Electrical impedance of the pituitary gland

Nicholas T. Zervas, M.D., Akira Shintani, M.D., and Kenneth S. Pickren
Department of Neurosurgery, Harvard Medical School, and the Beth Israel Hospital, Boston, Massachusetts

Experimental and clinical measurements of electrical impedance revealed a significant well-delineated difference between the pars distalis and the pars nervosa, providing an accurate and easy means of identifying the tissue interface between these two elements of the pituitary gland.

We have sought intraoperative means of identifying the neurohypophysis and the pituitary stalk in the course of transnasal stereotaxic hypophysectomy. These efforts have centered on exploring the hypophysis for intrinsic electrical activity or for differential electrical conductance. The report that follows will describe the successful delineation of the neurohypophysis by measuring electrical impedance across the sagittal axis of the hypophysis.

Method and Results

The impedance probe was a monopolar insulated stainless steel rod, 1 mm in diameter, with a tip uninsulated for a distance of 0.5 mm and sharpened to a tip diameter of 50 μ. Impedance was measured between the electrode tip and a stainless steel needle imbedded in muscle. The impedance meter was direct reading, with a constant current of 5 μA at an operating frequency of 5000 Hz.

Animal Studies

Preliminary studies were carried out in rhesus monkeys, weighing 2.2 to 3 kg. The animals were sedated with phencyclidine (0.2 mg/kg) administered intramuscularly. The head of the animal was fixed in a metal head holder. A No. 17 gauge thin-wall stainless steel hollow cannula was introduced through the upper eyelid at the lateral angle of the orbit, and under radiographic fluoroscopic guidance was advanced along the lateral margin of the orbit until it penetrated the superior orbital fissure. By means of a microdrive, the impedance probe was passed through the cannula and was directed into the sella turcica. Impedance was measured as the probe tip traversed the pituitary fossa. Initial values in pars distalis varied from monkey to monkey and ranged from 300 to 450 ohms (Fig. 1). A sudden sharp rise in impedance of from 40% to 93% occurred as the electrode was advanced into the posterior sella turcica. To identify the tissue site of impedance rise, a direct current anodal lesion was made (200 V, 3 to 5 mA, 5 to 10 sec). At a later date the animals were sacrificed under general anesthesia. In the fresh state, the pituitary was dissected from the sella turcica with the aid of the operating microscope. It was then possible, using the dissecting microscope, to identify the site of puncture both in the anterolateral aspect of the pars distalis and, by separating the two major lobes of the hypophysis, in the forward surface of the pars nervosa. Coronal

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Electrical impedance of the pituitary

serial histological sections were obtained every 25 μ (Fig. 2). Examination of these preparations revealed in each case the presence of the electrode track in the adenohypophysis and an electrolytic lesion on the surface of the pars nervosa.

**Human Studies**

Measurements in patients were also obtained with the impedance probe, using the transnasal-sphenoidal stereotaxic technique described by Talairach and Tournoux. Most recordings were carried out under general anesthesia. The puncture in the anterior wall of the sella turcica was usually 1 to 2 mm from the midline and 2 to 3 mm above the floor. In the anterior hypophysis, impedance values of 310 to 560 ohms were obtained.

With further advance of the electrode, a discrete rise occurred to levels of 790 to 940 ohms (Fig. 3). More posteriorly a slight fall occurred until the dorsum sellae was encountered, where impedance fell to about the original value found most anteriorly. With repeated insertions of the probe, however, the increase in impedance became less marked; and after several penetrations, the level failed to rise. The point of initial impedance rise varied with each patient but was generally in the posterior aspect of the sella turcica and from 2 to 6 mm in front of the dorsum sellae.

Following the induction of radiofrequency heat lesions in the hypophysis to totally ablate the gland, impedance measurements were again carried out. The impedance level

Fig. 2. Photomicrograph of sagittal serial section of the monkey pituitary gland. Left: Note the electrolytic lesion (arrow) in the forward surface of the pars nervosa. This point corresponds to the rise in impedance observed in Fig. 1. Right: Serial section farther lateral showing electrode track artifact (arrow) just prior to penetration indicated. H. & E., ×10.

Fig. 3. Typical impedance curve taken at time of stereotaxic hypophysectomy in patient with hemorrhagic diabetic retinopathy.
N. T. Zervas, A. Shintani and K. S. Pickren

was now constant along the entire probe track and at about the lower level previously found in the anterior sella turcica.

Discussion

Impedance recording appears to be a simple and reliable method for detecting the interface of pars nervosa with pars distalis. Since the gland was destroyed at operation, anatomical confirmation could not be obtained in any of our patients. The results in monkeys, however, indicated that the rise in impedance was due to penetration of the neurohypophysis. The higher values of pars nervosa probably reflect the higher impedance of neural tissue in general.

The attenuation of differential impedance with repeated penetrations of the same gland was probably due to tissue disruption and seepage of conductive fluid along the electrode track. Aguillar has observed that small electrode tips give better impedance differentials and suggests that this is due to reduced tissue disruption by the smaller tip.

The differences in the depth at which impedance rise was observed from patient to patient in part reflects the known variability in the morphology of the substructures of the hypophysis and points out the difficulty in assessing the position of the pars nervosa or the dimensions of the hypophysis from plain radiographs alone. Hacker and Alonso have demonstrated beautifully the angiographic delineation of the pars nervosa in patients, a technique which should aid measurably any one requiring non-operative evaluation of that structure. But for precise intraoperative work, measurement of impedance is an easily obtainable discriminant.

References

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Address reprint requests to: Nicholas T. Zervas, M.D., Department of Surgery, Beth Israel Hospital, 330 Brookline Ave., Boston, Massachusetts 02215.

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