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SUPERSENSITIVITY OF THE VESSELS OF THE PAROTID GLAND AFTER DENERVATION

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Section of the postganglionic parasympathetic nerves to the parotid gland of the cat was found to cause supersensitivity of the blood vessels of the gland towards adrenaline. No supersensitivity or a slight degree only was found after cutting the preganglionic parasympathetic nerves to the gland. No supersensitivity of the vessels of the parotid gland could be demonstrated after excision of the superior cervical ganglion.

It has been found that section of the parasympathetic nerves to the parotid gland caused supersensitivity of the gland to the secretory effect of acetylcholine, pilocarpine and adrenaline (Strömblad, 1955). In accordance with the "Law of denervation" (Cannon, 1939), postganglionic denervation caused a higher degree of supersensitivity towards acetylcholine and pilocarpine than preganglionic denervation. The sensitivity to adrenaline was, however, not greater after postganglionic than after preganglionic denervation. It was thought that this discrepancy could be due to vascular changes caused by adrenaline. If the vessels obeyed the law of denervation, vasoconstriction might be greater in the postganglionically denervated than in the preganglionically denervated gland and thus the secretory effect would be restricted more in the former case. This has now been investigated further.

It is generally assumed that the parasympathetic nerves to the parotid gland of the cat contain vasodilator fibres and that the sympathetic nerve contains vasoconstrictor fibres. Evidence is, however, scanty and it therefore seemed of interest to make further observations on the effects of stimulation of these nerves.

METHODS

Cats were anaesthetized with chloralose (80 mg./kg. body weight). The parotid region was exposed on both sides; cannulae were tied into the posterior facial veins and branches of these veins, other than those coming from the parotid glands, were ligated. Heparin was used to prevent clotting. The drops of blood falling from the cannulae were signalled manually to ordinate recorders (Clementz and Ryberg, 1949). In most experiments cannulae were also introduced into the parotid ducts.

Injections were made through a cannula inserted into the femoral vein and blood collected from the parotid gland was returned to the animal from time to time by the same route. The blood pressure was recorded from the femoral artery. In some animals parasympathetic denervation of the parotid gland on one side was done by the methods previously described (Strömblad, 1955); in others the superior cervical ganglion was excised on one side. These operations were done two weeks before the acute experiment.

RESULTS

Blood Flow Through the Parotid Gland During Stimulation of Parasympathetic and Sympathetic Nerves

Fig. 1 shows the vasodilator effect of stimulation of Jacobson's anastomosis (preganglionic parasympathetic). There were often two phases of increased blood flow separated by a short period during which the flow was somewhat less. This was especially marked in the case shown in the left-hand record where the **W**-type response can be clearly seen. After atropine, vasodilatation still takes place but secretion is abolished. This atropine-resistant vasodilatation, similar to that in the submaxillary gland, was observed by Langley (1889), who, however, remarked that the flushing of the gland was less marked than he had expected. In our experiments the vasodilatation after a moderate dose of atropine (1 mg.) was usually as pronounced as without atropine in spite of the fact that atropine had completely suppressed the secretion. After atropine the **W**-shape of the response was not evident. Large doses of

atropine (8 to 10 mg.) lessened the vasodilatation caused by stimulation of the parasympathetic nerves though they did not abolish it.

Stimulation of the sympathetic nerve in the neck caused a pronounced decrease in the blood flow through the gland (Fig. 2). This decrease was maintained for as long as the stimulation was continued and was not interrupted by periods of flow greater than the resting flow, as is seen with the submaxillary gland. Even during intense vasoconstriction the gland was still able to secrete. In one case, for example, 7 drops were obtained during 5 min. of stimulation. Cessation of stimulation of the sympathetic was always followed by a period of increased flow through the gland.

Effect of the Injection of Adrenaline on the Blood Flow Through the Parotid Gland

The intravenous injection of adrenaline caused moderate changes in the flow of blood through the normal gland (Fig. 3, lower record). In some experiments there was an increase in flow coinciding with the increase in blood pressure while in others there was no change or a slight decrease. It was often found that, in the same animal, small doses (1 to 10 μg./kg.) caused an increase and larger doses a decrease in flow. Very large doses (100 to 200 μg./kg.) regularly caused a decrease. In most animals, after the blood pressure had returned to its original value, there was a period during which the flow was slightly diminished.

