow-up, while in the comparison group, cancer recurrence was identified in 89 patients and metastases was found during cytological and histological studies in 9 patients.

Conclusion. Determination of hemoglobin oxygen saturation of arterial blood during surgery in the subclavian, axillary and subscapular lymph nodes as well as in the pectoralis major and minor muscles allows clarifying the distribution of breast cancer, specifying the scope of the operation and improving the results of the surgical component of breast cancer treatment (T2–3N1–2M0).

Keywords: hemoglobin oxygenation, breast cancer.

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Background. Breast cancer treatment remains a complex and challenging endeavor [1–6]. After the surgical component of nodular breast cancer treatment is performed, relapses and metastases are found in some cases [7, 8] because mammologists usually leave non-palpable cancer foci in the breast parenchyma. Variants of the excessive and unjustified removal of healthy tissues of this organ are possible. The emergence of malignant tumor cell resistance to chemotherapy after preoperative chemotherapy and other drugs has been described and related to the volume of the forthcoming surgery [9–11]. These findings stress the need for a practical and affordable method to diagnose the prevalence of breast cancer intraoperatively.

A.A. Tashchyan et al. [12] applied molecular genetic methods during surgery to diagnose metastases in the sentinel lymph node, while P.V. Krivorotko et al. [13] used a gamma probe for metastasis detection and lymphadenectomy. In most cases, a radiopharmaceutical is injected into the tumor or subcutaneous tissue of the mammary gland on the eve of the surgery for intraoperative diagnostics. However, this method is unsuitable for a number of oncological dispensaries, such as in leading cancer centers, because of the lack of appropriate technologies and the fact that introduction of a radiopharmaceutical to a patient's body may be detrimental to their health.

We previously suggested the use of a multifunctional apparatus for intraoperative diagnostics

Table 1. Nosological forms of patients who underwent the surgical component of breast cancer treatment and the results of such treatment

Nosological form/stage		Number of patients		Surgery type	
	MG	Rel/	CG	Rel.	
T2N1M0/metastasis in the subclavian lymph node	30	0	30	3	Organ-preserving surgery with subclavian lymphadenectomy
T2N1M0/metastasis in the axillary lymph node	31	0	32	2	Madden mastectomy
T3N2M0/metastases in the subclavian, axillary and subscapular lymph nodes	25	0	27	4	Halsted mastectomy
Overall	86	0	89	9	—
Total		175			—

Note: $p = 0.101$; MG – main group; Rel. – relapse; CG – control group.

[14, 15]. This apparatus was self developed and successfully applied to the clinical setting for the intraoperative diagnostics of hemocirculation in the suture line of the intestine [16, 17]. The device may potentially be used to determine the oxygen saturation of arterial blood hemoglobin in the breast cancer focus and metastatic lymph nodes. The recorded readings are given in this work.

The aim of this work is to improve the outcomes of the surgical component of nodular breast cancer (T2-3N1-2M0) treatment by studying the intraoperative prevalence of cancer through determination of the oxygen saturation of arterial blood hemoglobin in the breast parenchyma, breast tumor focus, pectoral muscles, and regional lymph nodes.

Materials and methods. This work describes the surgical component of lateral and central nodular breast cancer treatment in 175 patients. The tumor was localized in the outer quadrants in 57.5% of the patients, at the border of the upper quadrants in 26.5% of the patients, and at the border of the lower quadrants in 16% of the patients. All patients underwent preoperative chemotherapy. The ages of patients in the main and control group were 60.4 ± 4.4 and 60.6 ± 4.2 years, respectively. The significance of differences was estimated to be 0.06897. The nosological forms of the disease are given in Table 1.

The prevalence of breast cancer was determined by studying the oxygen saturation of arterial blood hemoglobin in the breast parenchyma, the breast cancer focus, pectoral muscles, and regional lymph nodes by using a self-developed device (Patent No. RU 2581266 C2) [14].

