〔ORIGINAL ARTICLE〕

# Relation between the secretory potential of parotid glands and the generated potential of collected salivas.

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## Abstract

We determined that a different-electrode in the flowing saliva (on the papilla parotidea) showed a potential of about 18mV, but the different-electrode on the mucous membrane (around the papilla parotidea) or on the cutis (over the parotid gland) showed much smaller potentials (lower than lmV). We confirmed the existence of electric potential differences between saline and collected saliva. The potential difference between saline and resting saliva was about 6mV, and that between saline and stimulated saliva was about 2mV. The former always higher than the latter. Comparing the electric potential changes on the papilla parotidea with other potential changes, the maximum potential difference obtained between the pailla parotidea and lobulus auriculae was about 11mV, the potential between resting saliva and stimulated saliva was about 8mV, and that between saline and stimulated saliva was about 4. 5mV. The pattern of electrical changes between resting saliva and stimulated saliva or saline and stimulated saliva were similar to that of electrical changes between tha papilla parotidea and lobulus auriculae.

**Key words**: secretory potential, collected saliva potential, saliva-saline potential, bridge detection method

## Introduction

Electrical phenomena accompanying the process of secretion from salivary glands in animals were first described by Bayliss and Bradford (1885)[1], and further study has been done by a number of investigators. Iwama and Shinjo (1950)[2] reported that action currents accompanying the saliva secretion from the human parotid glands can be recorded. They found that changes in salivary flow rate closely resemble changes in the action currents, and suggested

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that the action currents originated from the gland cells of the parotid.

Inomata et al. (1984a)[3] have reported potential changes accompanying secretion of saliva with amplitudes of about 10mV, with an electrode placed on the papilla parotidea and by stimulation with tartaric acid. This potential change was not recorded when the electrode was placed at other places around the parotid gland. The potential changes accompanying the saliva secretion could not be explained by the theory of the so-called action current mechanism. Recently, Inomata et al. (1992)[4] have observed an electrical potential difference between saliva and saline by a simple method.

The present study aims to clarify the mechanism of the electrical changes on the papilla parotidea by using the simple method in Inomata at al. (1992)[4].

## Methods

The subject was a healthy 57 year old male with parotidea secreting more saliva than others. About 1h after a Carlson and Crittenden (1910)[5] type suction cup was placed over the papilla parotidea, the tongue was stimulated with 3% tartaric acid.

A small disc of cotton wool, about 1cm in diameter, was saturated with tartaric acid solution (3%) and this was quickly applied three times to the back and margin of the tongue from tip to base at the ipsilateral side of the Carlson type suction cup. About 0.4ml of tartaric acid was applied. When the effect of the stimulation reached a constant level after a few successive 5min interval tongue stimulations, the collection of saliva and recording of electrical changes started, as detailed in Inomata et al. (1984a[3], 1990a[6]) and Yoshida et al. (1990)[7].

The saliva of the parotid gland was collected through this suction cup, and simultaneously the electric potential was recorded from the cup. A diagram of this experiment is shown in Figure 1.

Parotid salivas were collected in a small sample cup at every 0.2ml secretion for 5min. The dead space in the drainage tube of the Carlson type suction cup between the papilla parotidea and the end of the tube was 0.2ml, equal to the volume of saliva collected from the collection cup. The saliva on the papilla parotidea was collected in the next cup, and this delay was corrected.

A vinyl tube (ca. 1mm in diameter) with a cotton thread inside was filled with saline, and used as the different-electrode to detect the electric potential on the papilla parotidea. One end of this tube was placed on the papilla

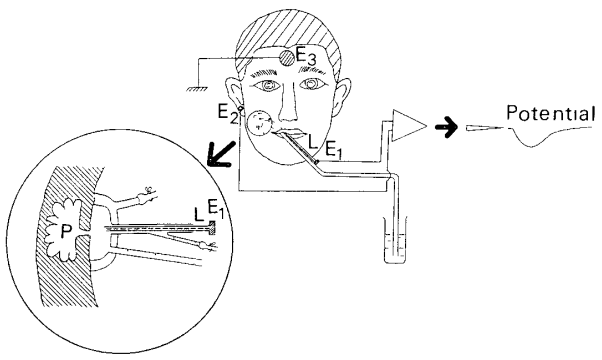



Figure 1. Diagram of the experiments
P: Parotid gland
L: Lead wire (vinyl tube with cotton thread filled with saline)
$E_1$, $E_2$: Ag-AgCl electrode (8mm in diameter: NT-211U, NIHON KOHDEN)
$E_3$. Ag-AgCl electrode (3×3cm)

