PHYSIOLOGY OF THE GLANDS OF THE HUMAN EAR CANAL: PRELIMINARY REPORT

WALTER C. LOBITZ, JR., M.D. AND CLARENCE J. CAMPBELL, M.D.

Apparatus and Technic

It has been our clinical impression that some patients suffering from recurring eczematoid dermatitis of the external auditory canal present hypersecretion of the glands of the ear canal (Shelley's observations confirmed this (1)). It was also a clinical impression that this secretion could be stimulated in the same manner as palmar (emotional) sweat. Many such patients volunteered the information that exacerbations of the dermatitis in the ear canals were associated with "emotional stress" or anxiety. The question arose as to whether "ear gland hyperhidrosis" might play a role in the production of dermatitis of the external auditory canal.

Before clinical studies could be properly evaluated, fundamental knowledge on the structure and physiology of normal glands of the ear canal was needed.† Some information on such structure was available in the literature. Studies on the physiology of the glands of the external auditory canal of man are very meager. This report deals with the apparatus and technic found necessary to carry out such studies.

STRUCTURE

"The adult external auditory meatus of man is approximately 26 mm. in length. The outer region has a framework of elastic cartilage which is continuous with that of the pinna. The inner region near the typanium has a bony framework. Auricular glands are found in the cartilaginous canal while the bony portion is usually aglandular (2)."

There are three types of glands in the external ear—(1) Sebaceous glands which are large and numerous at the tragus and orifice of the canal and become smaller and less numerous toward the inner portion of the cartilaginous canal. They disappear in the innermost portion of the tube. (2) Eccrine sweat glands (merocrine sudoriparous), which are present in the concha at the level of the tragus, disappear at the orifice of the canal and are replaced by (3) large, alveolar, ceruminous (wax) glands which are apocrine in type. Normally then, the external

* From the Department of Dermatology and Syphilology, Dartmouth Medical School and Hitchcock Clinic, Hanover, New Hampshire, and the Department of Physiological Sciences, Dartmouth Medical School, Hanover, New Hampshire.

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† Dr. William Montagna graciously made his histological material of the normal external auditory canal of man available to us in his laboratory at Brown University. His advice concerning the undertaking of this study was greatly appreciated.

auditory canal contains apocrine ceruminous glands and sebaceous glands in decreasing numbers, but no eccrine sweat glands.

The apocrine ceruminous glands lie, in aggregates of six or more, deep in the connective tissue layer of the ear canal, often resting upon the perichondrium of the cartilaginous tube. The secretory cells (epithelium) of these glands are like those of apocrine glands elsewhere in the body. They are tall in tubules which have a comparatively narrow lumen (fig. 1). When the lumen is distended, the secretory cells are flat (Such distention is considered a normal variation of structure, contrary to the opinion of Senturia (3)). These secretory cells rest on a layer