The apparatus consisted of two chambers. The large chamber contains LED bulbs, while the small chamber contains the emitter. An eyepiece comprising organic glass was installed over the large chamber for transillumination and blood pressure measurements of the intramural and extramural

vessels of hollow organs and brought closer to the cameras. A metal plate installed above the small camera served as an extension of the eyepiece and featured a photodetector connected by wires to the monitor. The large chamber enables blood pressure measurements in the intramural vessels of the hollow organs according to M.Z. Sigalu [18] via transillumination. The small chamber examines the oxygen saturation of the arterial blood hemoglobin in organs and tissues to determine pulse, perfusion level, and tumor spread.

All of the patients in the main group were operated on by the head of this work at the surgery and oncology clinic of Kazan Medical Academy from 1978 to 1986 and the oncology clinic of Dagestan State Medical University from 1986 to 2021. This study was approved by the local ethics committee of Dagestan State Medical University on May 16, 2019.

Our apparatus was not used during the surgery of patients in the control group. The prevalence was determined visually, by palpation, by mammography, and, in some cases, by urgent cytological or histological examination. Patients in the control group were operated on by other mammologists. It should be emphasized that this result was obtained by the authors via intraoperative diagnostics by using our self-developed apparatus.

Besides surgery, the 86 patients in the main group underwent polychemotherapy to determine the sensitivity of chemotherapy to breast cancer (Patent No. RU 2534410); this procedure was not received by the 89 patients in the control group.

The inclusion criteria for patients in the study were the presence of nodular breast cancer (T2–3N1–2M0) and informed written consent from the patient to participate in the study.

The exclusion criteria for this study were severe renal or hepatic failure, chronic heart failure, and patient's refusal to participate in this study.

The criteria for withdrawal from the study were the appearance of adverse side effects following drug treatment and patient's refusal to continue the study and treatment.

Statistical processing of the research results was conducted using the Statistica 10 for Windows application package. The arithmetic mean, standard error of the mean, and standard deviation were calculated to describe quantitative indicators. Comparison of the mean values of different groups was performed via Student's *t*-test. The null hypothesis was rejected at a significance level of $p < 0.05$.

Results. The prevalence of breast cancer in the main group was evaluated via intraoperative diagnostics collected by using a self-developed device [19]. During surgery, the oxygen saturation of the arterial blood hemoglobin of the parenchyma of the mammary gland was determined to $90\% \pm 1.5\%$, which is within the normal range. The oxygen saturation of arterial blood hemoglobin was $50\% \pm 1.2\%$ in the breast cancer focus and $50\% \pm 1\%$ in the affected regional lymph node. We investigated the oxygen saturation of arterial blood hemoglobin in the pectoralis minor and pectoralis major muscles and obtained a value of $90\% \pm 1.5\%$ (normal). The oxygen saturation of arterial blood hemoglobin in the finger was found to be $90\% \pm 1.6\%$. The ratio of oxygen saturation of arterial blood hemoglobin in the breast cancer focus (50%) to that in the finger (90%) is called the breast cancer index; in the present study, the breast cancer index was 0.5 ($50\%:90\% = 0.56$).

Similarly, the index of breast cancer metastasis to the regional lymph nodes was determined to be 0.5. In the absence of breast cancer metastasis to the pectoral muscles, this index was 1. These results confirm the validity of our patent (Patent No. RU 2736163: Method for the intraoperative diagnosis of breast cancer) [19].

Our studies indicate that any indication for a particular surgery should consider the results of the intraoperative diagnostics of breast cancer, which is conducted by examining the oxygen saturation of arterial blood hemoglobin in the parenchyma, cancer focus, along the resection line, in the pectoral muscles, and in regional lymph nodes. Taking into account these our developments, we performed three typical surgeries in patients in the main group, as described below.

1. Organ-sparing surgeries were performed in 30 patients in the main group (Table 1). During surgery, the arterial blood hemoglobin oxygen saturation during surgery was $50\% \pm 1.5\%$ in the breast cancer focus and $50\% \pm 1.2\%$ in the subclavian lymph node. The tumor in all patients was localized in the outer upper quadrant, and normal

values (i.e., $90\% \pm 1.5\%$) of arterial blood hemoglobin oxygen saturation in the pectoralis major and minor muscles were established during the surgery.

