Effects of Nerve Stimulation and Denervation on Secretory Material in Submandibular Striated Duct Cells of Cats, and the Possible Role of these Cells in the Secretion of Salivary Kallikrein

J. R. Garrett and A. Kidd*

Department of Oral Pathology, King's College Hospital Dental School, Denmark Hill, London SE5 8RX, England

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Summary. Striated ducts in cats after 24 hours starvation normally contained glycogen, especially in the basal regions. They also contained neutral mucin and tryptophan in apical parts of "light" cells and small irregular "secretory" granules were found in a similar distribution by electron microscopy.—Parasympathetic nerve stimulation caused a loss of glycogen but no apparent change in the apical secretory material, despite a copious secretion.—Sympathetic stimulation caused a loss of glycogen and an extensive depletion of apical secretory material, although the salivary flow was small.—Parasympathetic denervation caused progressive atrophy of striated ducts and oedematous degeneration of some cells occurred. Persisting "light" cells tended to contain few basal infoldings, few mitochondria and little apical secretory material.—Sympathetic denervation caused a loss of apical secretory material between 2-4 days, which may have been due to "degeneration activation". Thereafter little change was evident but some ductal atrophy had occurred by 32 days.—These changes in ductal secretory material correspond more closely than acinar changes to the alterations in glandular and salivary kallikrein resulting from similar experiments by other workers. It therefore seems likely that submandibular salivary kallikrein in the cat is present in the secretory material of striated ducts.

Key words: Submandibular glands (cat) — Striated ducts — Autonomic nerves — Denervation — Salivary kallikrein.

Introduction

Striated ducts are prominent in submandibular salivary glands of the cat. They are long and tortuous, and it has been estimated that they occupy 30% of the parenchyma in a given lobule of the gland (Shackleford and Wilborn, 1970). They receive the primary salivary fluid from the acinar cells via the short intercalary ducts, and they drain into the interlobular ducts.

Rawlinson (1934, 1935), using conventional histology, studied the changes in striated ducts after stimulating the sympathetic or parasympathetic nerves to submandibular glands in cats, and also after respective denervations. He concluded that both nerves had an effect on the cells but his interpretations were severely

Send offprint requests to: Professor J. R. Garrett, Department of Oral Pathology, King's College Hospital Dental School, Denmark Hill, London SE5 8RX, England.

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limited by the techniques then available. More recently it has been shown that both adrenergic and cholinergic axons have neuro-effector relationships near the basal surfaces of striated ducts in the cat (see Garrett, 1972), but it is unlikely that each cell in a striated duct receives an innervation. Therefore, if the nerves do have an effect on the ducts as a whole it seems probable that electrotonic spread of nerve-induced activation must occur between the cells.

It is now generally accepted that the ducts have a role in modifying the ionic content of the primary acinar secretion (see Schneyer, Young and Schneyer, 1972) and, in so doing, perform work against an osmotic gradient. Kaladelfos and Young (1974) have recently confirmed that, during secretion, the submandibular ducts in cats perform ionic functions. However, it is debated whether the striated ducts contribute to the organic content of the saliva and it is with respect to this secretory possibility that the present paper is principally concerned: histochemical and electron microscopical techniques have been used for the assessment.

Materials and Methods

1. Nerve Stimulation Experiments

18 fasted adult cats of either sex, weighing from 2.1 to 5.35 kg, were used. Anaesthesia was induced by α-chloralose, (B. D. H.), 40 mg/kg and urethane, (Sigma), 500 mg/kg (McLeod et al., 1970). The chloralose/urethane mixture was dissolved in the minimum volume of propylene glycol without heat in order to avoid the production of β-chloralose which is a convulsant (Snow, 1973, personal communication) some 0.85% saline was added and the mixture was administered by intraperitoneal injection.

The lingual and cervical sympathetic nerves were sectioned on both sides and the appropriate nerve was prepared for stimulation on the test side. A nylon cannula (Portex—standard 1) was inserted in the submandibular duct of each stimulated gland. Bipolar electrodes were used for all stimulations. In 10 cats the chorda-lingual nerve to the right submandibular gland was stimulated continuously for 2 hours, using a square wave stimulator (Palmer) at 6 volts, pulse duration 2 milliseconds. The frequency was kept constant during any one experiment, and ranged in the series from 2 to 10 Hz.

In 6 experiments the right cervical sympathetic nerve was stimulated at 6 volts and 8 or 10 Hz intermittently for a period of over 4 hours, giving a total stimulation time of about 2 hours. Stimulation was usually given for 40 sec in every 2 minutes using a current interrupter, since interrupted stimulation gave much greater volumes of saliva than continuous stimulation. The efficacy of each stimulation period was monitored by noting the characteristic eye signs.

Two double stimulation experiments have also been carried out. In each of these experiments both glands received stimulation via the chorda-lingual nerves at 2 Hz using a double channel stimulator (Scientific Research Instruments). The right gland in one experiment received uninterrupted superimposed sympathetic stimulation at 8 Hz, but stimulations were intermittently discontinued when flow rates on the right side became reduced; an actual stimulation time of about 2 hours was finally achieved. In the other experiment the right gland received interrupted sympathetic stimulation at 6 Hz during continuous parasympathetic stimulation.

Salivary flow was monitored by digital recording of drops formed from the cannulae and the total volumes of saliva secreted by each gland were measured.

Preservation of Tissues

The fixation of the salivary glands was by bilateral perarterial perfusion (after Bowes et al., 1970), via the common carotid arteries using a peristaltic pump (Watson and Marlow). The cats were usually given about 0.5 ml of heparin (Pularin, 1000 Units/ml, Evans Medical)