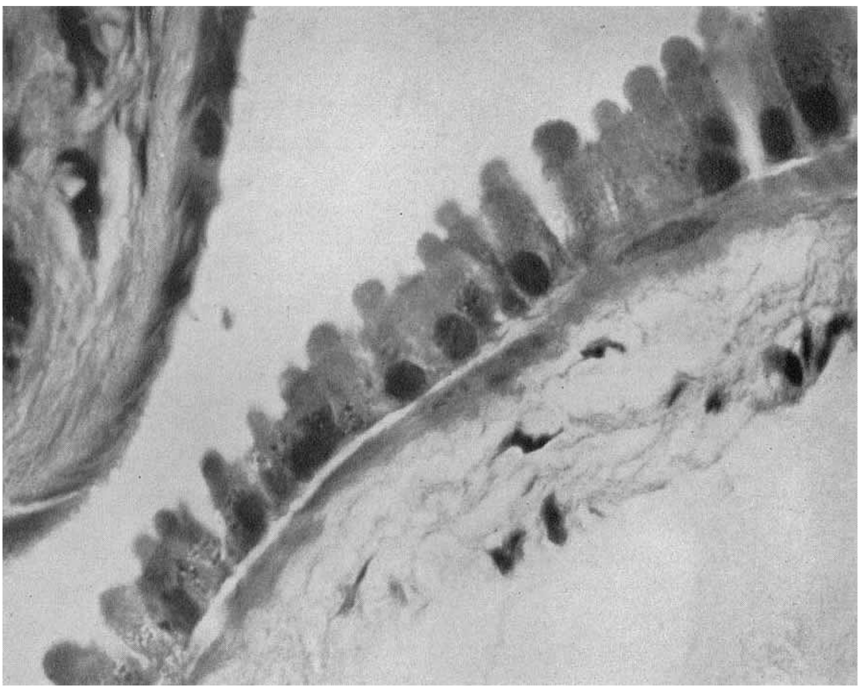

FIG. 1 Tall, columnar epithelial cells of apocrine ceruminous glands. Note the pigment in the cytoplasm, the myoepithelial cells, and the thick hyalin basement membrane (×945)

of myoepithelial cells, which in turn rest on a thick, hyalinized basement membrane. Thus, as in the cases of eccrine sweat glands, these ceruminous glands possess the power of contraction. The ducts of these glands usually open directly onto the skin surface; occasionally they open into sebaceous ducts.

Preliminary observations on the external auditory canals of normal individuals in a constant temperature room, using an ordinary clinical otoscope or a binocular skin microscope and a skin temperature meter, added more evidence that with mental stimuli the glands of the ear canal would discharge "bursts" of clear, glistening material from the openings of their pores. However, such secretions were more difficult to obtain than similar secretions from the palmar sweat glands (4).

Therefore, in order to evaluate the activity of the glands of the ear canal properly, certain observations were thought to be necessary—(1) The openings of the pores of the glands should be kept under visual observation during the experiment in order to determine the manner (rate, cycle, volume, etc.) in which the secreted material appears at the opening of the pore. (2) The activity of the palmar sweat glands should be known and correlated with the activity of the glands of the ear. (3) Other psychomotor responses, such as the heart rate and the rate and amplitude of respirations, should also be noted and correlated.

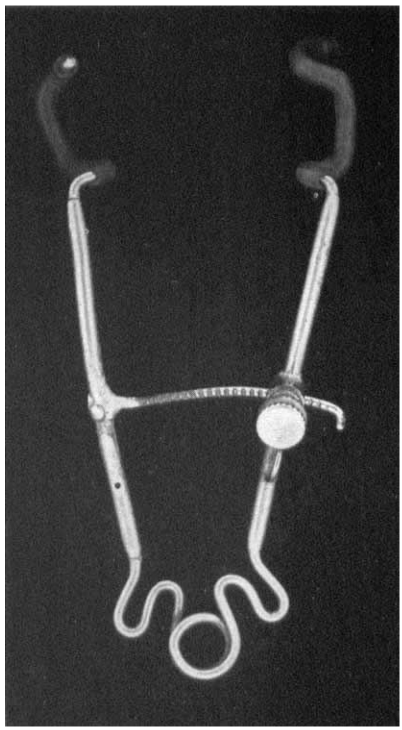

FIG. 2. Retractor for the tragus (on reader's left) and posterior wall of the external acoustic meatus (on reader's right).

APPARATUS FOR VISUAL OBSERVATION OF THE ACTIVITY OF THE GLANDS OF THE EAR CANAL

The anterior wall of the outer third of the cartilaginous portion of the external auditory canal was the area selected for observation. It was necessary to retract the tragus of the ear anteriorly and the posterior wall of the external acoustic meatus posteriorly in order to obtain adequate unobstructed vision. This was accomplished by reshaping an eyelid retractor and covering its ends with rubber (fig. 2).

