Biphasic Secretory Potentials in Cat and Rabbit Submaxillary Glands

Lundberg was the first to record transmembrane potentials in salivary glands. Stimulation of the secretory nerves to the submaxillary gland in the cat produced three types of potential changes (secretory potentials). The type I response to parasympathetic or sympathetic stimulation was a membrane hyperpolarization. Lundberg suggested that the type I response was derived from the acinar cells and proposed that it was caused by an active transport of chloride ions through the contraluminal membrane from the interstitial fluid to the cytoplasm. Recently, Yoshimura and Imai and Petersen have reported that the type I secretory potentials obtained from submaxillary glands in cat or dog are of normal size during perfusion with chloride-free solutions. Petersen suggested that the mechanism of action of acetylcholine on the contraluminal acinar cell membrane is to increase the permeability to both potassium and sodium ions. In the following some new and unexpected features of salivary gland electrophysiology will be reported.

Methods. Cats and rabbits anesthetized with chloralose (60–80 mg/kg) and urethane (1.5 g/kg), respectively, were employed. Membrane potentials were measured in the exposed submaxillary glands in vivo by using glass microelectrodes filled with 3M KCl, having resistances of 20–50 MΩ. An indifferent electrode was placed under the neck skin opposite to the gland under study. The preganglionic lingual nerve fibres (parasympathetic) were stimulated at 0.2 or 20 c/sec through conventional stimulating electrodes.

Results. Single shock stimulation in both the cat and the rabbit resulted in either biphasic secretory potentials (type IB) (depolarization followed by hyperpolarization) or monophasic hyperpolarizing secretory potentials (type IM) (Figure 1).

In the cat submaxillary gland the mean latency of the type IB response was 176 msec ± 17 (80–300 msec) and that of the type IM was 291 msec ± 11 (100–500 msec). The resting membrane potentials for the cells displaying type IB responses were higher (−31.0 mV ± 0.4) than for those displaying type IM responses (−31.0 mV ± 0.8). Each histogram showing the frequency distribution of the resting potentials for these 2 groups exhibited

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asymmetry (Figure 2). However, the histogram showing the frequency distribution of all the resting potentials (type IM + IB) showed a fairly good symmetrical distribution. The mean resting potential of all the cells was $-35.0 \text{ mV} \pm 0.7$. The amplitude of the initial depolarization of the type IB response was roughly proportional to the size of the resting potential. The membrane resistance in the type IM cells decreased during lingual nerve stimulation. Single or repetitive stimulations decreased membrane resistance from $2.9 M \Omega \pm 0.2$ to $2.5 M \Omega \pm 0.2$ and $2.1 M \Omega \pm 0.2$, respectively.

In the rabbit submaxillary gland, the mean resting potential was $-54.0 \text{ mV} \pm 3.1$. The latency of the type IB response was $168 \text{ msec} \pm 34$ ($100-300 \text{ msec}$), while that of the type IM response was $550 \text{ msec} \pm 130$ ($400-1000 \text{ msec}$). The secretory potentials in the rabbit submaxillary gland were more complex than those in the cat. Repetitive stimulation changed the configuration of the secretory potentials caused by single shock stimulation. For a short time following repetitive stimulation, the initial depolarization had a larger amplitude and the secondary hyperpolarization was reduced in a number of type IB cells. Sometimes the type IM response of one cell could be changed into a type IB response, concomitantly herewith the latency was considerably shortened (Figure 1 Rc). In the type IM cells, single shock stimulation decreased membrane resistance from $8.7 M \Omega \pm 1.4$ to $7.2 M \Omega \pm 1.0$ while repetitive stimulation reduced the resistance from $7.4 M \Omega \pm 1.0$ to $4.5 M \Omega \pm 0.6$. The decrease in membrane resistance slightly preceded the potential change (Figure 3 upper tracings). In the type IB cells the membrane resistance decreased concomitantly with the potential change (Figure 3 lower tracing). Single shock stimulation decreased the membrane resistance from $6.0 M \Omega \pm 1.8$ to $3.2 M \Omega \pm 0.7$ while repetitive stimulation caused a reduction from $6.6 M \Omega \pm 1.1$ to $1.9 M \Omega \pm 0.7$.

**Discussion.** SChneYER and YOSHiDA showed the existence of biphasic secretory potentials in the rat submaxillary gland. In all previous studies of membrane potentials in cat submaxillary glands, it has been shown that the contraluminal membrane of the acinar cells hyperpolarizes when the gland is stimulated to secrete. The present work shows clearly that biphasic secretory potentials also exist in the cat submaxillary gland and indeed in the rabbit submaxillary gland. The initial depolarization has not been observed previously, probably because only low resting membrane potentials (20–30 mV) have been recorded. The facts that only the

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**Fig. 1.** Transmembrane secretory potentials in cat (C) and rabbit (R) submaxillary glands obtained by single or repetitive chorda-lingual (Chor) nerve stimulations. a) and b) are examples of monophasic hyperpolarizing and biphasic secretory potentials, respectively, obtained by single stimulation, c) represent examples of secretory potentials obtained by repetitive stimulation.

**Fig. 2.** Cat submaxillary gland: Frequency distribution of the resting membrane potentials from the cells displaying monophasic hyperpolarizing (type IM) and biphasic (type IB) secretory potentials, and of the entire cell population (type IM + IB).

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