A REVIEW OF THE RELATIONSHIP BETWEEN UPPER AND LOWER RESPIRATORY AIRWAYS

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The well-known book "The Lung" by Comroe and his co-workers begins with the sentence: "Pulmonary physiologists understand pulmonary physiology reasonably well". The word reasonably is of course an underestimate of their very high qualification but it may also be interpreted as a recognition of the fact that pulmonary physiologists often neglect the upper respiratory airways in their studies of respiratory physiology. The relationship between the upper and lower respiratory airways deserves more attention both from otolaryngologists and from pulmonary physiologists. This relationship has several aspects.

The nose has influence on the pulmonary function, the lungs have influence on the nose, and thirdly there is an interaction where it is difficult to know whether the process starts in the lung or in the nose but once started a vicious circle may develop.

Influence of the nose on the pulmonary function

The influence of the nose on the pulmonary function also has several aspects. Three of the primary functions of the nose are to warm, to humidify and to filter the inspiratory air and all these functions are of great importance for protecting the lower airways from cooling, drying and from dust. Ingelstedt (1956) has shown that the temperature of the inspired air on reaching the subglottic region is 32.3° C during nasal breathing at room temperature and the air in the subglottic region also has a high humidity. Mouth breathing gives a lower temperature and lower humidity. Even nasal breathing in an environmental climate with a temperature below freezing point gives a somewhat higher air temperature in the subglottic region than oral breathing at room temperature, and the humidification is also better. Oral breathing therefore places greater demands on the lower airways than nasal breathing. The frequency of oral breathing is higher in persons with nasal diseases than in normal subjects. Uddströmer (1940) found oral breathing in 36% of cases with septal deviation.

Each of the two nasal chambers has a relation to the homolateral lung. Chauvet (1909) showed in rabbits that unilateral nasal obstruction caused inspiratory dyspnea and after about a month the homolateral half of the thorax was deformed and considerably smaller than that of the other side.

Such a unilateral relationship is also present in man, which has been shown by Samzelius-Lejdström (1939) and others. When one nostril is occluded the amplitudes of the contralateral half of the thorax become greater

than those of the other half. The explanation for this phenomenon was investigated mainly by Sercer in the 1930's. Blowing of air into one of the nostrils caused an expansion of the corresponding side of the thorax which was observed especially in laryngectomized patients. This reaction was absent when the nasal mucosa was anesthetized. Injection of atropine also decreased the reflex considerably. It is thus a reflex transmitted from the nasal mucosa to the lungs, probably via the trigeminal and vagus nerves. The phrenic nerve may also play a role, since the naso-pulmonary reflex was shown to be lacking in a patient in whom this nerve had been damaged. Sercer later continued his investigations on the naso-pulmonary reflexes (Sercer, 1952). He showed that mechanical, chemical or thermal stimulation of the nasal mucosa gave a constriction of the bronchi which was sometimes followed by dilatation. This naso-bronchial reflex is principally homolateral. The bronchial changes are not always accompanied by movements of the thorax and a direct reflexive influence from the nose to the bronchial tree has thus been assumed. Sercer also suggested that the naso-bronchial reflex acts physiologically as a change in tonus of the bronchial muscles evoked by the respiratory pressure changes in the nose.

These naso-pulmonary and naso-bronchial reflexes have been assumed to give an increased bronchial tone in cases with nasal obstruction which would also explain the reversibility of the pulmonary changes after successful operations on the nose, as described by Ogura et al. (1964, 1968a, 1968b, Unno et al., 1968). His outstanding investigations about the naso-pulmonary relationship will not be discussed in this paper, as Doctor Ogura will present the results of his work during the plenary session of The IX International Congress of Oto-rhino-laryngology.

Another aspect of the influence of the nose on the lower airways is the effect of nasal obstruction on the manner of breathing. A nasal obstruction gives slower and deeper breathing than normally due to the increased resistance. This kind of breathing may, according to Davies et al (1919), change to a more frequent and shallow breathing if anoxia develops. Some investigations have shown that the gas exchange in the lungs is disturbed in cases with nasal obstruction. Lüscher (1930) showed that an experimentally produced nasal obstruction which forced the subjects to oral breathing gave a decrease of the alkaline reserve; patients with a spontaneous nasal obstruction also had a low alkaline reserve but not to the same extent as in those with artificial nasal obstruction. Also patients with hypertrophic tonsils without nasal obstruction showed low values. Some reports from the United States during recent years (Menashe et al., 1965); Noonan, 1965; Luke et al., 1966; Levy et al., 1967; Massumi et al., 1969) have described serious heart diseases caused by partial obstruction of the upper respiratory tract. These cases have been children mainly with severe nasopharyngeal obstruction due to enlarged adenoids, and they have had cardiorespiratory complications ranging from moderate cardiomegaly and right ventricular hypertrophy to severe right cardiac failure and pulmonary edema. Hemodynamic studies showed wide swings in pulmonary arterial and aortic pressures due to the obstruction to respiration, and the carbon dioxide concentration in arterialized capillary blood was elevated. No other reason for the right cardiac failure