In the initial period, a force of at least 20 kg had to be applied to several patients to abduct the pectoral muscles by the hook and create access to the subclavian lymph nodes; as a result, the muscles were detached at the attachment site. After subclavian lymphadenectomy, the ends of the muscles were sutured. Thus, the latter were crossed, and the ends moved apart in opposite directions. Access to the subclavian lymph nodes was created in this manner, and subclavian lymphadenectomy was performed. After the subclavian lymph nodes were included in the preparation, the ends of the transected pectoral muscles were sutured.

Organ-preserving resection of the mammary gland was performed, stepping back from the edge of the tumor within healthy tissues. The oxygen saturation of arterial blood hemoglobin along the resection line of the mammary gland was determined using our self-developed apparatus to determine the radicality of surgery required. Histological examination revealed breast cancer with metastasis to the subclavian lymph node in the postoperative period.

2. The tumor was localized in the lateral quadrants in 31 patients in the main group (Table 1). During surgery, the oxygen saturation of arterial blood hemoglobin in the pectoral muscles was $90\% \pm 1.5\%$, which is normal. Similar indicators were found in the subclavian and subscapular lymph nodes. The oxygen saturation of arterial blood hemoglobin in the breast cancer focus and axillary lymph node was $50\% \pm 1.2\%$. A second focus with a cancer index of 0.5 was found during intraoperative examination, and Madden's mastectomy was performed [20] with axillary lymphadenectomy and preservation of the pectoral muscles and subclavian and subscapular lymph nodes. In the postoperative period, two breast cancer foci with metastases to the axillary lymph nodes were found.

3. Breast cancer with metastases to the subclavian, axillary, and subscapular lymph nodes, as well as lesions of the pectoralis major and minor muscles (T3N2M0) were found in 25 patients in the main group (Table 1) during surgery in the lateral quadrants. During surgery, the oxygen saturation of arterial blood hemoglobin in the pectoral muscles was $50\% \pm 1.2\%$, which indicates cancer damage. The oxygen saturation of arterial blood hemoglobin in the subclavian, axillary, and subscapular lymph nodes was $48.6\% \pm 1.2\%$. Mastectomy was performed according to Halsted [20]. In the postoperative period, pathological examination

revealed breast cancer with metastases to the axillary, subclavian, and subscapularis lymph nodes and lesions of the pectoral muscles.

Relapses and metastases were not observed in patients in the main group during the postoperative period.

Relapses and metastases were found in 3 out of 30 patients in the control group in whom organ-preserving surgeries were performed without examination of the oxygen saturation of arterial blood hemoglobin. Among 32 patients in the control group who received a Madden mastectomy [20], relapses were found in 2 patients. Halsted mastectomy was performed in 27 patients in the control group [20]; of the patients in this group, 4 women had relapses and metastases. These findings indicate that breast cancer foci were left in patients in the control group during the surgery.

Discussion. Intraoperative diagnostics serves as an additional diagnostic method for detecting breast cancer because some cases of breast cancer and metastases are insensitive to preoperative chemotherapy. The oxygen index in the breast cancer focus is 0.5. According to the literature data, mistakes are made in 15% of patients during intraoperative cytological examination of the punctate of this pathology. Moreover, puncture or open biopsy promotes cancer dissemination [20].

This study allows the intraoperative diagnosis of the spread of breast cancer to determine the scope of surgery necessary. The proposed method eliminates the need for repeated fine-needle puncture and urgent intraoperative biopsies.

In the main group, 86 patients did not show relapses and metastases after intraoperative diagnostics of nodular breast cancer via determination of the oxygen saturation of arterial blood hemoglobin.

In the control group, among 89 patients whose arterial blood hemoglobin oxygen saturation was not examined during surgery for breast cancer, 9 patients revealed relapses and metastases ($p=0.101$).

CONCLUSION

Determination of the oxygen saturation of arterial blood hemoglobin during surgery of the subclavian, axillary, and subscapular lymph nodes, as well as the pectoralis major and minor muscles, allows for the intraoperative diagnosis of breast cancer, clarification of the scope of the surgery, and improvements in the outcomes of the surgical component of nodular breast cancer treatment.

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