BLOOD VESSEL REACTIONS IN THE NASAL MUCOSA

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Various methods have been used for studying the vascular reactions in the human nasal mucosa to different stimuli. None of the methods as yet reported are entirely satisfactory. They give a qualitative picture of the type of vascular reactions produced, permitting no quantitative evaluations of the magnitude of the change in blood flow. Furthermore the measuring instruments often give rise to irritation of the mucosa, which can affect the vessels and their reactions.

The most common methods used in studies of the vascular reactions in the human nasal mucosa are rhinomanometric and temperature measurements. The **rhinomanometric methods** show the changes in the mucosal thickness, at least when the ostium internum inside the nasal opening is not considerably narrower than the nasal cavity behind. Rhinomanometry permits the recording of changes in the blood content of the mucosa, assuming that the quantity of interstitial or intracellular fluid is not altered at the same time. The measurements do not allow any definite assessment of the mucosal blood flow, since the large venous vessels in the mucosa may be filled with blood without any resulting increase in the blood flow.

Measurements of the temperature of the nasal mucosa can give some indication of changes in the blood flow, assuming, inter alia, that the temperature and flow of the respiratory air and also the evaporation of fluid from the mucosa are constant. The temperature of the nasal mucosa is usually measured with thermoelements, by which means continuous recordings may be made. By measuring the heat radiation from the mucosa with a thermopile the mucosal temperature can be measured intermittently without touching the mucosa. By combining rhinomanometric measurements, which can also be performed without touching the mucosa, with temperature measurements, a better assessment of the vascular reactions in the nasal mucosa may be obtained.

Two methods have been reported up to the present time for recording changes in the blood flow in the human nasal mucosa. Davis & Hertzman (1957) used **photoelectric plethysmography** on the nasal septum. The method reported by Hensel & Bender (1956) for **thermal conductivity measurements** on the skin can also be used on the nasal septum (Demling et al., 1959, Drettner, 1961). The measuring plate is held against the septum by an air-filled rubber balloon. Both methods involve the introduction of relatively large instruments into the nose.

Naumann (1961) carefully studied with **intravital microscopy** the influence of different factors on the blood circulation in the septal mucosa of the rabbit. This method, which requires extirpation of the maxilla, is not applicable to human research subjects.

The vascular reactions in the nasal mucosa may be spontaneous or caused by different factors, e.g. physical, pharmacological, emotional or allergic or infectious conditions. These reactions may be localized to the nasal mucosa alone or may occur simultaneously in other parts of the body. The vascular

reactions in the nasal mucosa are generally of the same type as those in the skin, at least on the finger. The chief subject of discussion here will be the vascular reactions in the nasal mucosa, occuring in normal healthy persons.

The **spontaneous** cyclical change in the thickness of the nasal mucosa, described by Kayser as early as in 1895 and later studied by Stoksted (1953), is probably due to variations in the blood content of the vessels, possibly influenced by the autonomic innervation, since swelling and shrinkage alternate between the two nasal cavities. This cyclical variation, the duration of which is generally 2½ hours, is usually disturbed when the subject is in the recumbent position, since according to the law of gravitation the nasal mucosa swells in the lowermost nasal cavity (Kayser, 1895; Heetderks, 1927). Relatively regular spontaneous variations in the blood flow of the nasal mucosa with considerably shorter intervals, viz. ½—2 minutes, are often recorded with thermal conductivity measurements on the septal mucosa, and these changes are similar to those found on the fingertips.

Muscular exercise gives rise to widening of the nasal cavities as an expression of a decrease in the blood content of the nasal mucosa (Aschan et al., 1958). A similar observation has been made on asphyxia, voluntary apnoea and the inspiration of air with a high carbon dioxide content (Tatum, 1923). Conditions with an **increased oxygen requirement** thus appear to result in widening of the nasal passage, while voluntary hyperventilation has the opposite effect (Tatum).

The **thermally provoked** vascular reactions in the nasal mucosa have attracted most interest, partly due to the fact that cooling has often been considered of importance in the occurrence of common colds.