The remainder of the apparatus was an ordinary "slit-lamp" microscope adapted to our needs (fig. 3). The subject under observation rested quietly, with the usual chin-forehead support properly adjusted for comfort, in a sitting position. The lenses of the binocular microscope portion of the apparatus were adjusted for a magnification of 15. It was impossible to direct the usual source of light of the instrument into the ear canal. For this reason, a new light source was developed and placed on top of the microscope exactly between the binocular objectives. The light source consisted of a 3.5 volt lamp, with a small condenser lens. The light was then conducted down a plastic tube tapered from 1.5 cm. at its origin to 0.4 cm. at its free end. In this manner, a "cool," but adequate,

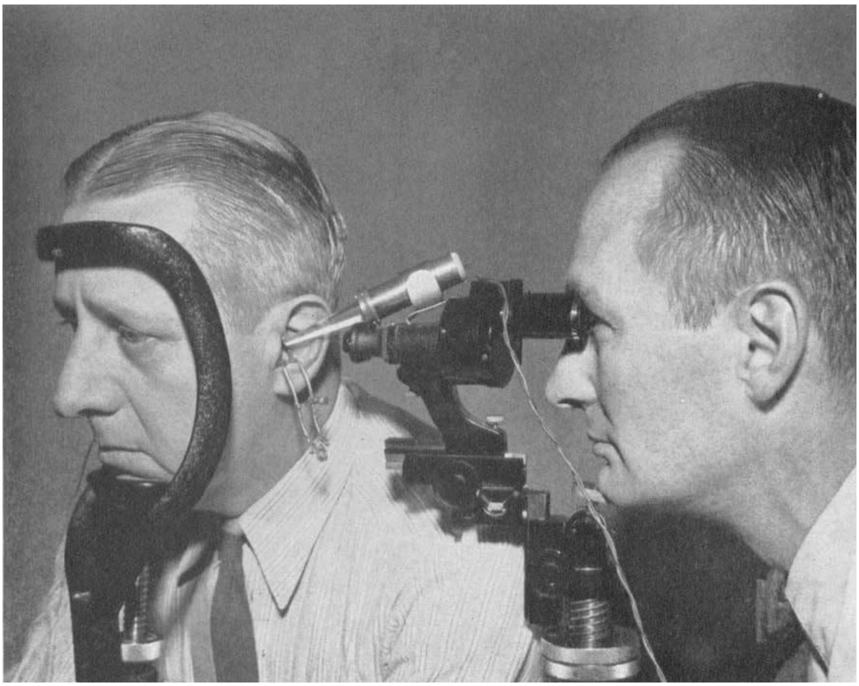

FIG. 3. Apparatus for visual observation of the activity of the glands of the ear canal. The source of light is on top of the microscope and is conducted down the tapered plastic tube. The "ear retractor" is in place.

source of light could be projected into the ear canal without shadows and without interfering with the vision of the observer (fig. 4).

SKIN IMPEDANCE

The electrical resistance of the skin varies with emotional stress and mental activity and can be used as an indication of function of the eccrine sweat glands (5). As the activity of the sweat gland increases, the resistance of the skin decreases.

In any such studies, in which continuous observations are to be carried out and in which continuous data and tracings are to be obtained, the direct current conduction properties of the skin (electrical skin resistance) become inaccurate because of polarization effects (6).

Skin impedance, using alternating current, however, eliminates such a technical difficulty (6, 7). For this reason, skin impedance was selected in these studies