Postganglionic Parasympathetic Denervation.—On the denervated side, adrenaline always caused a pronounced fall in blood flow through the gland. In Fig. 3 the effects caused in the normally innervated gland (lower records) and in the contralateral denervated gland (upper records) can be compared. In the denervated gland, the decrease in flow both during the phase of increased blood pressure and in the following period is much greater. Even in cats in which an injection of adrenaline caused an increased flow through the control gland, there was a decreased flow through the denervated gland.

The changes after denervation described above were found in 9 out of 11 cats used. In one of the remaining two cats, denervation was found to

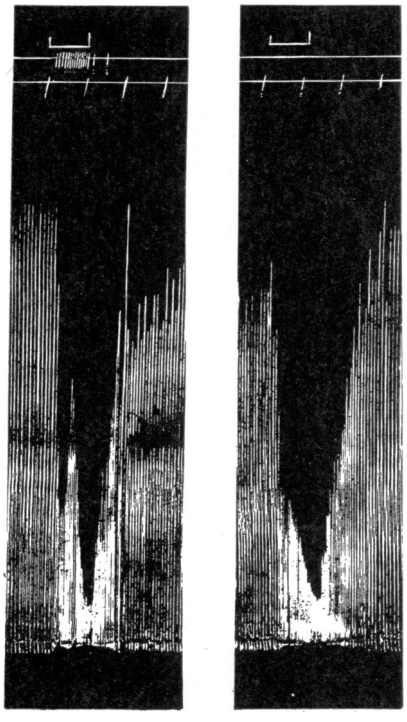

FIG. 1.—Effect of stimulation of Jacobson's anastomosis (preganglionic parasympathetic) on blood flow through the parotid gland. Cat 2·9 kg. Tracings from above downwards: signal; drops of saliva; time in min.; blood flow. An increase in the height of the lowest trace indicates a reduction in blood flow. Atropine (1 mg.) was injected during the interval between the two tracings.

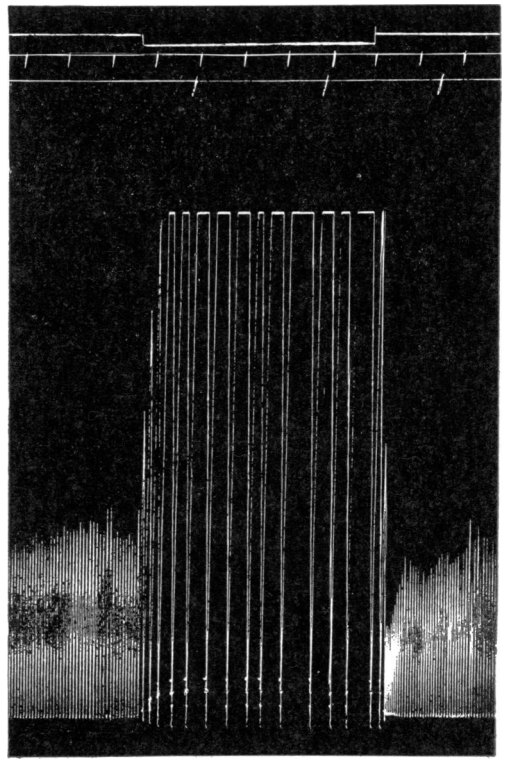

FIG. 2.—Effect of stimulation of the sympathetic nerve in the neck on blood flow through the parotid gland. Cat 2·8 kg. Tracings from above: signal, time in min., drops of saliva and blood flow.