On cooling of the skin on the feet or back, for example, there is a rapid decrease in the blood flow in the nasal mucosa and a reduction of its temperature. The blood flow and mucosal temperature usually return to their original levels after a few minutes, even if the cooling is still in process, and the reaction usually lasts for approximately the same length of time in the nasal mucosa as in the finger. A further temporary decrease of the blood flow in the nasal mucosa sometimes occurs when the cooling procedure is discontinued. The initial decrease in the blood flow in the nasal mucosa on foot cooling appears to be mediated by nervous pathways; the reaction persists even if the blood flow in the legs is stopped before cooling. After unilateral stellate block the blood flow in the nasal mucosa does not decrease on the homolateral side of the nose, when ice is applied to the feet, while the nasal mucosa on the contralateral side shows a decrease in blood flow. This reaction is thus mediated via the cervical sympathetic of the same side. The decrease in the blood flow of the nasal mucosa, which sometimes occurs when skin cooling is discontinued, can be provoked bilaterally even after unilateral stellate block, and it is therefore conceivable that this reaction is due to blood pressure reduction associated with the cessation of cooling.

Cooling of the inspiratory air does not appear to produce any obvious decrease in the blood flow of the nasal mucosa. Thermal conductivity measurements on the nasal mucosa on cooling of the inspiratory air are techni-

cally difficult, and no accurate assessment of the blood flow in the nasal mucosa on the inspiration of cold air is therefore possible with this method.

The decrease in temperature which occurs in the nasal mucosa on different types of cooling is, on an average, more pronounced in women than in men. Since temperature measurements constitute no direct measure of the blood flow, these results can only be regarded as an indication, and not proof, that the blood flow in the nasal mucosa decreases to a greater extent in women than in men in identical cooling experiments. It is not possible to measure the blood flow in the nasal mucosa quantitatively with thermal conductivity measurements, and this method cannot therefore illuminate the question of whether or not the vascular reactions in the nasal mucosa on cooling exhibit sex differences. Studies of the blood flow in the hand indicate that the peripheral vascular systems of women are more labile than those of men on thermal stimuli, since the decrease in the blood flow of the hand on cooling and the increase on warming are more pronounced in women than in men (Hustin, 1935; Burckhardt, 1950; Heidelmann & Schmidt, 1957; Drettner, 1961, 1963 b). It is impossible to determine whether the sex difference in the temperature reduction in the nasal mucosa on cooling has any connection with the fact, demonstrated by Dowling et al. (1958), that after cooling the transmission of viruses gives rise to a higher infection frequency in women than in men, while there is no definite sex difference in the infection frequency in uncooled persons.

The temperature reduction in the nasal mucosa on foot cooling has been found to be of longer duration in patients with vasomotor rhinopathy than in normal persons (Flisberg & Ingelstedt, 1962). During a period of upper respiratory infection the reduction in the temperature of the nasal mucosa on foot cooling is usually less pronounced than during an infection-free period.

General warming of the body, as for example by a sauna bath, usually produces an increase in the blood flow of the nasal mucosa. If a sauna bath is followed by a cold shower there is a very pronounced decrease in the nasal blood flow.

Local warming of the nasal mucosa is carried out therapeutically in treatment with infrared lamps and short-wave diathermy. Both of these forms of treatment result in an increase in the temperature of the mucosa. Irradiation with short infrared rays in healthy persons produces an initial shrinkage of the mucosa, while long-wave infrared irradiation gives swelling (Hill, 1933; van Dishoeck, 1935; Drettner, 1963 a). When thermal conductivity measurements are performed during treatment with short or long infrared rays or with short-wave diathermy, no change in the nasal blood flow can generally be shown. In these experiments, however, the nasal cavity studied was occluded by an inflated rubber balloon, and the result can only be applied therefore to persons with a blocked nasal passage.

When cold water or cold food is taken there is sometimes a transient decrease in the blood flow in the nasal mucosa and also in the finger. This reaction, however, can hardly be purely thermal, since the blood flow can also decrease on the intake of warm drinks or food or water of body temperature. The blood flow in the nasal mucosa and finger can decrease when water

of different temperatures is administered through a gastric tube or is held in the mouth for only a few seconds. The actual introduction of the tube, and similarly the inflation of a balloon in the oesophagus can produce the same reaction. When relatively large quantities of water are drunk or administered through a tube the reaction is usually more pronounced than when small quantities of water of the same temperature are taken. The mechanical contact with the mucosa in the upper digestive tract seems to constitute the triggering factor which may cause a re-distribution of the circulating blood volume. Purely thermal vascular reactions sometimes appear to be added to this reaction, since the decrease in the blood flow usually persists for a longer period after the administration of cold than of warm water, and the administration of warm water is sometimes followed by an increased blood flow in the nasal mucosa following an initial transient decrease.

