Resistance and capacitance vessels in the nasal mucosa

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SUMMARY

Venous blood flow from the mucosa of one nasal cavity and changes in nasal patency of the same cavity were simultaneously recorded in the cat. Information about responses evoked in resistance vessels (mainly small arteries and arterioles) and in capacitance vessels (mainly venous vessels and sinusoids) could thus be provided. Close arterially administered infusions of angiotensin, noradrenaline, adrenaline and dihydroergotamine elicited constrictions in the resistance as well as the capitance vessels. Analysis of the ratio of the resistance and the capacitance responses allowed an evaluation of the relative effectiveness of the drugs in constricting the two types of vessel.

A functional way of dividing the blood vessels in a tissue is to regard them as a number of series-coupled sections with different purposes (Mellander and Johansson, 1968).

1. *Windkessel vessels,* consisting of large distensible arteries, which damp the pulsatile cardiac outflow and render the blood flow to the periphery steadier.
2. *Resistance vessels,* which can be divided into a precapillary and a postcapillary section. Changes in these vessels determine the regional blood flow.
3. *Precapillary sphincter vessels,* which determine the size of the capillary exchange by modifying the number of capillaries perfused at any one moment.
4. *Capillary exchange vessels,* through which the exchange between blood and extravascular tissue occurs.
5. *Capacitance vessels,* which are the whole of the venous compartment. Changes in the luminal configuration and diameter of these vessels evoke shifts in regional blood content or volume.
6. *Shunt vessels* (arterio-venous anastomoses), which permit bypasses of parts of the capillary bed.

The vascular bed of the nasal mucosa differs from the vascular pattern in most other regions by an abundance of arterio-venous anastomoses and of sinusoid. Filling of the sinusoids with blood apparently affects nasal patency, and since such congestion can be pronounced, they must contribute in an important way to the vascular capacitance function of the nasal mucosa.

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By measurements in animal experiments of blood flow, arterial and venous pressure and changes in tissue volume in various regions, such as skeletal muscle, skin, or intestine, it has been possible to anlyse in detail the various peripheral vascular functions (for ref. see Folkow and Neil, 1971). It has been found, for instance, that certain pharmacological agents are more effective constrictors of capacitance vessels than of resistance vessels in relation to the effects of other agents on these two vascular sections (Mellander and Nordenfelt, 1970).
What do we know about the constricting drugs used as decongestive nose drops? Are they affecting mainly capacitance vessels or mainly resistance vessels? A pure decongestive effect, i.e. an effect only on the capacitance vessels, seems to be desirable. A reduction of the blood flow, i.e. a constriction of the resistance vessels, may, however, affect reparative processes in mucosal diseases.
Changes in blood volume (capacitance function) in the human nasal mucosa have been studied extensively with rhinomanometric methods, but studies of the nasal blood flow (resistance function) are rare, restricted to capillary blood flow and performed with indirect methods, using temperature and color changes (cf. Drettner, 1963).

An investigation of the effects of different pharmacological agents on the nasal resistance and capacitance vessels, respectively, seemed difficult to perform in man. Therefore, the author instead studied such effects in the cat and the results have been published previously (Malm, 1974 a). In the cat it was possible to cannulate the pterygopalatine vein, which drains most of the nasal mucosa in one of the nasal cavities, and to record changes in nasal venous blood flow (Malm, 1973; Malm, 1974 a). The cats were anaesthetized and tracheotomized and after partial dissection of the mucosa of the hard and of the soft palate, a thin catheter was inserted into a vein near the innermost molar tooth and carefully advanced into the vessel until the tip of the catheter was lodged only a few mm from the pterygopalatine foramen. There a ligature was tied around the vein and the catheter. The reason that this method for measuring nasal blood flow has not been used previously may be that textbooks of anatomy describe a venous plexus in the pterygopalatine fossa, i.e. in the region just proximal to the pterygopalatine foramen. Golding-Wood, however, with a rich experience of pterygomaxillary surgery in man, wrote in 1962: "A small vein or two is seen, generally near the artery, but in over 200 transantral explorations I cannot recall meeting the venous plexus so often mentioned." Nor, in the course of nearly 100 dissections, has a venous plexus ever been observed in cats (Malm, 1974 b). Simultaneously with recording the venous blood flow, volume changes of approximately the same nasal mucosa were recorded as pressure changes in a thin-walled, water-filled balloon located in the nasal cavity. The resting pressure in the balloon was 4 cm of water above atmospheric level. Volume changes may of course be due not only to changes in tone of capacitance vessels but also to secretion and to transcapillary fluid changes such as oedema formation. The drugs were, however, given in doses which are supposed not to stimulate glands, and as a rule oedema formation is a slow process. The arterial and venous blood pressures were also recorded. In order

