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Estimation of the diagnostic accuracy of organ electrodermal diagnostics

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3.0 ESTIMATION OF OPTIMAL OED ELECTRICAL PARAMETERS

3.1 PATIENTS AND METHODS

3.1.1 Study Design/Sampling

The evaluation of electrical impedance and resistance of 180 auricular organ projection areas (OPA) corresponding to stomach, gall bladder and kidneys (Fig 3.1) has been done on a group of 120 inpatients at Helen Joseph Hospital's surgical department. The group consisted of 56 men and 64 women of mean age 39 (SD = 9) years:

Thirty patients presented with stomach pathology diagnosed on the basis of history and physical examination, barium meal and gastroscopy with biopsy for confirmation/exclusion of mucosal inflammation or a neoplastic process. Operative findings were included if the patient had undergone surgery. This subgroup included 10 cases of gastritis, 10 ulcers, 10 cancers.

Thirty patients presented with pathology of the gall bladder diagnosed on the basis of history and physical examination, acute phase indicators, liver function tests, hepatitis markers, urine for bilirubin and urobilinogen assessment, ultrasound examination, cholecystogram/cholangiogram (if indicated). Operative findings were included if the patient had undergone surgery. This subgroup comprised 10 cases of acute cholecystitis, 10 chronic cholecystitis and 10 cases with asymptomatic gallstones.

Thirty patients presented with pathology of the kidneys diagnosed on the basis of history and physical examination, urine for microscopy, culture and susceptibility, urea and electrolytes, creatinine clearance, acute phase indicators, ultrasound examination, intravenous pyelogram and CT scan. Cystoscopy and renal biopsy were performed if indicated. Operative findings were included if the patient had undergone surgery. This subgroup consisted of 15 cases of nephrolithiasis and 15 cases of pyelonephritis.

The control group consisted of 30 patients with proven healthy stomach, gall bladder and kidneys (on the basis of the abovementioned examinations): in total 90 OPA have been checked on patients belonging to the control group.

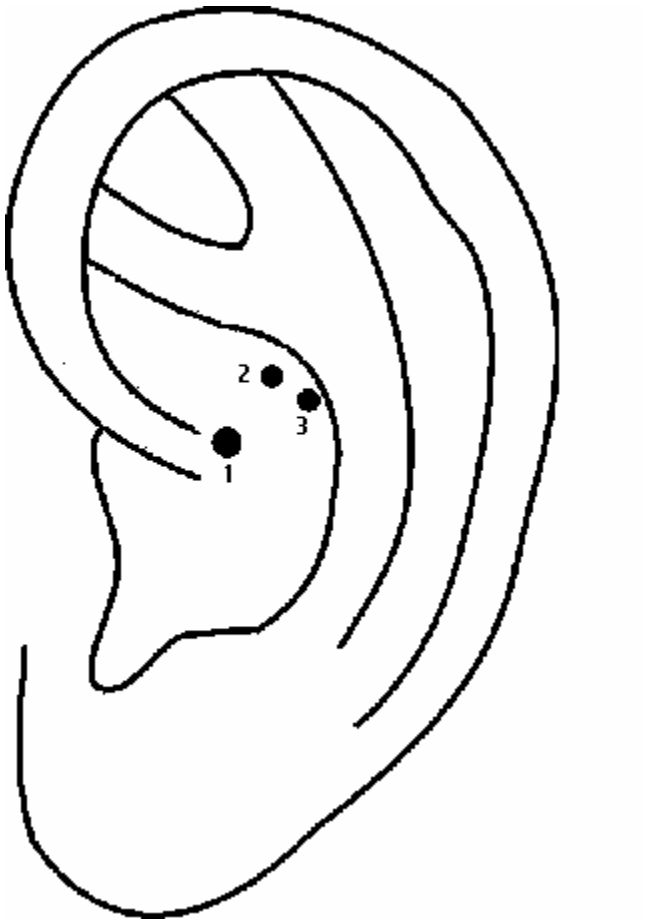

Fig. 3.1 Location of auricular organ projection areas of stomach (1), gall bladder (2) and kidneys (3).

