Electric Impedance Imaging of the Mammary Gland in Circumstances of Skin Abnormality or Damage

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Abstract—**The results discussed in the article demonstrate that the electric impedance mammography technique is highly reliable in the detection of various skin abnormalities and damages. The status of the patient's skin integuments may influence the electric impedance images, but this influence is of local significance. Further research may shed more light upon the specific features of the electric impedance images in circumstances of skin tumors, both benign and malignant, as well as inflammatory processes and injuries.**

Keywords— **Electrical Impedance Tomography, Computer Mammography, Mammary Gland, Electric Impedance Mammography.**

I. Introduction

Electric impedance scanning of the mammary gland is a complex process, many aspects of which are still not fully understood. Electric charges are faced by biological tissues with the opposite electric properties. Creating a "blank wall" of the cell mass (1) skin integuments form a barrier hard enough for the charges to penetrate. However, this barrier is threaded by numerous excretory ducts of the eccrine perspiratory glands (200 ducts per 1cm^2) containing electroconductive secreta, which is expected to facilitate the passage of the electric current through the epidermis and the inner skin. The tissues under examination are moistened as well. The structural uniformity and continuity of the skin integument provide for the accurate electric impedance image of the mamma. Yet, patients, both in health and disease, may suffer from skin abnormalities or damages which often distort the image of the mammary gland. These involve nevi, warts, cicatrices, etc. (2). The research in hand aims to reveal the peculiar features of the mammary gland electric impedance image in circumstances of various skin abnormalities.

II. Methods and materials

We have conducted an examination of 20 patients with various types of breast skin abnormality or damage. They fell into the following groups: patients with nevi, warts, cicatrices, sun tan and acne after-effects. The examination was carried out on the "MEIK" (version 5) electric impedance computer mammograph. The weighted reciprocal projection method was employed to reconstruct the 3-D electric conductivity distribution of the examined organ. The results obtained in the course of calculating the surface intensity of a homogeneous object served as referential measurements. We also made a visual and quantitative evaluation of the image which involved the calculation of the electric conductivity index (IC) as well as the assessment of the local electric conductivity changes (4).

III. Results

A. Electric impedance imaging of the mammary gland + nevus.

The intracutaneous nevus or mole is the most widespread skin abnormality. This is a sharply marginated round spot, tawny- or brown-tinted, of about 1cm in diameter. From the histological point of view it presents a number of bands and clusters of melanin-containing nevus cells located in the derma center. Fibrous sheets are to be found between the cell groups (2). The peculiar features of the mammary gland image in circumstances of a nevus are conditioned by the absence of structural changes in the layers of the epidermis and the inner skin as well as the absence of the perspiratory glands in the nevus itself.

The electric impedance mammogram (Fig.1) shows the nevus as a well-defined round hyperimpedance spot (IC=0.15 – 0.20) of about 7mm in diameter. The specific character of the survey technique – breast compression – accounts for the 18mm extension depth.

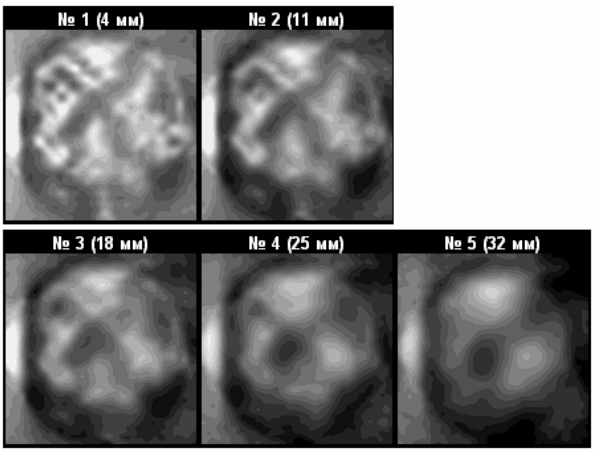

Fig. 1 Electric impedance images of the mammary gland (5 scan planes). A hyperimpedance spot at 10 on the clock dial, corresponding with the location of the nevus.

B. Electric impedance imaging of the mammary gland + wart.

Warts are benign skin tumors. They are well-defined semispherical indurated brown papules of about 5 – 20cm in diameter. The papule surface is covered with sebum. As far as histology is concerned, this is a focal epidermal hyperplasia with acanthosis, hyperkeratosis and papillomatosis. The skin has abnormal papillary structure (2). The peculiar features of the mammary gland image in circumstances of a seborrheic wart are conditioned by the structural changes in the layers of the epidermis and the inner skin as well as the presence of a large amount of loose keratic mass impregnated with sebum. The electric impedance image (Fig.2) displays the wart as a well-defined round isoimpedance spot (IC=0.7 – 0.8) measuring 30x20mm with a hyperimpedance contour (IC=0.20) in the circumferential direction.

