

The influence of vegetative stimuli on the human nasal mucous membrane

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SUMMARY

Measuring probes were inserted into the inferior nasal meatus in humans to record the effects of certain defined vegetative stimuli on the cavernous state and the temperature of the mucous membrane.

An unilateral carotis compression induces a bilateral reactivity of the mucous membrane in the sense of a sympathetic stimulus.

An unilateral bulbus pressure causes a bilateral reaction of the mucous membrane opposite to that of carotis compression.

Blocking of the stellate ganglion produces a tonus reduction of the nervus sympathicus as was also found in animal experiments by other authors. Trigeminus stimulation induces a swelling of the nasal mucous membrane, whereas a voluntary breathing stop causes decongestion. Facial blushing, the only undefined and involuntary stimulus, is followed by an unswelling and a decrease of mucous membrane temperature.

The results of our investigations are in agreement with analogous animal experiments. This is not surprising as man has a vegetative nervous system which is essentially unchanged from the beginning of evolutionary development. Only blushing is an expression of a reaction behaviour characteristic of human beings only.

INTRODUCTION

Under physiological conditions human beings do not become aware of changes in the blood congestion of cavernous bodies in the nose. Only in case of pathological conditions, such as infections of the upper respiratory tract, allergic and vasomotor rhinitis, swelling of nasal conchae caused by medication etc., it becomes apparent how the disregulation in the cavernous bodies of our noses affects our entire organism.

Vegetative interaction in the nasal mucous membrane has been described in animal experiments (Undritz, 1930; Kawai, 1933; Christensen, 1934; Krajina, 1975; Eccles, 1983). But even this knowledge only allows deductive conclusions as to the physiological function of the vegetative nervous system in the human nose. By the regulation of the temperature of the mucous membrane and of the cavernous state the inspiratory air is prepared in such a way that the gas exchange in

the lungs always takes place at 37°C and the air will be saturated by water vapour, regardless of environmental conditions. Rhinomanometry is a method to study regulative interaction between sympathetic and parasympathetic. By means of this method, the right-left-rhythm could be observed in human beings, with intervals of one to four hours, and the circadian rhythm with a frequency of 24 hours (Stoksted, 1952; Keuning, 1968; Eccles, 1978). We tried to develop a method which in addition to an extremely sensitive registering of the cavernous state could also record the temperature of mucous membranes. Small measuring probes were placed in the inferior nasal meatus, which is a technological prerequisite (Simon et al., 1971).

Undritz (1930) observed, in animal experiments, an increase of the blood congestion in the nasal cavernous bodies during compression of the vena jugularis. In order to check whether or not the measuring probes had been inserted into the human nose in an optimal measuring position we made use of these experimental findings. Thus testing the probes by means of compressing the vena jugularis bilaterally. The light absorption in the lower concha changed distinctly, when the probe was in an optimal measuring position and we were then able to start further investigations. Additionally, the common carotid artery was compressed unilaterally during our experiments on human beings. In agreement with numerous animal experiments (Krajina, 1975), we proved for the first time using procedure on human beings, that a bilateral reaction takes place during a unilateral compression of the arteria carotis communis. After carrying out these pre-experiments, it was the aim of our experiments to apply a series of vegetative stimuli on healthy test persons to register the responses they induced.

MATERIAL AND METHOD

The temperature of mucous membranes was measured by means of NTC (negative temperature coefficient) resistor in the inferior nasal meatus on both sides with a dissolution of 0.05°C. The cavernous state of the inferior nasal concha was recorded by means of a method using light absorption with great sensitivity, however only qualitatively. These two methods are reported in another paper (Simon, 1971). During the individual tests the temperature in the room was between 21°C and 23°C, and the humidity of air between 43% and 50%. Fifty measurements were carried out on 24 healthy persons, 22 male and 2 female with a mean age of 28 years. Additionally we performed an unilateral blocking of the stellate ganglion on four patients with sudden deafness. The recumbant position of the tested persons, which had already proved successful in previous experiments, allowed testing periods between 60 and 145 minutes. During the investigations special care was taken to exclude psychic excitements. If, nevertheless they occurred and if they caused changes in the cavernous state and in temperature, these recorded changes were attributed to these events. Also when these changes were apparently insignificant.

As a result of our experimental procedure we were able to register the temperature bilaterally although the cavernous state could only be measured on one half of the nose at a time. Because we expected complex reactions we first applied simple stimuli.

The responses to the following stimuli were investigated in detail:

- a. unilateral carotis compression
- b. unilateral pressure of the eye
- c. unilateral stimulus of the trigeminus
- d. unilateral blockage of the stellate ganglion
- e. voluntary breathing stop
- f. facial blushing.