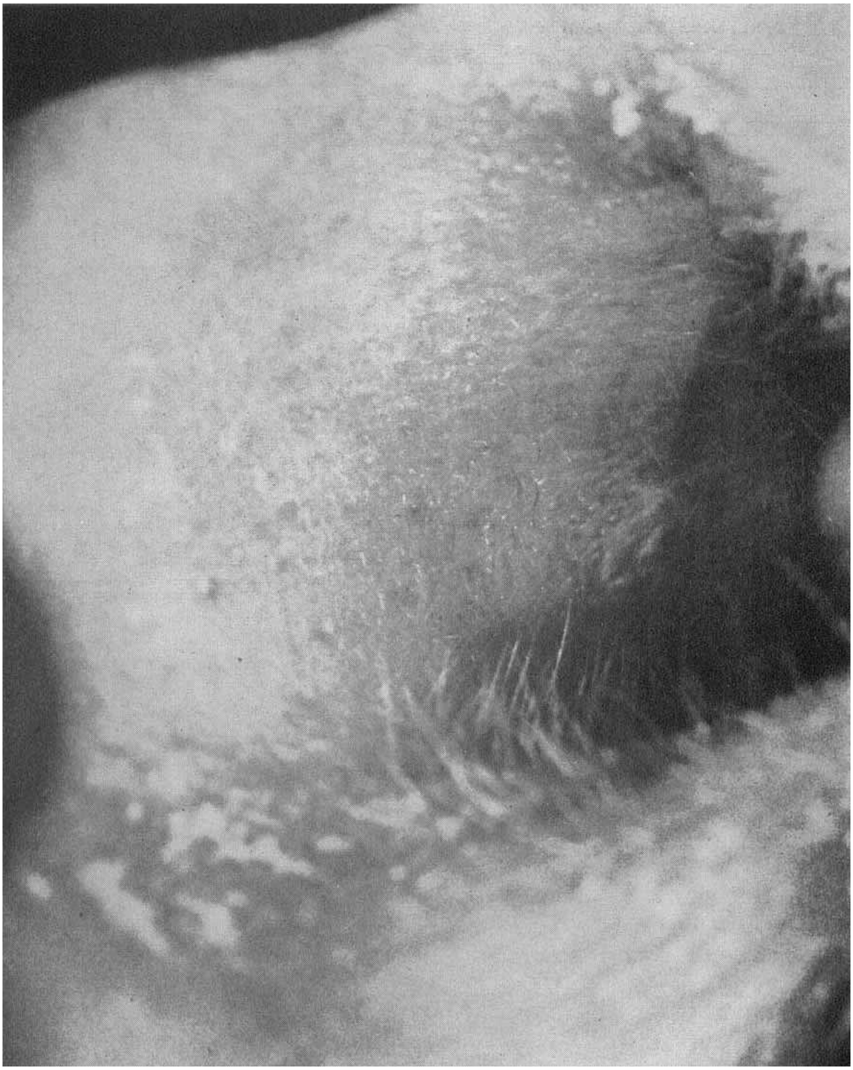

FIG. 4. The anterior wall of the outer third of the cartilaginous portion of the external auditory canal as seen with the "slit-lamp" microscope. (×15).

to indicate the activity of the palmar sweat glands and of the glands of the external auditory canal. Two separate impedance bridges were thus constructed (8).

The impedance bridge to measure palmar sweat gland activity was attached to the subject with silver circular electrodes 0.8 cm. in diameter. After cleaning the skin with acetone and ether, the electrodes were placed on the palmar surface of the skin of the right index and middle fingertips. The contacting material was electrocardiographic electrode paste. The electrodes were held in place with adhesive tape (5 g).

The impedance bridge that was to measure the activity of the glands of the ear canal was attached to the ear, opposite from the one being visually observed, as follows: An ear canal electrode was made by wrapping the inner end of a commercial rubber swimmer's ear plug with silver wire. This wire was then covered with candlewick cotton that had been soaked in a physiological sodium chloride solution (fig. 5). After the skin of the ear canal had been cleaned with acetone and ether and allowed to dry, the ear electrode was inserted into the ear canal. This brought the active portion of the electrode in contact with the skin of the outer one-third of the external auditory canal (the area that was under observation in the opposite ear). The other ear electrode, of the same type used on the fingertips, was attached to the lobe of the ear that contained the electrode in the canal.

