http://dx.doi.org/10.35630/2199-885X/2022/12/2.3

CHARACTERISTICS OF SKIN DIELECTRIC PROPERTIES IN PREGNANCY (EXPERIMENTAL STUDY)

Received 11 February 2022;
Received in revised form 10 March 2022;
Accepted 14 March 2022

***Andrew Martusevich*[1,2]✉, *Kristina Kishoyan*, *Alexandra Surovegina*[1,2], *Elena Golygina*[1], *Ivan Bocharin*[1,2], *Vladimir Nazarov*[1,3]**

[1] *Privolzhsky Research Medical University, Nizhny Novgorod;*
[2] *Nizhny Novgorod State Agricultural Academy, Nizhny Novgorod;*
[3] *Institute of Applied Physics, Nizhny Novgorod, Russia*

✉ *cryst-mart@yandex.ru*

ABSTRACT — The purpose of our study was to evaluate the dielectric characteristics of the skin that occur during pregnancy in an experiment. The study included 60 Wistar rats, 30 of which were pregnant (in the 3rd trimester; parturition took place 2–3 days after the study). Once, on a pre-epilated area of the skin of the back, the dielectric properties were studied using the method of near-field resonant microwave sensing. The diagnostic software and hardware complex for microwave sensing allows calculating the level of dielectric permittivity of the medium and conductivity based on the shift of the resonant frequency. Based on the conducted studies, it was found that the integumentary tissues of pregnant rats have a significantly higher level of dielectric permittivity and conductivity compared to non-pregnant animals. Such shifts are caused by the formation of edematous syndrome associated with pregnancy, and predispose to the development of postpartum skin changes.

KEYWORDS — dielectric properties, skin, permittivity, conductivity, pregnancy.

INTRODUCTION

It is known that pregnancy is accompanied by significant structural and functional changes in the mother's body [1, 3, 7]. At the same time, the main attention of researchers is focused on assessing the condition of the fetus itself, the placenta and the regulatory (neuro-immune-endocrine) mechanisms of the latter's activity [1, 3]. In addition, pathological conditions directly associated with pregnancy (the classic triumvirate *edema — proteinuria — hypertension*, gestational diabetes, etc.) are considered in detail [2, 7], while changes occurring in other organs and tissues are monitored less carefully.

On the other hand, dermatological manifestations are one of the important functional and cosmetic shifts that form during pregnancy [1, 7]. They can consist of the development of initially non-manifested allergic reactions, the formation of *stretch marks* in the abdominal region, as well as systemic changes in the structure of the skin, even in anatomically remote areas [1, 3, 7]. It should be noted that these consequences and *side effects* of gestation have not been fully studied.

Currently, the study of the skin condition can be carried out in various ways, and the most informative is its histological examination, however, it is invasive, long-term, requires a specialized laboratory and can be performed only in case of suspicion of pronounced pathological processes (primarily neoplasms). A common alternative to this is dermatoscopy, based on the reflection of a light beam from the surface layers of the skin, but this method allows you to evaluate only their and trichological status [8]. Another diagnostic instrumental approach is optical coherence tomography, but it also makes it possible to detect changes only at a shallow depth (up to 100–120 microns), and the equipment for its implementation is exclusive and has a high cost.

In this regard, an innovative technology based on near-field microwave sensing of biological tissues attracts attention [4–6]. Unlike ultrasound, this technology does not require reflection of the probed signal from biostructures, which makes it universal and applicable for assessing the morphostructure of surface tissues [4, 5]. Sufficient depth of probing (up to 10 mm or more) provides an opportunity to study the condition of not only the nearest, but also more distant layers of the skin from the surface [5, 6]. The most indicative microwave tomographic assessment of the structure of the integumentary tissues in laboratory animals, in which the study in question allows us to study both the morphological features of the epidermis and the dermis (in some cases, even subcutaneous fat) [4, 5]. In our previous studies performed on healthy Wistar rats, the features of spatial variability of the distribution of dielectric parameters of the skin in different regions of the body (abdomen, back, forehead, lumbar region) were established [6]. The heterogeneity of the considered regions according to the studied indicators is shown. At the same time, the dielectric properties of rat skin during pregnancy have not been evaluated before.

In connection with all of the above, the purpose of the study was to evaluate the dielectric characteristics of the skin that occur during pregnancy in an experiment.

MATERIAL AND METHODS

The study included 60 Wistar rats, 30 of which were pregnant (in the late stages, in the 3rd trimester; childbirth took place 2–3 days after the study). Once, on a pre-epilated area of the skin of the back, the dielectric properties were studied using the method of near-field resonant microwave sensing [4–6]. The diagnostic software and hardware complex for microwave sensing allows calculating the level of dielectric permittivity of the medium and conductivity based on the shift of the resonant frequency [5, 6]. Probing was carried out using an integrative sensor evaluating the dielectric properties of tissues at a depth of 5 mm.

Experiments with animals were provided in accordance with the rules of the European Convention ET/S 129, 1986 and Directives 86/609 EEC.

Statistical processing of the results was performed using Statistica 6.1 program.