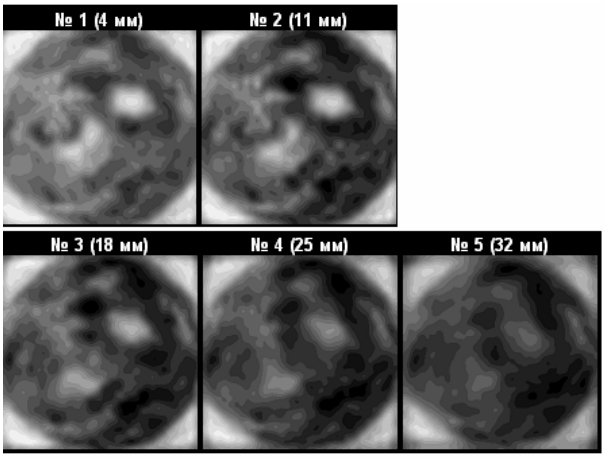

Fig. 2 Electric impedance images of the mammary gland (5 scan planes). In the upper area to the right of the center one observes a hypoimpedance spot with a hyperimpedance contour, corresponding with the location of the seborrheic wart.

C. Electric impedance imaging of the mammary gland + scars.

Scar is the final (terminal) stage of the inflammatory process. Infiltrate regresses and is replaced by the connective tissue, which results in the restoration of the affected tissue electric properties. When the tissue has suffered a significant damage it may heal in two possible ways (3). In case the defect heals by first intension, the scar formed in its place consists of smooth epidermis and derma, the latter being made up of collagen fibers and devoid of any skin adjuncts (hairs, perspiratory or oil glands). When the defect heals by second intension, the point of damage is separated from the rest of the tissue by collagen fibers, the focus itself being filled with the amorphous substance of the connective tissue. The peculiarities of the mammary gland electric impedance image in circumstances of a scar with the 1st type of healing are determined by the formation of numerous collagen fibers which act as dielectrics. The mammogram (Fig.3) images the scar as a hyperimpedance linear zone (IC=0.1 – 0.2) which corresponds with the real scar in shape and size.

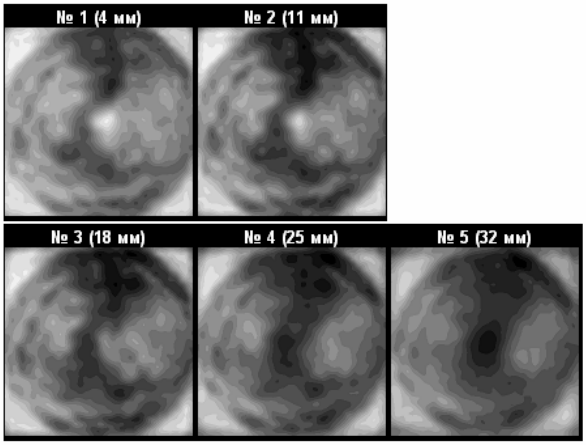

Fig. 3 Electric impedance images of the mammary gland (5 scan planes). In the central upper area one observes a hyperimpedance linear zone which corresponds with the real scar in shape and size.

The peculiarities of the mammary gland electric impedance image in circumstances of a cicatrix with the 2nd type of healing are conditioned by the separation of the damaged spot from the rest of the tissue by collagen fibers as well as the filling of the focus by the connective tissue amorphous substance, whose basic component is the hyaluronic acid (fig.4). Thus the zone of recovery will display both hyperimpedance areas typical of collagen an1d hypoimpedance areas characteristic of the connective tissue amorphous substance. In this case the scar is visualized in the form of a few hyperimpedance strips (IC=0,1-0,2) with an isoimpedance area located between them (IC=0,3-0,4).

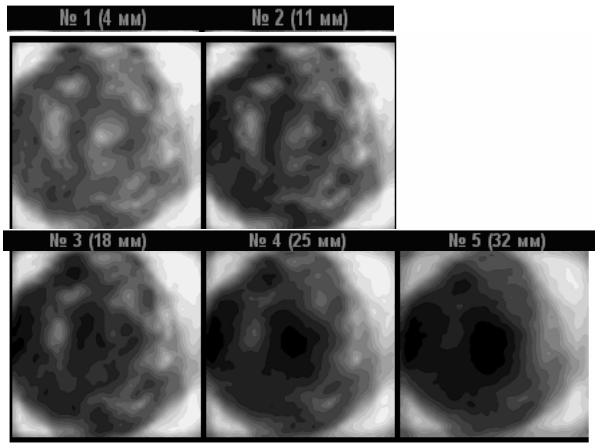

Fig. 4 Electric impedance images of the mammary gland (5 scan planes). In the central upper area one observes a hyperimpedance linear zone which corresponds with the real scar in shape and size.