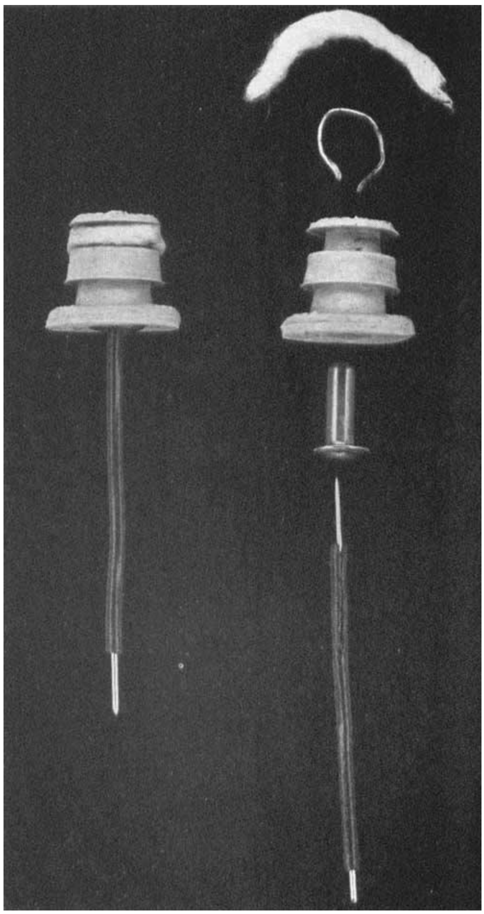

FIG. 5. Ear electrode, assembled (left) and unassembled (right).

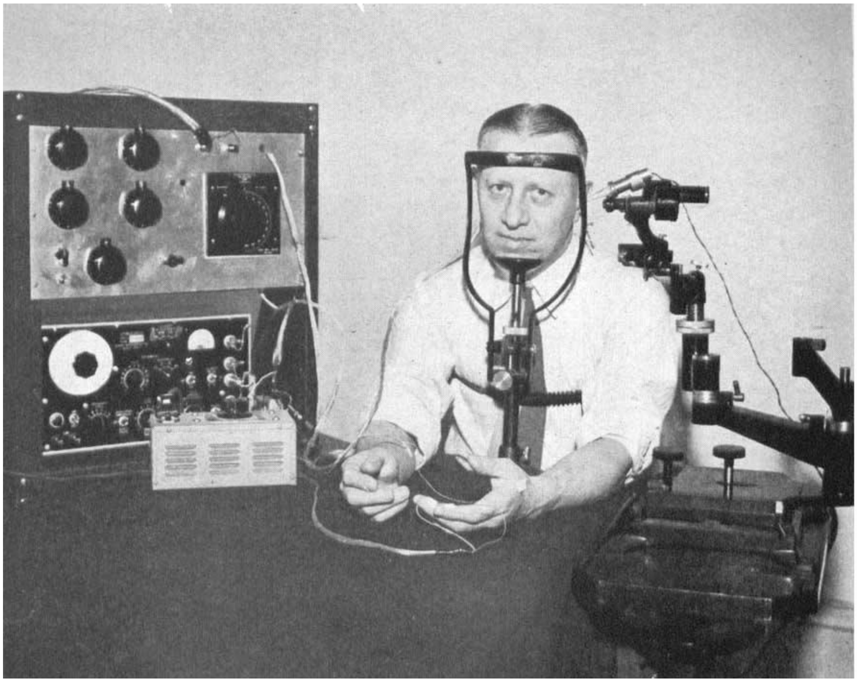

FIG. 6. The impedance bridges in the cabinet (on the reader's left) with all electrodes attached to the subject. The EKG leads are attached to the forearms. The pneumograph is around the subject's chest. The binocular microscope is in place.

