Particularities of electrical impedance images in different forms of growth of infiltrative breast cancer.

N. Sotskova[1], A. Karpov[2], M. Korotkova[2], A. Sentcha[1]

Outpatient Department №1 of the Yaroslavl Railway Clinical Hospital
attached to the JSC "RZhD", Russia[1]
Municipal Clinical Hospital №9, Yaroslavl, Russia[2]

Abstract- **The purpose of the research was to reveal particularities of the electroimpedance images in different forms of infiltrative breast cancer. Among 558 patients, subjected to examination, 15 were diagnosed as having breast cancer. The research was carried out utilizing the electrical impedance computer tomograph «MEIK»®. Visual estimation of images of complicated form of breast cancer revealed deformation of the mammary gland contour in 50 % of the cases, subcutaneous fat infiltration - in 61 %, anatomic changes with displacement of internal structures in 78 %, perifocal infiltration in 94 %. The quantitative analysis established the following: the mean electrical conductivity index of a healthy mammary gland, as a rule, exceeded the index of the mean electrical conductivity of the affected one; and the index of the mean electrical conductivity of a tumour exceeded the index of the mean electrical conductivity of the affected gland almost two times. In case of noncomplicated nodular forms of breast cancer, when no visual changes were detected on the electroimpedance tomograms, the researchers identified hypoimpedance areas in the place of probable tumour location. The electrical conductivity index of these hypoimpedance areas, detected at several scanning planes, exceeded 0,95. The article is illustrated with electroimpedance mammograms and tables.**

Keywords- **impedance, breast, cancer.**

I. Introduction

The process of a cancerous growth development falls into several pathophysiological phases, characterized by their own particularities: avascular phase of the tumour development – metabolism in malignant cells is supported by diffusion; vascularization and metastasis – "pathological angiogenesis" develops; and the phase, featuring metabolic disorder and disintegrating of the tumour – the process of the tumour diffusion, vascularization and nutrition are affected.

The phasic development of breast cancer is to be accompanied by changes in electrical conductivity at various forms of the pathology in questions. The changes in electrical properties of neoplastic cells are connected with increase of membranes permeability, leading to increase of electrical conductivity. In vascularization phase the current changes of electrical conductivity in malignant cells are accompanied by the changes in impedance. The decrease of the tumour electrical conductivity in the third phase is connected with swelling of the cells, membrane surface increase and decrease of intercellular space volume, leucocytic infiltration. Thus, tumour growth is regularly accompanied by changes of electrical properties of the tumour itself as well as the surrounding tissues (1).

The purpose of the research was to reveal particularities of the electroimpedance images in a nodular form of cancer, which lacks such features as edema, inflammation and abnormalities of vascularization (noncomplicated breast cancer – NBC); in a nodular form of cancer in combination with the above-mentioned complications (complicated breast cancer – CBC); and in an edematous-infiltrative form of breast cancer (EIBC).

II. Materials and Methods

In 2005 in the Clinical Hospital # 9 and the Yaroslavl Railway Clinical hospital 558 patients were subjected to examination; breast cancer was diagnosed in 31 patients out of 558. The patients fell into the groups according to the following clinical stages: Ia- 9, IIa-IIb -16, IIIa – IIIb -2, IV – 4. Histological study confirmed breast cancer in 28 patients, cytological analysis confirmed breast cancer in 3 patients. Two groups were formed the main group and the reference group. The main group comprised 31 patients, who were divided into three subgroups. The results of clinical as well ultrasound examinations, being evidence of presence or absence of complications, (hyperemia, "lemon rind", perifocal infiltration and edema) were used as criteria for the patients division into the subgroups. The Ia subgroup comprised 9 patients with NBC, the Ib subgroup – 18 patients with CBC, the Ic subgroup – 4 patients with EIBC. The patients' average age was 57±11,2 years. The reference group comprised 102 healthy women, being on average 50 – 60. The research was carried out utilizing the electrical impedance computer mammograph «MEIK» (current 0.5 mA, frequency 50 kHz). The electrical impedance image analysis of the mammary gland consisted of a visual and qualitative estimation. During the visual estimation the following was taken into consideration: the breast contour (deformation, infiltration), anatomic changes and displacement of internal structures, existence of local changes of electrical conductivity, perifocal infiltration. The quantitative estimation comprised computation of healthy