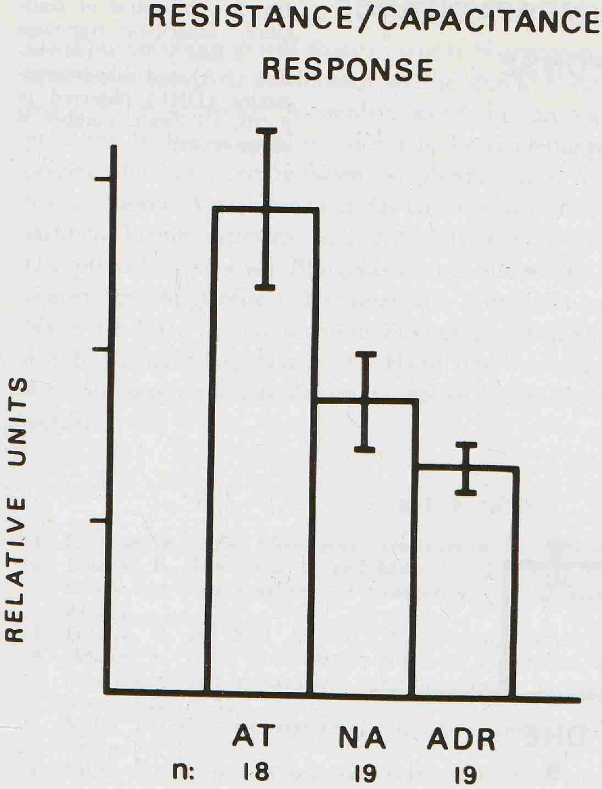

Fig. 1 The ratios of resistance / capacitance responses (± S.E.M.) to angiotensin (AT), noradrenaline (NA) and adrenaline (ADR) observed in 8 cats. *n* indicates number of observations.

to avoid arterial blood pressure changes caused by the drugs, these were given as infusions close arterially into the lingual artery in retrograde direction.

In a series of experiments (8 cats) the vascular effects of angiotensin, noradrenaline, and adrenaline were compared. Different doses of each drug were given in each experiment. These drugs always caused a decrease of regional venous blood flow, and occasionally, when the larger doses were given, an increase of arterial blood pressure. Regional vascular resistance was expressed in the conventional way in peripheral resistance units (arterial pressure - venous pressure in mm Hg / regional venous blood flow in ml/min) and the responses of the resistance vessels to the drugs as per cent change of vascular resistance from the control value before drug administration (cf. Folkow and Neil, 1971). Nasal patency was always increased by the drugs, as evidenced by fall of pressure in the balloon in the nasal cavity.

If the effect of each dose and drug is expressed as the ratio between the resistance response and the capacitance response, the relative effectiveness of the drugs on the resistance and the capacitance vessels respectively can be assessed. The mean values of these ratios are shown in Fig. 1. There was a significant difference between the ratios for angiotensin and noradrenaline ($p<0.05$), for angiotensin

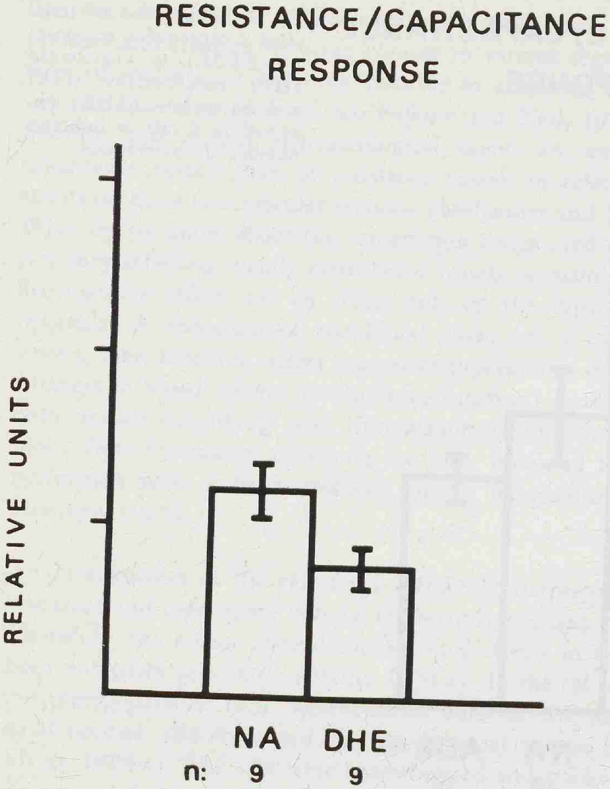

Fig. 2 The ratios of resistance / capacitance responses (± S.E.M.) to noradrenaline (NA) and dihydroergotamine (DHE) observed in 9 cats. *n* indicates number of observations.