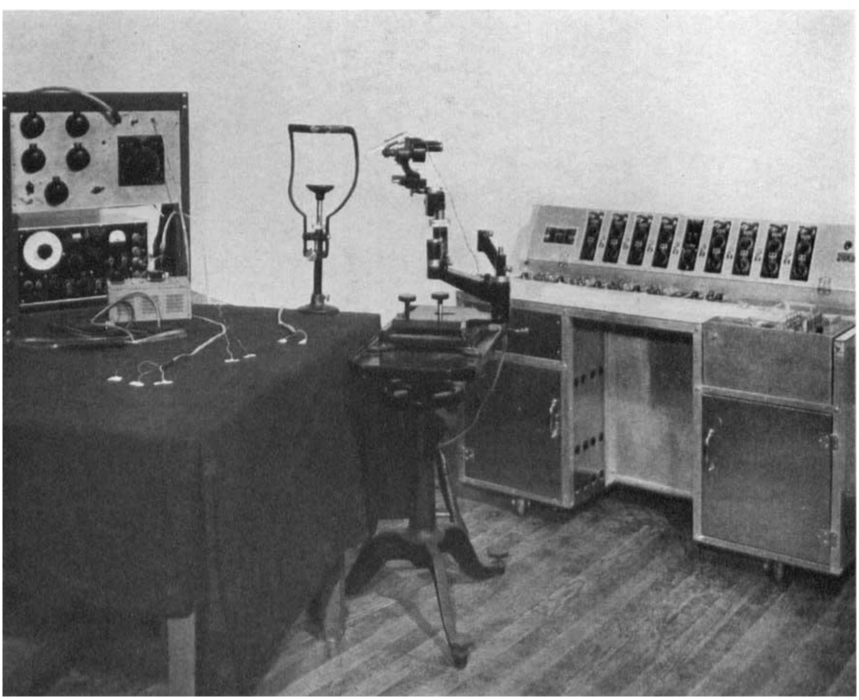

FIG. 7. All the equipment used in the study, including the recording electro-encephalograph (on reader's right).

The rate and amplitude of the respirations were measured by a pneumograph attached to a crystal diaphragm (Sanborn piezoelectric pulse transducer).

The heart rate was measured by recording the electrocardiogram of lead one.

Both impedance bridges, the crystal diaphragm from the pneumograph, and the electrocardiographic leads were connected to a Model 3 Grass Electroencephalograph, thus making it possible for all the changes to be simultaneously and continuously recorded. All the studies were carried out in a room with a constant temperature maintained at 20° Centigrade (figs. 6 and 7).

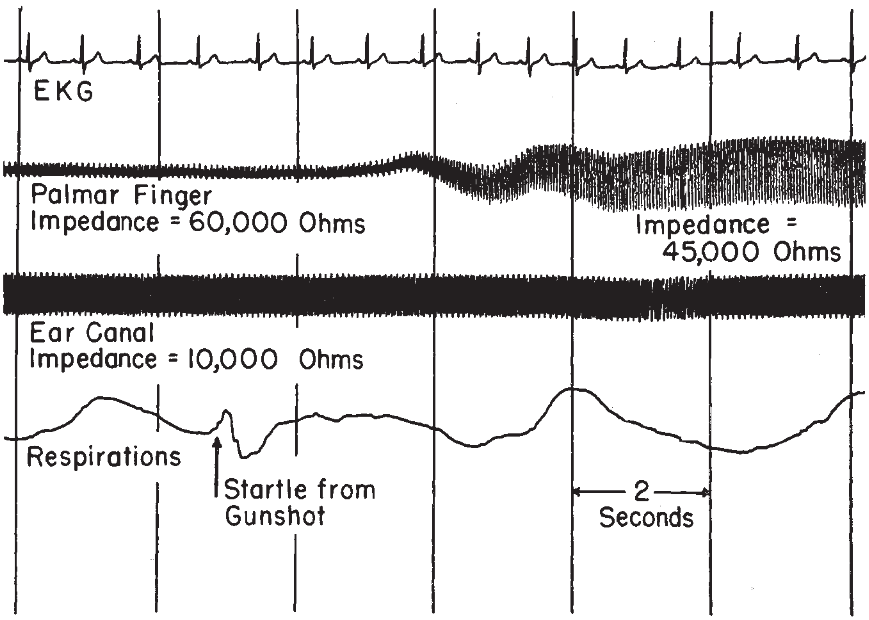

FIG. 8. A "tracing" showing a startle response of a normal subject to the loud noise of a gun shot. The skin impedance of the palmar fingers falls 15,000 ohms (increase in amplitude of line). The skin impedance of the ear canal does not change.