3.1.2 Electrical Impedance Evaluation Procedure

Investigations of the electrical impedance of the above described OPA were done with a spring-mounted constant pressure Ag/AgCl dry point electrode (1 mm diameter) and a larger ($10cm^2$) wet reference electrode (also Ag/AgCl). The point electrode was placed on an OPA while the reference electrode was placed on the patient's hand. Measurements were done using a signal generator and oscilloscope. The magnitude of the skin impedance vs frequency was estimated at 5Vpp. Measurements were taken at 10 Hz, 100 Hz, 1KHz and 10KHz. The magnitude of skin impedance vs signal amplitude was estimated at 50Hz. Measurements were taken at 1, 1.6, 2.5, 4, 6.3 and 10 Vpp.

3.1.3 Electrical Resistance Evaluation Procedure

Investigations of the electrical resistance of particular OPA were done with the same electrodes. Skin resistance vs. voltage was evaluated with custom built electronic circuitry which applies a programmable voltage (-40V to +40V) or current (-50uA to +50uA) and measures the resistance between the electrodes.

3.2 RESULTS

3.2.1 Results of Impedance Evaluation

During the investigations of the electrical impedance of the auricular OPA a relationship was found to exist between the skin impedance at various frequencies and the condition of the internal organ related to the investigated OPA (Fig.3.2)

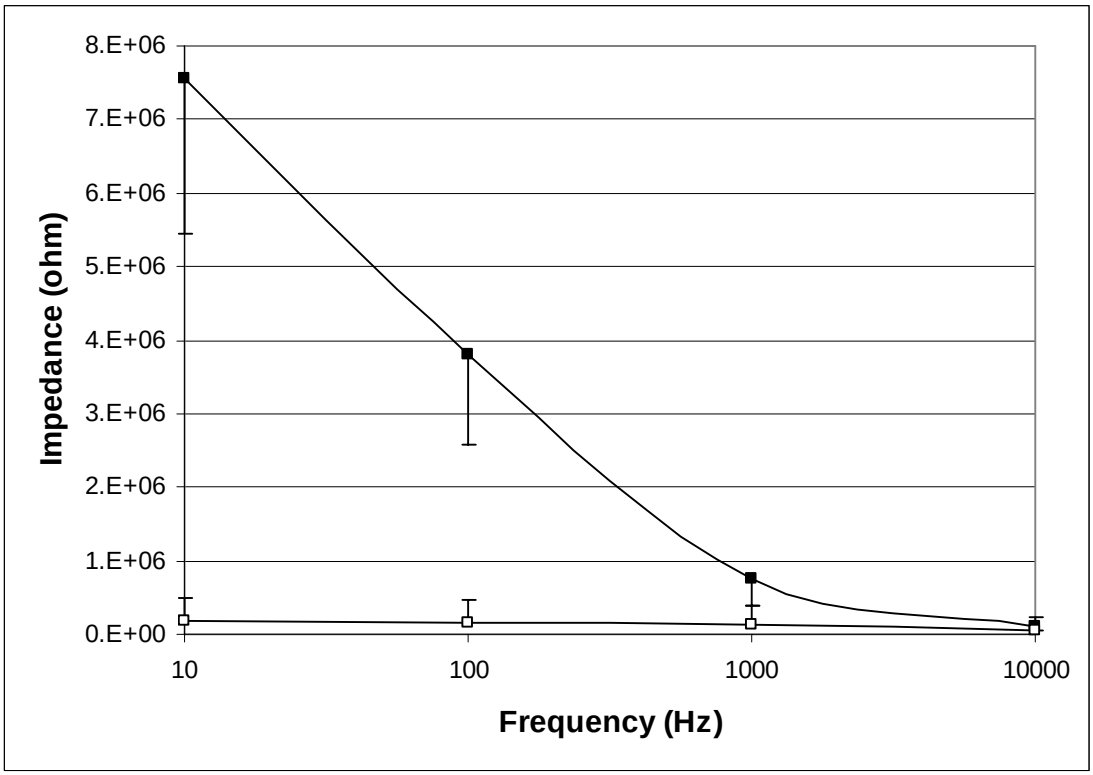

Fig.3.2 Skin impedance versus measurement frequency (at 5 Vpp): measurements were taken at skin zones related to diseased (solid squares) and healthy (empty squares) internal organs

The impedance of OPA corresponding to healthy internal organs equaled 185 ± 89 kΩ at 10Hz and decreased to 64 ± 49 kΩ at 10kHz. The impedance of AP related to diseased organs equaled 7.5 ± 6.2 MΩ at 10Hz and 99 ± 50kΩ at 10kHz. The difference in impedance for OPA related to diseased and healthy organs was statistically significant at a level of $p < 0.001$ (single factor Anova) at 1KHz and became more significant at lower frequencies. It was observed that measurements at 10Hz and to a lesser degree 100Hz produced uncomfortable sensations under the measuring electrode.