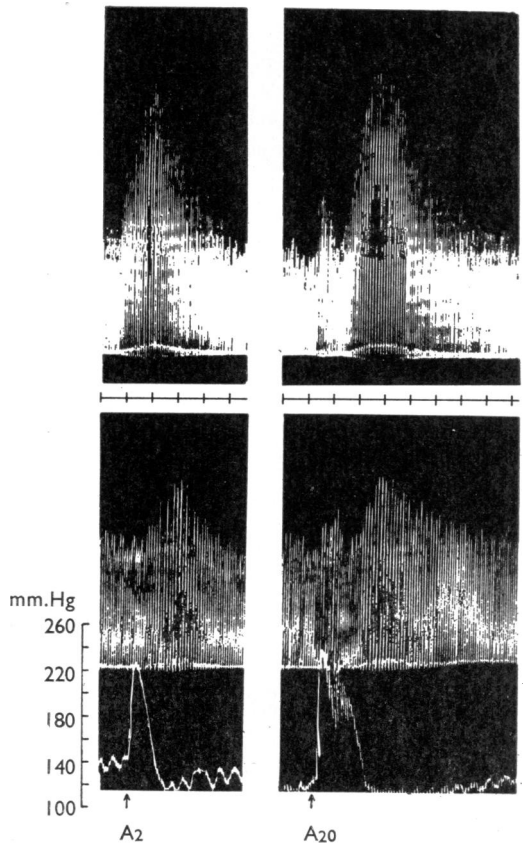

FIG. 3.—Effect of adrenaline on blood flow in the postganglionically denervated (upper) and the contralateral normally innervated gland (lower). Cat 3·1 kg. Time, in min. between upper and lower tracing. A_2 and A_{20}, 2 and 20 μg./kg. of adrenaline, respectively.

have been incomplete: preganglionic stimulation evoked secretion. In the other, the success of the operation was unfortunately not tested. Acute denervation of the gland was never followed by the changes described above. In the resting state, the flow of blood was not appreciably different through the previously denervated and through the normal gland.

Preganglionic Parasympathetic Denervation.—In 5 out of 7 cats used, the vascular response to adrenaline was the same on the innervated and denervated sides, and there was no difference in the resting flow. It was found in the remaining two animals that 20 to 50 μg./kg. of adrenaline caused a decrease in the flow of blood on the denervated but not on the control side. On further increasing the dose to 100 μg./kg., a decreased flow was found on the control side as well. No difference could be seen after small doses of adrenaline. It may be concluded from these experiments that preganglionic parasympathetic denervation causes no or only a slight degree of supersensitivity of the parotid vessels.

Excision of the Superior Cervical Ganglion.—In both acute and chronically operated animals the flow through the gland in the resting state was about twice as much on the operated as on the unoperated side. There was no difference in the vascular response to adrenaline on the two sides, but the difference in resting flow could have affected this result and a change in sensitivity cannot be excluded.

DISCUSSION

The difference in the effect of adrenaline on the flow of blood through the normally innervated and postganglionically denervated gland may well be explained by the development of a supersensitivity in the vessels of the denervated gland.

Supersensitivity of blood vessels has been shown to follow sympathetic denervation in various vascular regions, but in some cases none has been found (see Cannon and Rosenblueth, 1949; Griffin, Green, Youmans and Johnson, 1954; Burn, Philpot and Trendelenberg, 1954). We would not exclude, on the basis of the present experiments, the possibility that sympathetic denervation of the parotid vessels may cause supersensitivity, but the experiments do not support the idea. On the other hand, they do show that postganglionic parasympathetic denervation causes supersensitivity of the vessels, and so far as we know it is the first time that this has been demonstrated. No supersensitivity or a slight degree only was found after preganglionic parasympathetic denervation. Thus, the vessels of the parotid gland are another example of the superiority of postganglionic, as opposed to preganglionic, denervation in causing supersensitivity.

In earlier experiments, it was found that the supersensitivity to the secretory action of adrenaline after preganglionic denervation was of the same magnitude as after postganglionic denervation, and the suggestion was put forward that this was due to the higher sensitivity to adrenaline of the blood vessels after postganglionic denervation. This suggestion is supported by the results obtained in the present series of experiments. It is therefore possible that the secretory response was restricted by the vascular reactions in the postganglionically denervated parotid gland.

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