Of the **pharmacologically** active media with influence on the vessels of the nasal mucosa, nasal drops which shrink the nasal mucosa are of the greatest practical importance. These nasal drops give vascular contraction with decreased blood flow. Naumann (1961), who studied differences in the vasoconstrictive effects produced by different nasal drop preparations, showed that the effect is exerted mainly on the capillary sphincters and precapillary arterioli. Histamine may be mentioned among other vasoactive substances studied by Naumann; this gives rise to transient vasoconstriction followed by vascular dilatation mainly affecting capillaries and veins, in which the blood flows more slowly and undergoes intravasal agglutination.

Cigarette smoking often produces a decrease in the blood flow of the nasal mucosa and the reduction is more common with the smoking of cigarettes of high than of low nicotine content. The smoking of cigarettes with a high content of nicotine sometimes, however, results in an increase in the nasal blood flow. Similar observations have been made regarding the blood flow in the hand, which usually decreases but sometimes increases on tobacco smoking (Lampson, 1935; Friedell, 1953).

A number of vascular reactions in the nasal mucosa are provoked purely by **emotions.** Careful studies of such reactions have been made by Holmes et al. (1950) and Wolf (1954). The sight of surgical instruments or the personnel in the operating theatre can be sufficient to produce an obvious decrease in the blood flow of the nasal mucosa in a patient about to undergo an operation (Fig. 1). Pain can also result in a similar decrease. It may be discussed whether the decrease which occurs in the blood flow of the nasal mucosa on skin cooling may sometimes be due partly to a pain reaction. During a fainting attack the nasal blood flow shows a definite decrease.

The practical importance of the vascular reactions in the nasal mucosa as a result of different stimuli certainly varies. Many of the vascular reactions in the normal nasal mucosa, mentioned here, are probably only an expression of reactions also present in other parts of the body, and such changes in the nasal blood flow may principally be of theoretical interest. For studies of the vascular reactions in pathological conditions, such as infections and allergies, however, knowledge of the normal reactions in the human nasal mucosa is a necessary requirement.

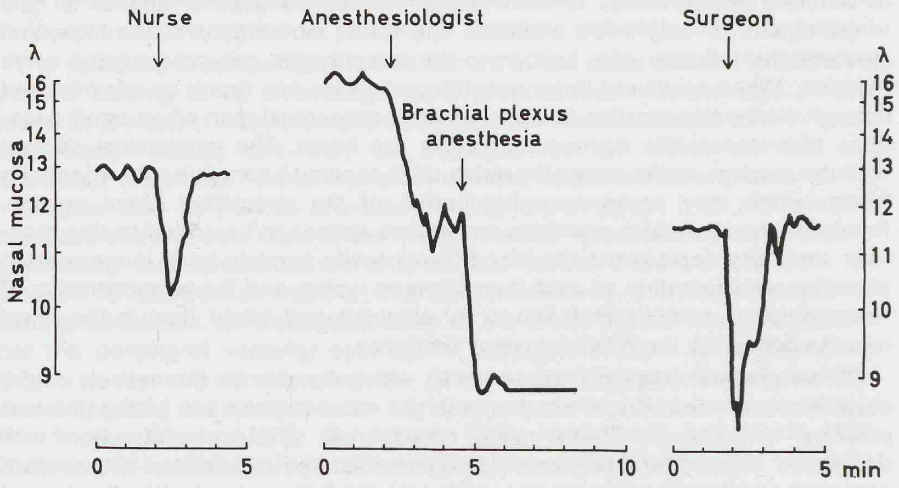

Figure 1

Recording of the thermal conductivity of the nasal mucosa (λ expressed in 10^{-4} cal · cm^{-1} · sec^{-1} · $°C^{-1}$) in a patient immediately before a hand operation. The sight of the nurse, anesthesiologist and surgeon produced a decrease in the blood flow of the nasal mucosa, and the same reaction was provoked when a needle was introduced into the axilla for the injection of the anesthetic.