Investigations of skin impedance vs. voltage (Fig. 3.3) suggest that the disparity between the impedances of diseased and healthy organs related OPA is greater at higher potentials (limited by pain threshold).

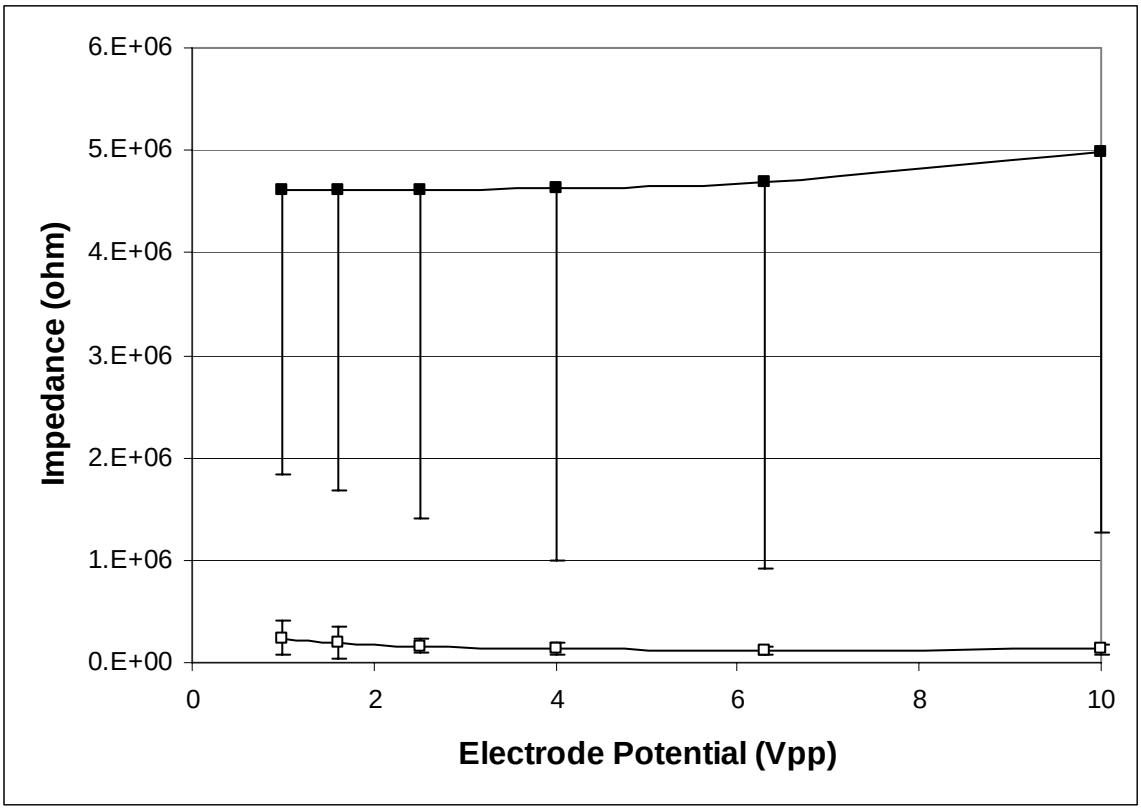

Fig. 3.3 Skin impedance versus applied voltage (peak to peak) at 50 Hz : measurements were taken at skin zones related to diseased (solid squares) and healthy (empty squares) internal organs.

The results obtained were reproducible and not dependent on the patient's skin perspiration and all factors which influence sweat gland activity. However, a slight correlation with the pressure of the measuring electrode was noticed (up to 5% of the result value)

3.2.2 Results of Resistance Evaluation

Investigations of the electrical resistance revealed that the resistance of skin beneath the point electrode, when polarized negatively, undergoes a rapid resistance decrease of approximately two orders of magnitude (Fig. 3.4), if the applied current is sufficient.