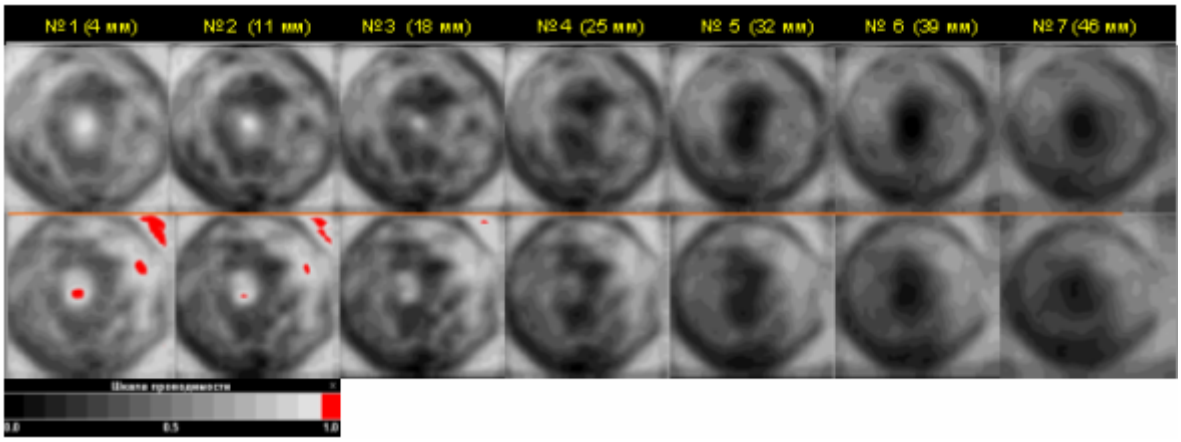

Fig. 1 Noncomplicated forms of breast cancer (the first row - scanning planes, the second row - electroimpedance tomograms of the healthy breast, the third row - electroimpedance tomograms of the affected breast with the hypoimpedance area at 2 o'clock.)

and affected breasts electroconductivity index, electroconductivity index of the tumour.

III. Results

The conducted research revealed the following particularities of electrical impedance images during various forms of the breast cancer.

A. The noncomplicated nodular form of breast cancer (subgroup Ia).

Absence of the breast contour deformation on electroimpedance tomograms in 100% of all cases. The contour hyperimpedance was observed only in 11% of all the cases. The breast anatomy was unchanged in 100% of the cases. Focal lesions were differentiated in 100% cases of the tumour site, taking form of a hypoimpedance area in several scanning planes (fig. 1). The electroconductivity index of the healthy breast and the affected one didn't differ significantly, being correspondingly 0,51±0,09 and 0,50±0,10 ($p>0,05$). The electroconductivity index of the hypoimpedance area exceeded 0,95 and amounted to 0,97±0,02.

B. The nodular form of breast cancer, involving edema, infiltration or abnormalities of vascularization (subgroup 1b).

In 50% of the cases the electroimpedance tomograms revealed deformation of the breast contour. The contour hyperimpedance was registered in 61% of the cases. Anatomic changes and displacement of the breast internal structures were revealed in 78% of the cases (fig. 2). An isoimpedance area, corresponding to the tumour site, was revealed in 100% and a hyperimpedance contour on the