RESULTS

Unilateral carotis compression

During 19 measurements the common carotid artery was compressed unilaterally after the preliminary equilibrium temperature (T_v) was reached (Figure 1). This series of experiments showed in the majority of cases a bilateral temperature decrease, which was frequently attended with a reduction of the cavernous state. Although the testing procedure for measuring the cavernous state could only be inserted unilateral, we found a reduction of the cavernous state in every case. We

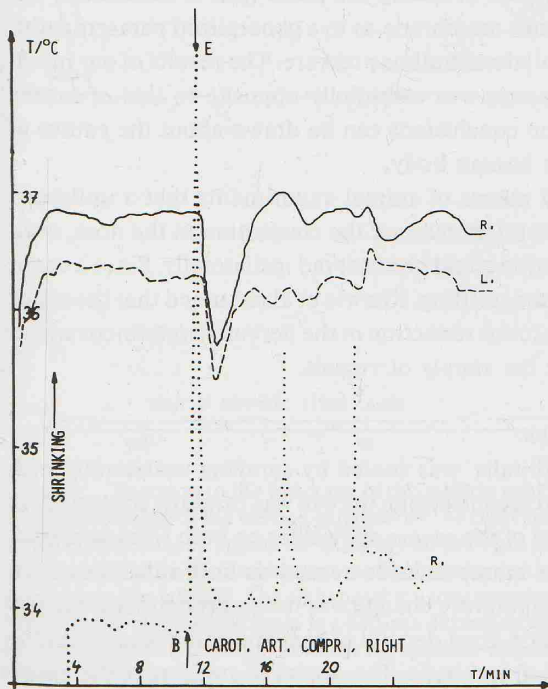


Figure 1. Reaction to an unilateral carotis compression. In the 11th minute, the right common carotid artery is compressed on the level of the carotid sinus. Within few seconds the right nose unswells (...) and both mucous membrane temperatures decrease (right ———, left - - - -). After a compression lasting for 30 sec, the nose swells just as quickly, whereas the mucous membrane temperature returns to the initial value after 2 min on the left side and after 3 min on the right side.

concluded that the shrinking process took place bilaterally in the same way as the decrease of the temperature.

Undritz (1930) using dogs and cats was able to prove that the constricting fibres of the nasal mucous membrane are united in the cervical sympathetic. These fibres switched over in the ganglion cervicale sup., and either reach the mucous membrane as post-ganglionic fibres of the nervus pterygopalatinus or follow the vessels leading to the nose. Whereas in this way a unilateral sensitive stimulus causes a bilateral constricting response, the afferent nerve tract takes a strictly unilateral course. Christensen (1934) and Kawai (1933) found similar results. These results in humans show that the stimulus response to an unilateral carotis compression cannot have an exclusively mechanical cause but is to be viewed as a vegetative overall response.

Unilateral pressure of the eye

This test was carried out on 17 test persons. In more than half of the cases both the mucous membrane temperature and the cavernous state increased on both sides. We gave the same stimuli to the same test-persons on two following days and we registered the cavernous state on the other side of the nose. In case of the remaining test persons non-uniform results were recorded.

We knew that in case of an occurring tachycardia the bilateral bulbus pressure serves as an emergency measure for reducing the pulse rate. If indications can also be found on the nasal mucous membrane as to a generalized parasympathicus we tested by means of an unilateral bulbus pressure. The results of our measurements showed that the response was essentially opposite to that of carotis compression. At the moment no conclusions can be drawn about the course of the stimulus conduction in the human body.

Khawla et al. (1982) proved by means of animal experiments that a unilateral vagus stimulation causes a bilateral increase of the congestion in the nose, even though a more pronounced reaction could be observed ipsilaterally. Since a cervical sympathectomy also induced a swelling, Khawla et al. assumed that the vagus stimulation caused a temporary tonus reduction in the nervus sympatheticus which is permanently responsible for the supply of vessels.

Unilateral trigeminus stimulation

In three cases the regio infraorbitalis was cooled by spraying unilaterally with ethyl chloride for a period of two seconds while the eye was carefully protected. In all three cases a distinct swelling of the cavernous bodies on both sides occurred. The temperature of the mucous membranes decreased on both sides; however, the quality and extent of the temperature change was not so pronounced. Hensel (1973) was able to detect, on cats, a great density of heat and cold receptors in the innervation area of the nervus infraorbitalis. The observed swelling of the caver-

nous bodies in man as a response to a cutaneous cold stimulus corresponds to a ingenious course of reflexes: the thermal receptors of the face signalize to the functional complex of the nose for instance cold of the environment puts the cavernous bodies into operation to provide all measures for warming up the breathing air.

Unilateral blockage of the stellate ganglion

In case of four patients who underwent a blockage of the stellate ganglion in order to stimulate the circulation of the blood in case of an acute sudden deafness, the measuring probes were inserted after the blocking was carried out. So 10 min. after the application of the anaesthetic the measurement could begin (Figure 2). At the beginning of the measurement the temperature of the mucous membrane on the blocked side was already 2.0 °C to 2.5 °C higher. The temperature oscillations were considerably lower compared to the unblocked side. The inferior concha on the blocked side was strongly swollen. After 60 to 90 minutes the side of the nose which was blocked decongested heavily, the mucous membrane temperature of the blocked side sank by 1.5 °C to 2 °C, whereas on the other hand the temperature increased on the contra-lateral side by 0.5 °C to 1.0 °C.