Enregistrement du coefficient de conductibilité calorifique de la muqueuse nasale (λ exprimé par 10^{-4} cal · cm^{-1} · sec^{-1} · $°C^{-1}$) chez un malade immédiatement avant une opération de la main. La présence de l'infirmière de la salle d'opération, de l'anesthésiste et de l'opérateur a provoqué une diminution de la circulation sanguine par la muqueuse nasale et la même réaction a été déclanchée en introduisant une aiguille dans l'aisselle pour l'injection de l'anesthésique.

RÉACTIONS VASCULAIRES DE LA MUQUEUSE NASALE

Pour l'étude des réactions vasculaires de la muqueuse nasale de l'homme on emploie des méthodes se basant sur le principe de l'évaluation objective des altérations du taux sanguin (par exemple la rhinomanométrie) ou du flux sanguin (par exemple la mesure des températures, la plétysmographie photoélectrique ou la mesure de la conductibilité calorifique).

Les réactions vasculaires de la muqueuse nasale peuvent être de nature spontanée ou engendrées par divers stimuli parmi lesquels les excitations thermiques se sont attirées le plus grand intérêt. A la suite d'un refroidissement de l'épiderme le flux sanguin de la muqueuse nasale diminue temporairement et cette réaction est transmise par voie nerveuse via le sympathique cervical. La chute de la température de la muqueuse nasale à la suite d'un refroidissement est en général plus prononcée chez la femme que chez l'homme.

Le réchauffement général du corps engendre ordinairement une augmentation de la circulation sanguine du nez. En cas de traitement du visage par radiations infrarouges ou par ondes courtes, on ne peut pas constater d'ac-

croissement de la circulation sanguine dans la muqueuse nasale chez les sujets dont la cavité nasale a été obturée pour des raisons expérimentales par un ballon de caoutchouc gonflé.

L'ingestion de boissons ou d'aliments cause parfois une diminution de la circulation sanguine dans la muqueuse nasale ou dans les doigts et cette réaction se produit indépendamment de la température de la boisson. Elle peut également être constatée quand de l'eau est introduite par une sonde gastrique ou même quand elle est gardée dans la bouche pendant quelques secondes.

Certains médicaments peuvent influencer la circulation sanguine de la muqueuse nasale par contact direct (par ex. gouttes nasales, histamine) ou par d'autres modes d'administration (par ex. la fumée de cigarettes).

Les stimuli émotionnels causent aussi des réactions vasculaires dans la muqueuse nasale.

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THE SMALL BLOOD VESSELS OF THE CONJUNCTIVA AND NAILFOLD IN VASOMOTOR RHINOPATHY

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The synonyms of vasomotor rhinitis are many, indicating the diversity of views as to its etiology (anatomical and functional background). The term "Rhinopathia vasomotoria" was introduced by Adlersberg and Forschner in 1928 (1, 2). The name of "Vasomotor Rhinopathy Syndrome" (2) would more properly fit the nature of this illness, in which the nasal manifestations seem to be but a local expression of a general, systemic symptom complex.

Indeed these patients often suffer from headache, peripheral vascular disturbances such as acrocyanosis, angiospasm and cold extremities (3, 4), indicating that "the phenomenon should be studied in the capillaries" (4).

Recent developments in microcirculatory researches as well as in clinical in-vivo observations of the capillary bed or of the "terminal circulation * (5, 6) gave the stimulus to investigate the conjunctival and nailfold blood vessels, by slit lamp and capillary microscopy, in an attempt to collect information on the vascular background of vasomotor rhinopathy (VMR).

Material and Methods

We investigated 50 patients of both sexes, of whom the youngest was 15 years old, and the oldest 71. The diagnosis of VMR was established by history, by the characteristic objective findings of the nasal mucosa, both before and after shrinking, by X-Ray studies of their sinuses, and by referring the patients to the allergy clinic for exclusion of an atopic allergic rhinitis. In these patients the conjunctival and nailfold vessels were examined by methods previously described (7), and compared with those of 150 patients

* = "die terminale Strombahn" (Ricker).