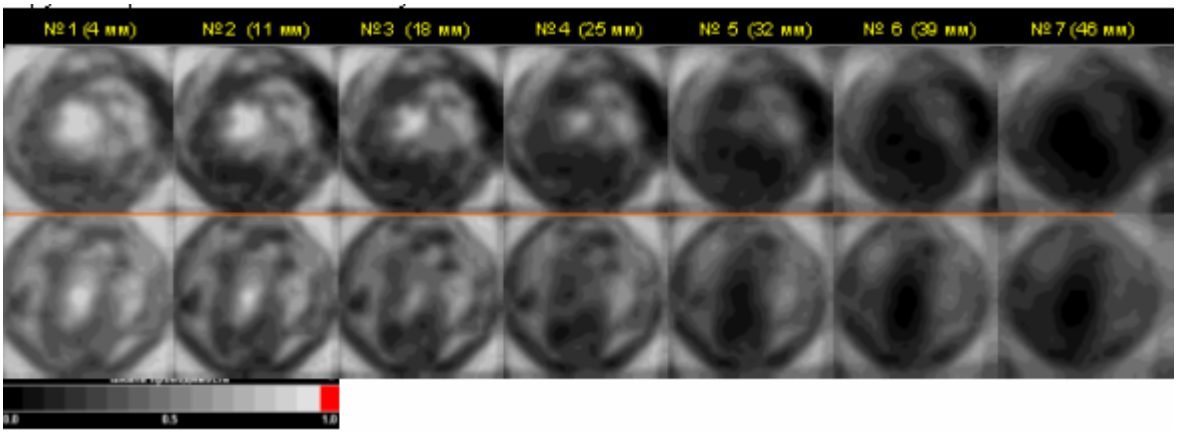

Fig. 2 Complicated forms of breast cancer (the first row - scanning planes, the second row - electroimpedance tomograms of the affected breast with isoimpedance area in the middle and the hypoimpedance contour around it, the third row - electroimpedance tomograms of the healthy breast).

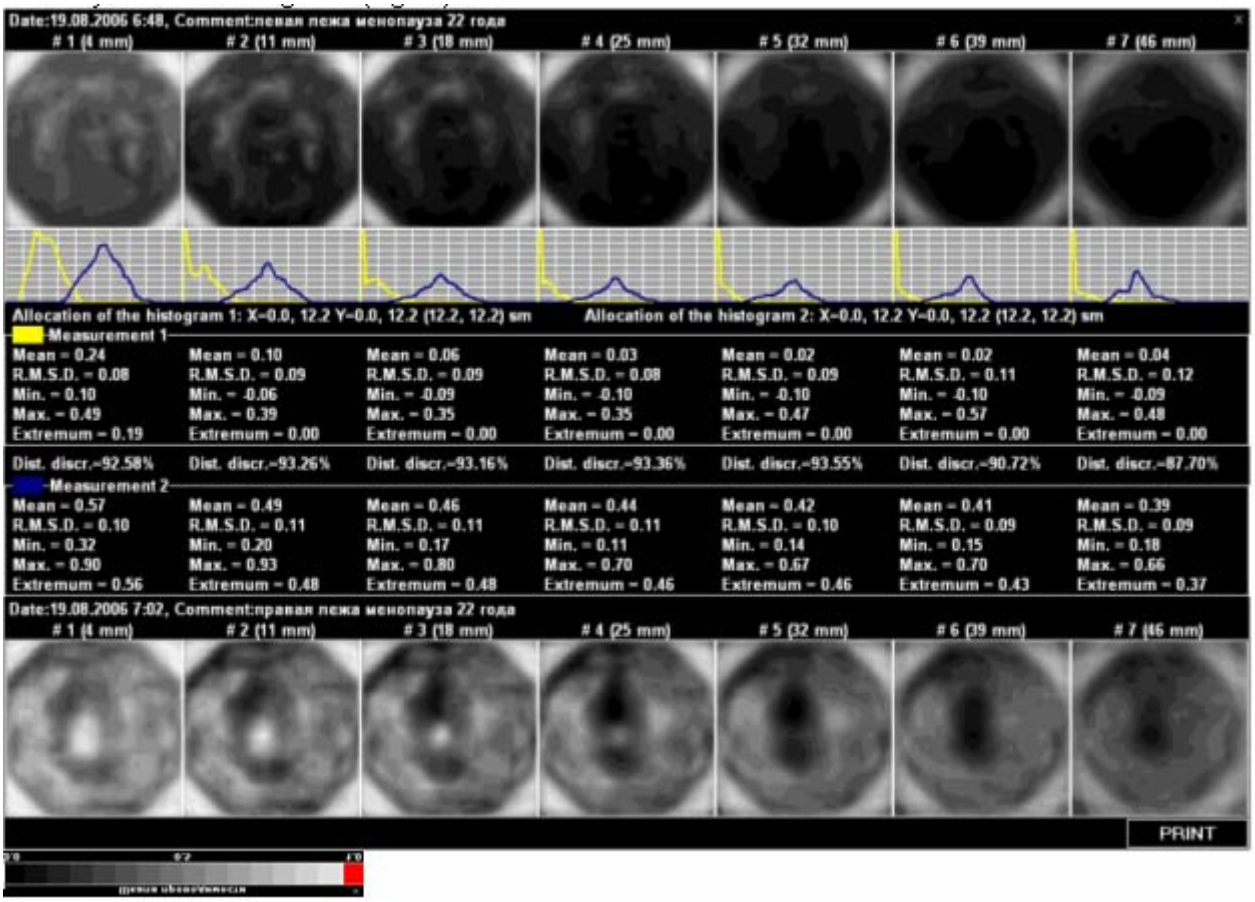

Fig. 3 Edematous-infiltrative form of breast cancer (the first row - the affected breast, the second row – histogram of electroconductivity distribution, the third and the fourth rows – a qualitative assessment, the fifth row – the healthy breast).