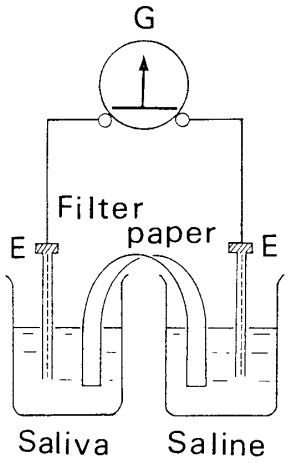



Figure 2. Diagram of the method for determining the potential differences between saliva (Gl. parotids) and saline.
G: detector

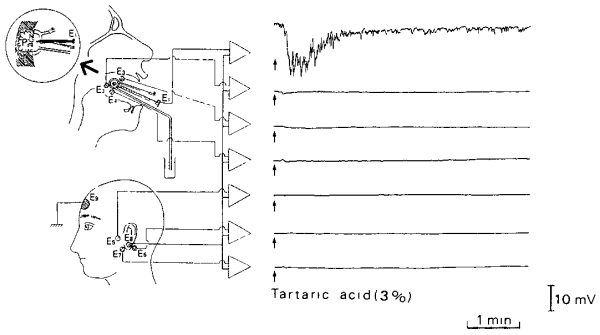
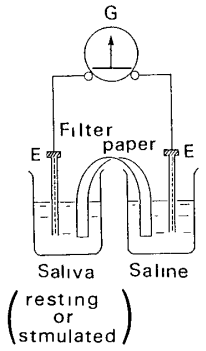



Figure 3. Recording method and records of electrical changes on the papilla parotidea and six other places.
Top record shows electrical changes on the papilla parotidea.
The next three records show changes on the mucous membrane around the papilla parotidea.
The lower three records show changes on the cutis over the parotid gland.




| Saliva − Saline (resting) | Saliva − Saline (stmulated) |
|---|---|
| 7.0 | 2.6 mV |
| 5.5 | 1.6 |
| 5 9 | 2.0 |
| 5 9 | 2.0 |
| 5.4 | 2.8 |
| 7.2 | 2.2 |
| av. 6 2 | 2.2 |

Figure 4. Method of detection of the potential differences between saline and saliva (resting saliva) or saliva (stimulated saliva), and the values recorded.

parotidea through the drainage tube of a Carlson cup, the other was connected to an Ag-AgCl electrode (8mm in diameter) using E. E. G. paste, and the lead of this electrode was connected to the input (+) port of a DC amplifier (micro-electrode-amplifier). Another Ag-AgCl electrode (8mm in diameter) was used as an indifferent-electrode and was placed on the lobulus auriculae using E. E. G. paste at the ipsilateral side of the Carlson type suction cup, and the lead of this electrode was connected to the input (−) port of a DC amplifier. A larger Ag-AgCl electrode (3×3cm) was placed in contact with the center of the forehead and earthed. The electrical changes on the papilla parotidea and at other places were continuously recorded on paper via a DC amplifier and pen-recorder system. The averages of potential differences in the time required to collect 0.2ml of saliva was plotted.

The potential defferences between two saliva or the saliva and saline were determined by a filter paper bridge with Advantec-Toyo No. 4A filter paper as shown in Figure 2. These potential differences were measured by the DC amplifier system. The electrodes of this potential were similar to the electrode placed on the papilla parotidea.

## Results

Figure 3 shows the electrical changes on the papilla parotidea and 6 other places (3 on the mucous membrane around the papilla parotidea and 3 on the cutis over the parotid gland)

induced by the stimulation with 3% tartaric acid. The potential change recorded on the papilla parotidea was about 18mV, while the potential changes recorded at the other 6 places were lower than 0.8mV.

After the effect of tartaric acid stimulation became constant, parotid saliva was collected before (resting saliva) and after (stimulated saliva) stimulation. The potential differences between resting or stimulated saliva and saline (0.9% NaCl) were measured. Figure 4 shows that the potential differece between resting saliva and saline was about 6.2mV, and that between stimulated saliva and saline about 2.2mV, significantly lower than the resting saliva.

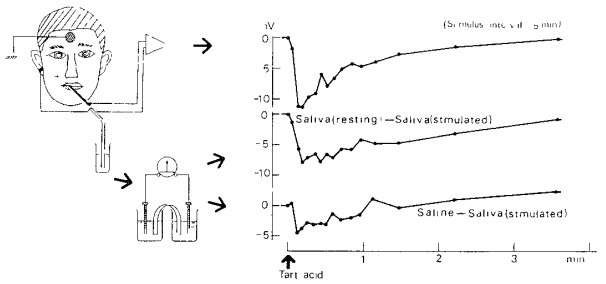



Figure 5. Diagram of the method of recording electrical changes on the papilla parotidea, and between saliva and saliva or saline
The upper curve shows the average potential difference in time required to collect 0 2ml of saliva The maximum voltage difference between resting and the stimulated state was about 11 4mV
The middle curve shows the voltage difference between salivas. The maximum voltage was about 8mV
The lower curve shows the voltage difference between saline and stimulaed saliva The maximum voltage was about 4 5mV

These results indicate that there is a potential difference between resting saliva and stimulated saliva, and it was hypothesized that this potential difference depended upon dissimilarities in the electric changes of the two salivas. This is supported by the report of Inomata et al. (1984b)[8] and Yoshida et al. (1990). The ion concentration ($Na^+$, $Cl^-$, etc.) in parotid saliva clearly changed after tongue stimulation (tartaric acid 3%), next the changes in ion concentration necessary to cause the changes in the electrical changes in the saliva were estimated.