D. Electric impedance imaging of the mammary gland + sunburn.

Ultraviolet rays affect the skin in the way that causes the aseptic inflammation type processes. At first the exposure zone suffers the arterial hyperemia accompanied by the increase of the vessel wall permeability and formation of edema. It manifests itself as erythema. Arterial hyperemia is followed by venous hyperemia which is attended by leukocyte migration and declares itself as infiltration (3). The accumulation of the cell substrate in the inflammatory zone results in the electric conductivity fall-off. The electric impedance mammograms (Fig.5) image the infiltrate as a well-defined hyperimpedance area (IC<0.1) of homogeneous structure.

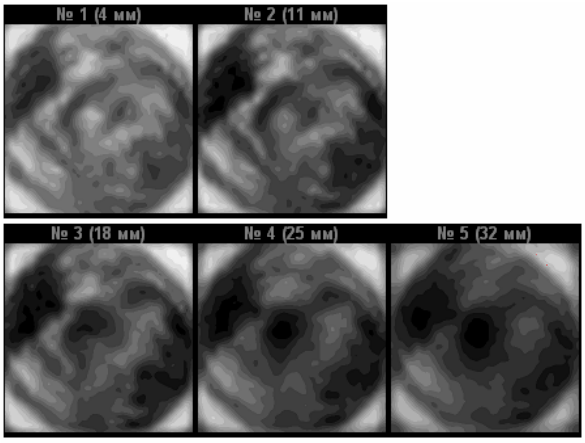

Fig 5. Electric impedance images of the mammary gland (5 scan planes). Between 9 and 11 on the clock dial one observes a well-defined hyperimpedance area of homogeneous structure which corresponds with the location of the sunburn area

E. Electric impedance imaging of the mammary gland + acne (oil gland inflammation) after-effects.

Oil gland inflammation is provoked by staphylococcus and manifests itself by a pink inflammatory boss of up to 5mm in diameter. This process terminates with the formation in the affected zone of a light sharply marginated spot. From the histological point of view the inflammatory tissue is replaced by the connective tissue, mostly its amorphous substance (2). These processes result in lowering the electric impedance of the affected skin zone. The electric impedance mammogram (Fig.6) images the zone as a well-defined isoimpedance spot (IC=0,6-0,7) of homogeneous structure.

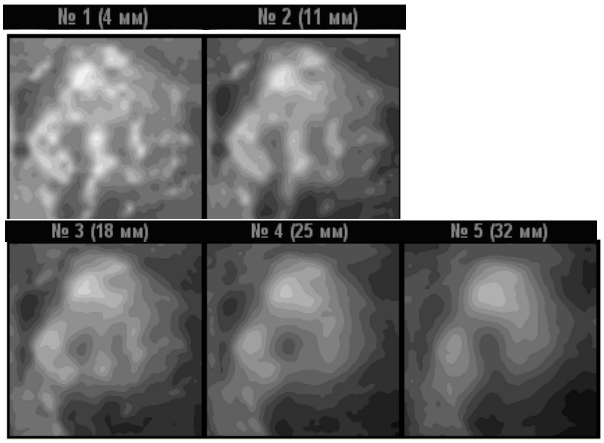

Fig 6. Electric impedance images of the mammary gland (5 scan planes). At 11 on the clock dial there is a well-defined isoimpedance spot (measuring 7x7mm) of homogeneous structure corresponding with the location of the affected skin zone.

IV. Conclusion

Thus, the examination results discussed above demonstrate that the electric impedance mammography technique is highly reliable in the revelation of various skin abnormalities and damages. The status of the patient's skin integuments may influence the electric impedance images, but this influence is of local significance. This must be taken into consideration when analyzing the electric impedance images. The peculiarities of the local electric conductivity changes depend upon the histological structure of the tissue. Structures causing a rise of the tissue electric impedance include collagen fibers and epithelium affected by hyperkeratosis. The structure providing for a fall of the tissue electric impedance is the amorphous substance of the connective tissue. The same effect is observed when large amounts of secreta are accumulated in the oil gland ducts. Further research may shed more light upon the specific features of the electric impedance images in circumstances of skin tumors, both benign and malignant, as well as inflammatory processes and injuries. This will enable to employ electric impedance scanning in oncologists' and dermatologists' daily practice as well as use it for dynamic monitoring and control of treatment quality.

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