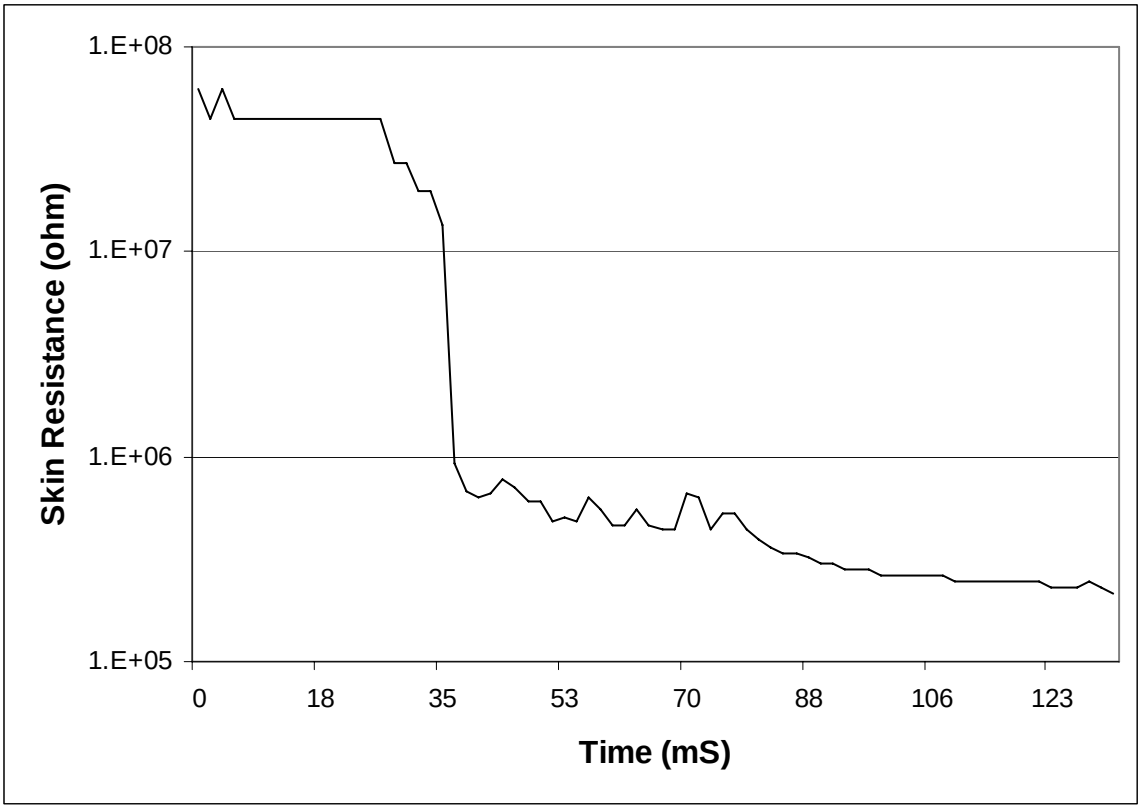

Fig.3.4 Example of reversible skin resistance 'breakthrough' under constant voltage stimulation.

After this reversible 'breakthrough effect' is obtained the skin exhibits rectification i.e. it behaves as a diode (Fig. 3.5). The degree of rectification is low for OPA related to healthy organs while the resistance measured with a positive polarization can be five times greater than the resistance measured with a negatively polarized electrode at the same voltage, if the related organ is diseased.