Electrical changes on the palilla parotidea was recorded from the Carlson type suction cup. At the same time, each 0.2ml of parotid saliva was collected in small sample cups, and the potential differences among these cups were determined and are shown in Figure 5. The upper curve in this figure shows the electrical changes on the papilla parotidea. Each point (solid circle) is an average of potential dfferences within the time required to collect 0.2ml of saliva, and the maximum potential differences between the resting and stimulated state was about 11.4mV. This voltage was similar to those reported by Inomata et al. (1984a[3] and 1992[4]). The middle curve in Figure 5 shows the changes in potential differences between the resting and stimulated salivas, and the maximum potential difference in this case was about 8mV. The lower curve of this figure shows the changes in potential differences between saline and stimulated saliva, here the maximum potenial difference was about 4.5mV. The pattern of changes in the middle and lower curves were similar to that of the top curve. In this experiment, the voltage difference of the resting state was set as the standard (0mV).

## Discussion

### [The characteristics of electrical changes on papilla parotidea]

The electrical phenomena accompanying secretion from salivary glands of animals was first reported by Bayliss and Bradford (1886)[1]. Iwama and Shinjo (1950)[2] have reported that electrical phenomena obtained from human papilla parotidea are the action current of salivary glands. It is generally accepted that the electrical changes accompanying the saliva secretion are caused by the salivary glands. This would require that the electrical changes from all recording electrodes must be similar to the top curve in Figure 3. However, the maximum deflection of the electrode on the papilla parotidea was about 18mV, and the other six electrodes showed only slight deflections.

The maximum voltage of the electrode on the papilla parotidea and of the other six electrodes were clearly different. Investigating the reasons for this difference, it was noted that there is salivary flow around the tip of the electrode on the papilla parotidea, while there is no salivary flow around the other electrodes. We therefore considered that the origin of this electrical change depends mainly on the parotid saliva itself, and not on the electrical changes in the parotid gland and/or acinar cells. To substantiate a potential difference between resting saliva and stimulated saliva or between stimulated saliva and saline must be established.

### [Electrical characteristic of collected parotid saliva]

The electrical potential cahnges of collected saliva were similar to those on the papilla parotidea, but were not the same (Figure 5). Reasons for the disagreement among the three curves may be: (1) The disagreement is dependent on the detection methods. If the detection method was better, the disagreements would become smaller. (2) While the electric potential in saliva was measured (middle and lower curves in Figure 5) the salivas were exposed to air and $CO_2$ in the saliva esasily escapes to the air, and this would change the ion concentrations in the saliva from that of the freshly collected saliva. (3) The saline did not contain $K^+$, $HCO_3^-$, $PO_4^{2-}$ ions, and the ions in the saline were clearly different from the ions in parotidea saliva. (4) The electric potential of the top curve in Figure 5 was detected directly from the papilla parotidea, but the potentials of the middle and lower curves were detected indirectly by the bridge method (Figure 2).

On the basis of the above results and considerations, we conclude that the electrical activity in salivary depends mainly on the concentration of each ion in the saliva as the "Total cahrges" as termed by Inomata et al. (1984a[8] and 1990b[9]). We consider that the electrical activity on all exocrine glands depend mainly on the "Total charges" in its secretion. We suggest that the evoked potential mechanism of the extracellular potential as E. C. G., E. E. G., E. R. G., etc. is related mainly to the "Total charges" in extracellular fluids.

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# 抄　　録

我々は耳下腺乳頭部（以下乳頭部と略す）に見られる電位変化の性質を検索して以下の結果を得た。1）乳頭部で唾液の流れる所においた電極からは18mV位の電位差が記録されたが，その付近の粘膜上や耳下腺上の皮膚等においた電極からは1mV以下の小さな電位しか記録されなかった。2）生食と唾液間の電位差を測定（6回）すると，生食と安静時唾液との間には約6mVの電位差が見られ生食と刺激時唾液との間では約2mVの電位差があった。そして前者の方がいつも高値を示した。3）舌背刺激時の乳頭部の電位変化と，その時に分泌された唾液自身にみられる電位変化を比較すると，乳頭部の電位変化の最大値は約11mVであり，安静時唾液と刺激時唾液との間では約8mV，生食と刺激時唾液では4.5mVであった。安静時唾液と刺激時唾液，又は生食と刺激時唾液との間のそれぞれの電位変化の経過は乳頭部の電位変化の経過と似た経過を示している。