tumour border with the surrounding tissue – in 94% of the cases. The hypoimpedance area with the electroconductivity index >0,95, typical for the NBC (2), was absent in 78% of the cases. The electroconductivity index of the healthy breast significantly exceeded the electroconductivity index of the affected one, correspondingly M_1=0,46±0,10; and M_2=0,39±0,9 (t=2,20, p<0,05), the tumour electroconductivity index exceeded the electroconductivity index of the healthy breast, correspondingly M_0=0,61±0,23; and M_1=0,46±0,10 (t=2,53, p<0,05).

C. Edematous-infiltrative form of breast cancer (Subgroup Ic).

Massive hyperimpedance of the affected breast due to considerable intracellular and lymphatic edema was obvious in 100% of the cases in the electroimpedance tomograms. Changes in the breast anatomy were registered in 100% of the cases. In 100% of the cases there were no hypoimpedance areas with the electrical conductivity index >0,95. The electroconductivity index of the affected breast was significantly below the same index of the healthy breast as well as below the norm, correspondingly M_0=0,12±0,08; and M_1=0,48±0,03 (t=6,36, p<0,001) and M_N=0,53±0,069 (t=11,6, p<0,001). When the electroconductivity distribution histograms of the healthy and the affected breasts were compared, it was revealed that the histogram of the affected breast is characterized by a shift to the left in respect of the healthy breast histogram (fig. 3).

The intergroup analysis data are represented in the table 1. The electroimpedance image of the NBC (subgroup 1a) differs significantly from the norm due to presence of the hypoimpedance area with the electroconductivity index >0,95. The electroimpedance image in case of the CBC significantly differs from the image in case of NBC as supported by the visual estimation data: changes of the breast anatomy and contour, isoimpedance formation at the tumour site with hyperimpedance infiltration when adjacent to the healthy tissue, absence of hypoimpedance area featuring the electroconductivity index >0,95. The electroimpedance image in case of the EIBC significantly differs from the CBC image by evident hyperimpedance of the image. The electroconductivity index of the affected breast in case of the EIBC is significantly below the index in the CBC.

Table 1. Visual and quantitative assessment data of the electroimpedance image of the patients' breasts from the main and the reference groups.

Characteristics		Norm	1a	1b	1c
Contour	Deformation	-	0%	50%	0%
	Hyperimpedance	-	11%	61%*	100%
Anatomy	Retained	100%	100%	22%**	0%
	Changed	-	-	78%	100%
Hypoimpedance area (electroconductivity index >0,95)	Distinguished on the image	-	100%	22%**	-
	Not present	100%	-	78%	-
Hyperimpedance infiltration	Present	-	11%	94%**	100%
	Not present	-	89%	6%	-
Breast electroconductivity index	Affected breast	-	0,51±0,09	0,39±0,09**	0,12±0,08**
	Healthy breast	0,53±0,069	0,50±0,10	0,46±0,10	0,48±0,03
	Lesion focus (area)	-	0,97±0,03	0,61±0,23**	

- reliability of discrepancy between this data and the data of the previous column $p<0,05$; ** - reliability of discrepancy between this data and the data of the previous column $p< 0,001$

IV. Conclusions

1. The revealed particularities of the electroimpedance image during various forms of the infiltrating breast cancer growth correlate with the pathophysiological phases of the tumour development.
2. It is primary important for diagnostics to detect noncomplicated forms of the diseases, characterized by high electroconductivity index of malignant cells as well as complicated forms, characterized by high local and total impedance.
3. High electroconductivity index and absence of the surrounding tissue reaction are key signs of noncomplicated forms of breast cancer on electroimpedance images.
4. Other criteria should be used for diagnostics of the infiltrating breast cancer, accompanied by edema, inflammation, abnormalities of vascularization, namely, changes of the breast contour, displacement of its internal structures, perifocal infiltration, etc.

Address of the corresponding author:

Author: N. Sotskova
Institute: Outpatient Department №1 of the Yaroslavl Raiway Clinical Hospital "RZHD"
Street Suzdalskoe
City Yaroslavl
Country Russia
Email Sim-tech@Net76.ru

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