and adrenaline ($p<0.01$), but not for noradrenaline and adrenaline ($p>0.2$). This means that angiotensin is a relatively effective constrictor of the resistance vessels, but a relatively poor constrictor of the capacitance vessels in the nasal mucosa as compared with the two catecholamines.

A similar comparative study was performed with noradrenaline and dihydroergotamine (9 cats). The latter drug, given in doses much smaller than those causing α-adrenoceptor blockade, constricted both resistance and capacitance vessels just like noradrenaline. When the mean values of the ratios between the resistance response and the capacitance responses of the different doses were compared, the differences were found to be significant ($p<0.05$) for the two drugs (Fig. 2). This implies that dihydroergotamine is a relatively effective constrictor of the capacitance vessels and a relatively poor constrictor of the resistance vessels in the nasal mucosa as compared with noradrenaline.

The investigation thus showed that the patterns of vascular response in the two series-coupled sections of the nasal mucosa evoked by the four vasoactive agents were differentiated, and, in fact, in the same way as previously described in the case of the vascular bed of skeletal muscle and skin (Mellander, 1960; Folkow et al., 1961; Mellander and Nordenfelt, 1970; Järhult, 1971).

ZUSAMMENFASSUNG

Die Durchblutung der Mukosa in einem Nasenraum von Katzen wurde mit einem Strömungsmesser, angeschlossen an die durch Foramen pterygopalatinum passierende Vene, gemessen. Ausserdem wurde in den gleichen Nasenraum ein wassergefüllter Ballon eingeführt, der Druckveränderungen übertragen konnte. Diese beiden Methoden ermöglichten es, gleichzeitigen Veränderungen folgen zu können und somit Aufschluss über das Geschehen in den Resistanzblutgefässen (hauptsächlich kleine Arterien und Arteriolen) und in den Kapazitanzblutgefässen (hauptsächlich venösen Blutgefässe und Sinusoide) zu erhalten. Arterielle Infusionen von Angiotensin, Noradrenalin, Adrenalin und Dihydroergotamin in der Nähe der Nase verursachten ein Zusammenziehen sowohl in den Resistanz- als in den Kapazitanzblutgefässen. An Hand des Verhaltens konnte der relative Effekt der Substanzen auf das Zusammenziehen bieder Arten von Blutgefässen beurteilt werden.

REFERENCES

1. Drettner, B., 1963: Blood vessel reactions in the nasal mucosa. Int. Rhinol. 1, 40-46.
2. Folkow, B., Johansson, B. and Melander, S., 1961: The comparative effects of angiotensin and noradrenaline on consecutive vascular sections. Acta Physiol. Scand. 53, 99-104.
3. Folkow, B. and Neil, E., 1971: Circulation. Oxford University Press. New York.
4. Järhult, J., 1971: Comparative effect of angiotensin and noradrenaline on resistance, capacitance, and precapillary sphincter vessels in cat skeletal muscle. Acta Physiol. Scand. 81, 315-324.
5. Malm, L., 1973: Stimulation of sympathetic nerve fibres to the nose in cats. Acta Otolaryng. 75 519-526.
6. Malm, L., 1974 a: Responses of resistance and capacitance vessels in feline nasal mucosa to vasoactive agents. Acta Otolaryng. 78, 90-97.
7. Malm, L., 1974 b: Physiological and pharmacological studies of the cats nasal vessels. Thesis, University of Lund, Sweden.
8. Mellander, S., 1960: Comparative studies on the adrenergic neurohormonal control of resistance and capacitance blood vessels in the cat. Acta Physiol. Scand. 50, Suppl. 176, 1-86.
9. Mellander, S. and Johansson, B., 1968: Control of resistance, exchange and capacitance functions in the peripheral circulation. Pharmacol. Rev. 20, 117-196.
10. Mellander, S. and Nordenfelt, I., 1970: Comparative effects of dihydroergotamine and noradrenaline on resistance, exchange and capacitance functions in the peripheral circulation. Clin. Sci. 39, 183-201.

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