RESULTS

It was found that in pregnant rats, the dielectric parameters of the integumentary tissues differ significantly from those in non-pregnant individuals (Fig. 1, 2). In particular, animals in the third trimester of pregnancy showed a marked increase in dielectric permittivity relative to rats of the control group (by 2.49 times; $p<0.05$). Taking into account the biophysical meaning of the shifts in the indicator level, we can assume a significant increase in the degree of tissue hydration due to edematous syndrome associated with gestation (Fig. 1).

A similar trend was registered for the dielectric permittivity of the skin and subcutaneous tissues (Fig. 2). It was found that in pregnant rats the indicator level is 1.94 times higher than the values characteristic of non-pregnant individuals ($p<0.05$). Such dynamics also indicates an increase in the proportion of the liquid component in the tissues, which further confirms the formation of systemic edematous syndrome in various regions of the rat body [2].

CONCLUSION

Based on the conducted studies, it was found that the integumentary tissues of pregnant rats have a significantly higher level of dielectric permittivity and conductivity compared to non-pregnant animals. Such shifts are caused by the formation of edematous syndrome associated with pregnancy, and predispose to the development of postpartum skin changes.

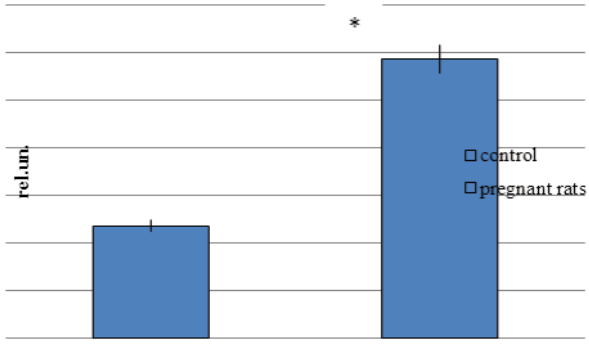

Fig. 1. The level of dielectric permittivity of integumentary tissues in pregnant and non-pregnant Wistar rats (— statistical significance of differences relative to non-pregnant animals $p<0.05$)*

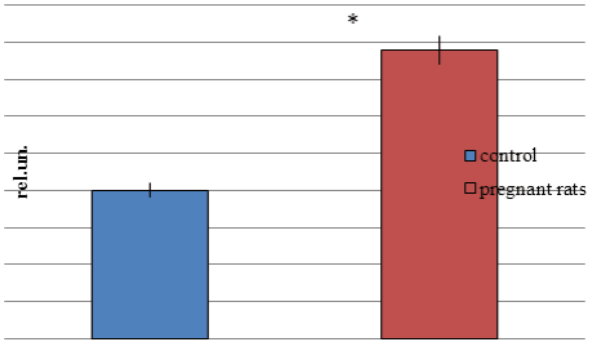

Fig. 2. The level of dielectric conductivity of integumentary tissues in pregnant and non-pregnant Wistar rats (— $p<0.05$ to non-pregnant animals)*

REFERENCES

1. **Carlin A., Alfirevic Z.** Physiological changes of pregnancy and monitoring // Best Pract Res Clin Obstet Gynaecol. – 2008. – Vol. 22, N 5. – P. 801–823. doi: https://doi.org/10.1016/j.bpobgyn.2008.06.005
2. **Filipek A., Jurewicz E.** Preeclampsia - a disease of pregnant women //Postepy Biochem. – 2018. – Vol. 64, N 4. – P. 232–229. Polish. doi: 10.18388/pb.2018_146
3. **Kohlhepp L.M., Hollerich G., Vo L., Hofmann-Kiefer K., Rehm M., Louwen F., Zacharowski K., Weber C.F.** Physiological changes during pregnancy // Anaesthesist. – 2018. – Vol. 67, N 5. – P. 383–396. German. doi: DOI: 10.1007/s00101-018-0437-2.
4. **Martusevich A., Golygina E., Anuchin A., Galka A., Tuzhilkin A., Fedotova A., Epishkina A.** Microwave detection of skin dielectric properties in some laboratory animals // Archiv Euromedica. – 2020. – Vol. 10, N 1. – P. 46. doi: 10.35630/2199-885X/2020/10/10
5. **Martusevich A.K., Galka A.G., Krasnova S.Yu., Yanin D.V., Kostrov A.V.** Comparative study

of dielectric properties of the skin of human and laboratory animals // EPJ Web of Conferences. – 2018. – Vol. 195. – 08004. doi: https://doi.org/10.1051/epjconf/201819508004

6. **Martusevich A.K., Epishkina A.A., Golygina E.S., Tuzhilkin A.N., Fedotova A.S., Galka A.G.** Near-Field Resonance Microwave Sounding to Study Dielectric Properties of Different Skin Areas (Experimental Study) //Modern Technologies in Medicine – 2020. – Vol. 12, No 5. – P. 57–61. doi: 10.17691/stm2020.12.5.06
7. **Tan E.K., Tan E.L.** Alterations in physiology and anatomy during pregnancy // Best Pract Res Clin Obstet Gynaecol. – 2013. – Vol. 27, N 6. – P. 791–802. doi: https://doi.org/10.1016/j.bpobgyn.2013.08.001
8. **Weber P., Tschandl P., Sinz C., Kittler H.** Dermatoscopy of Neoplastic Skin Lesions: Recent Advances, Updates, and Revisions // Curr Treat Options Oncol. – 2018. – Vol. 19, N 11. – 56. 10.1007/s11864-018-0573-6