DISCUSSION

At present the laboratory studies, using the apparatus and technics described, have been limited to observations of normal adult subjects. Such studies are necessary, of course, before attempting any observations on the abnormal patient. It is not within the scope of this discussion to present any extensive data thus far obtained. However, several findings may be of interest.

The hypersecretion that was noted clinically in patients with dermatitis of the external auditory canals did not seem difficult to stimulate (pain, startle, anxiety, etc.). This secretion could be the result of either hyperactivity of the normally present apocrine ceruminous glands or aberrantly placed eccrine sweat glands in the canal. Such mentally stimulated ear gland secretion was more difficult to obtain, however, in normal individuals.

If a reduction in skin impedance occurs in the ear canal, it may be the result of activity of eccrine sweat glands that are aberrantly present or it may indicate hyperactivity of the apocrine wax glands. We have been unable to find any reference in the literature regarding the latter.

If the skin impedance of the ear canal does not change when other psychomotor responses do change, the indication is that there are no emotionally-activated eccrine sweat glands present in that ear canal or that the activity of the apocrine wax glands does not affect skin impedance.

The values of normal skin impedance of the palmar surface of the fingertips, varying, of course, from individual to individual, ranged between 30,000 and 100,000 ohms. In contrast, the skin impedance of the ear canals ranged between only 3,000 and 13,000 ohms. To date we have been unable to demonstrate any psychomotor response manifested by changes of the skin impedance of the ear canal in normal individuals. Figure 8 is one such tracing. A normal, resting, white male was startled by the unexpected noise from the shot of a gun. The immediate response was a gasp followed by a short period of apnea. Two and eight-tenths seconds later the skin impedance began to fall, and reached its maximum change of 15,000 ohms in 7.6 seconds (manifested by a widening of the excursions of the pen making the tracing). Four and four-tenths seconds after the noise, the heart rate began to increase. There was no change in the skin impedance of the ear canal (10,000 ohms).

It is appreciated, of course, that just as patients with dermatitis of the external auditory canals (or a predisposition to such a dermatitis) are a selected group for normal ear gland function, so, on the other hand, do a group of normal individuals represent a selected sampling for information pertaining to the functioning of ear glands in the group with dermatitis. Future studies on these two groups are in progress.

SUMMARY

The anatomy of the glands of the external auditory meatus is reviewed. Skin resistance and impedance are discussed. The apparatus and technics used to study the physiology of the glands of the ear canals are described and include simultaneous measurements of (1) visual observation of one ear canal with binocular microscopy, (2) skin impedance of the other ear canal, (3) skin impedance of the palmar fingertips, (4) electrocardiogram, and (5) pneumogram. Preliminary results are discussed.

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DISCUSSION

Dr. Flesch, Philadelphia: I would like to ask Dr. Lobitz about the relative number of apocrine sweat glands and sebaceous glands in the ear canal. How much do these two types of glands contribute to the cerumen? My reason for asking this question is that I have found marked differences in the chemical reactivity between sebum and cerumen. The former inactivates sulfhydryl compounds, while the latter is inert. Could the question of electrical impedance be settled by spreading sebum (hair fat) over normal skin and observing whether or not this will influence the electrical resistance of the skin?

Dr. Lobitz: Thank you very much, Dr. Flesch, for the interesting points you have raised.

Before we undertook the experiment, Dr. Montagna of Brown University was good enough to let us study the material that Dr. Zak had sent him. We spent quite a bit of time going over the histology and the anatomy of the glands of the human ear canal with him, as well as with our own otolaryngologists and anatomists.

The sebaceous glands are present in the external ear and are especially large at the level of the tragus and the orifice of the meatus. These glands become progressively smaller in the inner portion of the cartilaginous meatus and finally disappear in the innermost portion of the tube.

The eccrine sweat glands which are present in the auricle of the external ear are replaced at the orifice of the meatus by the apocrine wax glands. These apocrine glands, too, become fewer in number as one goes down into the cartilaginous portion of the canal. In the inner two-thirds of the canal, there are no glands whatsoever; this is the bony portion.

I think your second point is very well taken and I would like to talk to you later about it.