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Asymmetrical response of oxyntic cells to direct current in nonstimulated frog gastric mucosa

Direct current is generally applied for measuring the total resistance across epithelia. The resistance is calculated by dividing the changes in PD by the magnitude of the applied step currents. DURBIN AND HEINZ[1], HARRIS AND EDELMAN[2], HOGBEN[3] and CRANE *et al.*[4], among others, have measured the so-called "d.c. conductivity or its reciprocal, the final resistances" in gastric mucosa. In other epithelial tissues different attempts have been made to measure the intracellular response to externally applied d.c. currents[5]. In these cases, different cell layers are arranged in series between the two solutions and the electrodes are implanted in sites with different potential levels.

In gastric mucosa, there are at least two different types of cells arranged in parallel in the same layer: the surface epithelial cells and the oxyntic cells. Since these cells maintain different intracellular electrical potentials[6], we attempted to measure the effect of step currents in the intracellular potentials registered from both types of cells. The mucosae obtained from the stomachs of *Rana pipiens* were separated by blunt dissection from the muscular coat and were mounted between two chambers as previously described[6]. Both chambers were filled with nutrient solution oxygenated with O_2–CO_2, 95–5 %. Glass microelectrodes (0.5 μ tip diameter) filled with saturated KCl were implanted in one cell from the mucosal surface. Another external electrode was immersed in the solution in contact with the mucosal surface. The potential differences between these electrodes and the reference electrode situated in the solution in contact with the serosal surface, were recorded in a (Varian G 2000) recorder through two operational amplifiers (Philbrick, Q 25-AH) with an input impedance of $1 \cdot 10^{12}$ ohms. Two Ag–AgCl electrodes located in each chamber entered them and were used to send current through the mucosa. The current source was battery-operated. In some of the experiments positive current pulses were applied first followed by negative pulses of the same magnitude as illustrated in part A of Fig. 1. In other cases, negative current pulses were applied first as shown in part B of the figure. The results were similar whether positive or negative current pulses were applied first. The lower parts of Fig. 1 show the recorded potential. Trace I corresponds to the transmucosal PD recorded between the external electrode in contact with the mucosal surface and the reference electrode. Trace II corresponds to the PD between the microelectrode and the reference electrode. In part A, the microelectrode was in a surface epithelial cell and in part B was in an oxyntic cell.

The results obtained are presented in Fig. 2. Potentials measured after 10 sec are presented as a function of the applied current. The values at zero current correspond to the mean spontaneous PD recorded before and after applications of the current steps. No significant differences exists between these values. Each point is the mean $\pm$ S.E. The lines were fitted by least squares to the experimental values. The slope of the lines has units of resistance. This slope is 508 $\pm$ 9 ohms$\cdot$cm^2 for the values obtained between the two external electrodes in part A of the figure. Measurements obtained with the microelectrode from 71 surface epithelial cells in 16 mucosae

Abbreviation: PD, potential difference.

(across serosal surface of the cell) give a slope of 282 ± 12 ohms·cm². The difference between the total change in PD and that measured in the serosal surface must be at the mucosal surface; so that in the mucosal surface the change in PD corresponds to a resistance of 226 ± 15 ohms·cm². The ratio between mucosal and serosal surface resistances is 0.81. Part B of the figure shows the results obtained in 50 oxyntic cells from the same 16 mucosae. The slopes are 540 ± 10 and 125 ± 8 ohms·cm² for the lines fitted to the transmucosal PD and to the PD recorded across the serosal surface of the oxyntic cells. The change in PD produced through the mucosal surface corresponds, in this case, to a resistance of 415 ± 14 ohms·cm². In oxyntic cells, the ratio of mucosal to serosal surface resistance is 3.3. The different ratio of resistances in the two types of cells contradicts the idea that the greater resistance of the mucosal surface of the oxyntic cells is due to the contribution of the resistance of the solution in the tubular lumen. In that case mucosal surface resistance should be a function of the position of the surface epithelial cells and oxyntic cells with respect to their distance from the surface. Such was not the case.

The measured changes in PD due to an externally applied d.c. current do not permit calculation of an absolute value of resistance because: (a) the total PD change

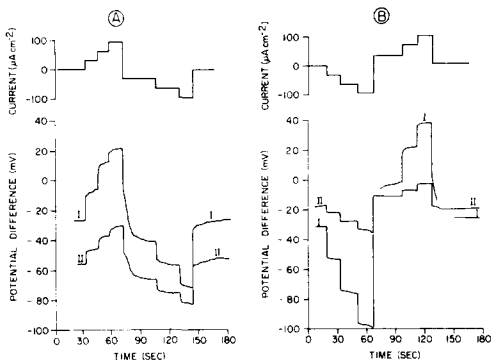

Fig. 1. Results obtained in a typical experiment. Applied current and simultaneous changes in transmucosal and intracellular PD are shown as function of time. In part A intracellular PD was recorded from a surface epithelial cell and in part B from an oxyntic cell. Negativity of PD means that secretory side is negative to serosal side and *vice versa*.

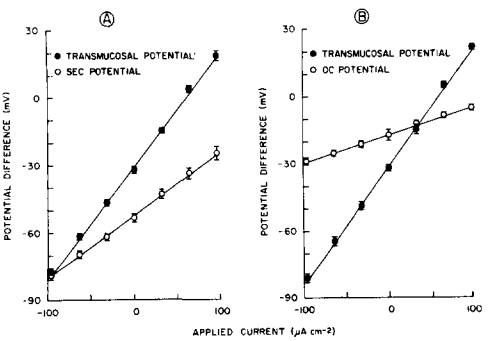

Fig. 2. Transmucosal and intracellular electrical potential differences as function of the applied current. In part A the intracellular potential was recorded from surface epithelial cells (SEC) and in part B from oxyntic cells (OC).

after 10 sec must include a change in electromotive force between cells and the external media as pointed out by NOYES AND REHM[7], (b) it is not possible to estimate the area of the different types of cells in the chamber and (c) it is also impossible to estimate the contribution of the shunt due to the other cells and intercellular spaces in parallel. However, these results could be interpreted as showing that (a) the resistance of the membrane at the serosal surface is lower than that of the mucosal surface in the oxyntic cells but not in the surface epithelial cell or (b) the membrane area at the serosal surface is larger than the membrane area at the mucosal surface in the oxyntic cells while in the surface epithelial cells this would not be the case. In the oxyntic cells the serosal surface area must include the lateral plasma membrane exposed to the 185 Å intercellular space.

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