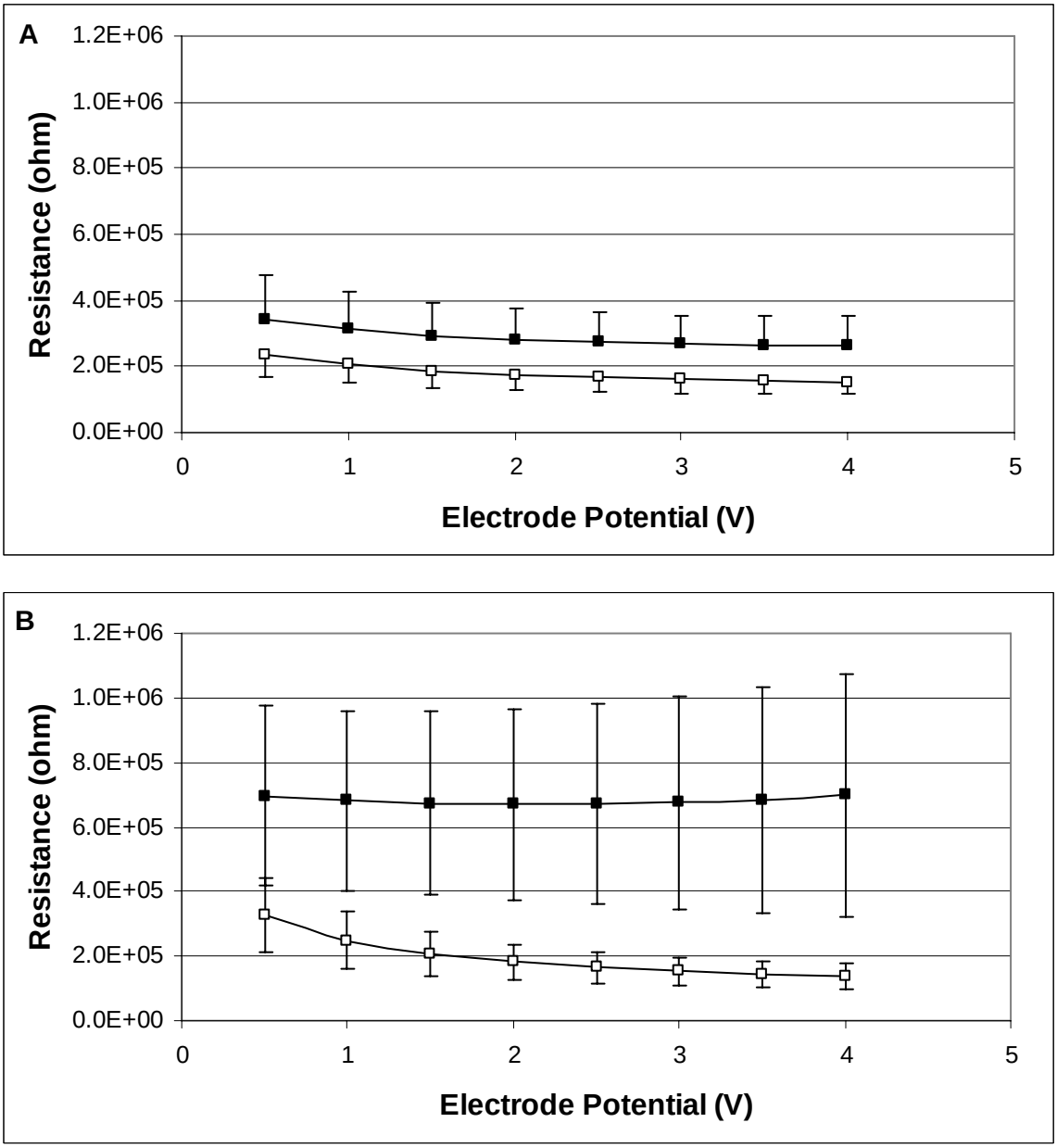

Fig. 3.5 Skin resistance versus voltage after the 'breakthrough effect':
A) Skin zones related to healthy internal organ.
B) Skin zones related to diseased internal organ.
Solid squares denote measurements taken with a positively polarized electrode.
Empty squares denote measurements taken with a negatively polarized electrode.

The disparity between the resistance measured with a positively and with a negatively polarized electrode at OPA related to diseased organs is greater at higher measurement voltages: at a measurement voltage of 0.5V the resistance difference was statistically significant with $p < 0.0001$ (single factor Anova), at higher measurement voltage differences became more significant. However, it was observed that currents greater than 25uA produced uncomfortable sensations

beneath the measuring electrode. The results of skin resistance measurements obtained by means of the method described above are consistent and reproducible, as in the case of skin impedance measurements. Skin resistance measurements taken before the ‘breakthrough effect’ did not demonstrate any diagnostic value and had a much greater dependence on the pressure of the measuring electrode.