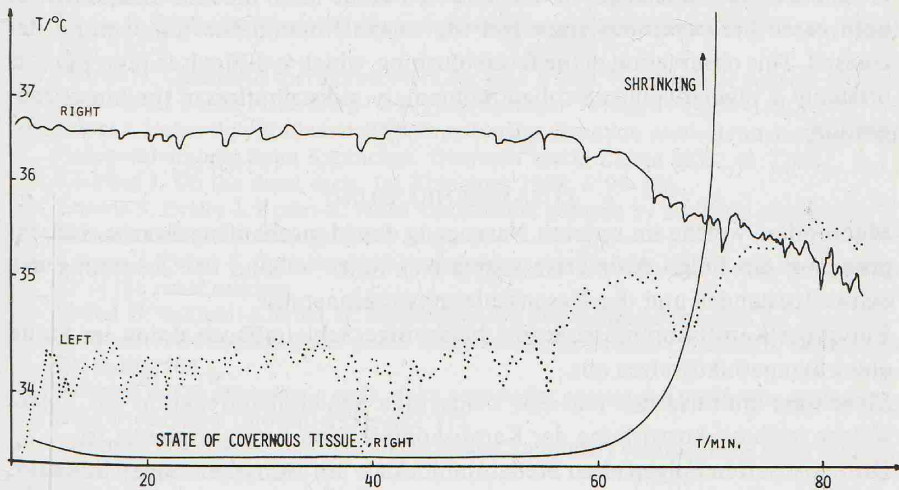


Figure 2. Reaction to the blockage of the stellate ganglion. The recording begins 10 min after the blocking of the stellate ganglion on the right side. The temperature of the mucous membrane is already approx. 2 °C higher on the right side than on the left side. Although while temperature oscillation can scarcely be recorded in the right half of the nose, they are apparent on the left side. The right nasal mucous membrane is strongly swollen up until the 60th minute. Afterwards there is a distinct decongestion (curve goes steeply upwards). In the 56th minute a tendency towards an opposite reaction of the temperature takes place. From the 75th minute a temperature inversion occurs.

An unilateral temporary exclusion of the sympathetic plexus within the frame of a therapeutic intervention proved that the cavernous state of the nasal mucous membrane depends on the tonus of the nervus sympathicus.

Eccles (1982) also proved this by means of a cervical sympathectomy on animals. Beikert (1951) also observed in humans the increase of the congestions after blocking of the stellate ganglion. He made use of button probes of various dimensions. Furthermore he observed several changes of the cavernous state in the sense of an oscillation after the blocking effect had diminished.

Voluntary breathing stop

In five cases we asked the test persons to hold their breath as long as they could. In all five cases the nasal mucous membranes descongested, and swelled again after the end of the experiment. The reaction of the mucous membrane temperature was not uniform and thus no distinct statement can be made about it. Tatum (1923) already observed a distinct and very quick decongesting of the nasal conchae during an experimental asphyxia in animals when the trachea was closed.

Facial blushing

In four measurements in two test persons a relationship was found between the facial blushing and changes in the condition of the nasal mucous membrane. In both cases the cavernous state and the mucous membrane temperature decreased. This observation of the facial blushing, which is difficult to reproduce, is probably a vegetatively controlled momentary redistribution of the blood congestion.

ZUSAMMENFASSUNG

Meßsonden, welche im unteren Nasengang des Menschen angebracht sind, registrieren die Folge definierter vegetativer Reize anhand der Änderung des Schwellzustandes und der Nasenschleimhauttemperatur.

Einseitige Karotiskompression löst beidseitige Schleimhautreaktion im Sinne eines Sympathikusreizes aus.

Einseitiger Bulbusdruck hat eine beidseitige Schleimhautreaktion zur Folge, welche in ihrer Auswirkung der Karotiskompression entgegengesetzt ist.

Die registrierten Folgen einer Stelatumblockade am Menschen zeigen in Analogie zu den Tierversuchen anderer Autoren, die medikamentös verursachte passagere Tonusminderung der N. sympathicus.

Trigeminusreiz löst ein Anschwellen der Nasenschleimhaut aus, wogegen willentlicher Atemstopp Abschwollen verursacht. Auf Rotwerden des Gesichtes, als einziger nicht definierter und nicht gewollter Reiz folgt Abschwollen und Schleimhauttemperaturabnahme.

Die Ergebnisse unserer Untersuchungen stehen voll im Einklang mit analogen

Tierversuchen. Diese Erkenntnis ist nicht verwunderlich, wissen wir doch, daß der Mensch als vorläufiges Endprodukt der Evolution, sein Vegetativum aus der entwicklungsgeschichtlich Anfangszeit der Warmblüter in Wesentlichen unverändert übernommen hat.

Nur das Rotwerden des Gesichtes ist Ausdruck eines nur den Menschen eigenen Reaktionsverhaltens.

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