than the nasopharyngeal obstruction was found, and tonsillectomy and adenoidectomy performed as an emergency procedure gave complete recovery, with decrease in the heart size radiographically and normalization of the electrocardiogram. The mechanism was assumed to be hypoxia causing an increased pulmonary resistance and elevated pulmonary arterial pressure which over a period of months resulted in right cardiac hypertrophy and right cardiac failure (Luke et al., 1966). The hypoxia and the swings in intrathorac pressure might have contributed to the development of pulmonary edema. An individual susceptibility to hypoxia and to pressure changes is essential since this syndrome is very rare in comparison with the frequency of nasopharyngeal obstruction in children.

One form of influence of the upper on the lower respiratory tract which is often encountered in clinical practice is the transmission of an infection in the upper respiratory tract to the lower. Sinusitis is often the primary cause of chronic bronchitis or bronchieetasis and the symptoms from the bronchial tree are often improved by treatment of the sinusitis. Connected with this relationship is the discussion of the sinuses as a focus. The discussion is somewhat academic since according to definition a focus should be silent. A chronic sinusitis without symptoms from the upper respiratory tract may occur and it may give symptoms only from the lower respiratory tract, mainly due to aspiration, but whether such a sinusitis should be called a focus or not is of no real practical significance. Of main importance is that the sinusitis is diagnosed and treated.

Influence of the lungs on the upper respiratory tract

The lungs also have influence on the upper respiratory tract. During dyspnea most patients breathe through the mouth due to the considerably higher resistance during nasal breathing than during oral breathing. The total work of nasal breathing is more than 2½ times greater than the work during mouth breathing in normal subjects, according to Butler (1960). Patients with pulmonary diseases often have too low a reserve capacity to be able to breathe through the nose. The nasal resistance can sometimes be beneficial, on the other hand, for patients with emphysema. The tendency to bronchiolar collapse in emphysema during forced expiration is to some extent counteracted by an additional resistance in the upper airways which can be obtained either by breathing out against half-closed lips or by breathing through the nose. Patients with chronic lung deseases therefore sometimes have a maximal voluntary ventilation through the nose which is only slightly lower than that through the mouth (Drettner, 1969).

Inadequate ventilation may also affect the nasal conductivity. Tatum (1923) showed that asphyxia or rebreathing via a bag caused widening of the nasal airways. Tagaki et al. (1969) have recently shown that breathing of air with 7% carbon dioxide also gives widening of the nasal passage. Physical exercise has the same effect (Aschan et al., 1958). Voluntary hyper-ventilation, on the other hand, causes narrowing of the nasal airways (Tatum, 1923). Situations with an increased oxygen demand therefore appear to give a widening of the nasal passage.

Another possible influence exerted by the lungs on the nose which is of more practical interest is the transmission of an infection from the lower to the

upper airways. Transmission of an infection from the bronchial tree to the sinuses is, however, certainly rather rare in comparison with transmission in the other direction. But the fact that the entrance of air into the paranasal sinuses occurs principally during expiration or during coughing entails pathophysiologically a risk of the entrance of infectious droplets into the sinuses.

Interactions between the upper and lower respiratory tracts

Finally, there are also interactions between the upper and lower respiratory tracts where it is difficult to determine whether a process has started simultaneously in the lungs and nose or whether it has started first in the one organ and later affected the other, giving an interaction between them. Cases with nasal allergy and bronchial asthma are typical examples. The combination of nasal polyps and asthma bronchiale is well known. There is often also an infection both of the upper and lower respiratory tract in these cases, and the allergy may be evoked by infections, so called bacterial allergy. This well known clinical picture is probably what most doctors think of when a topic with the title "Relationship between the upper and the lower respiratory airways" is discussed. A special syndrome worth mentioning in this connection is the Mounier-Kuhn syndrome in children with ethmoido-antritis and bronchiectasis, usually with an allergic background (Mounier-Kuhn 1945). Another syndrome which involves both the upper and lower respiratory tract is Kartagener's syndrome. (Kartagener, 1956). This includes bronchiectasis, sinusitis and situs inversus. The relationship between the changes in the upper and lower respiratory tracts in this syndrome is however to find in a hereditary disease affecting not only the airways but also other organs.

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RÉSUMÉ

Les rapports entre les voies supérieures et inférieures du système respiratoire comportent plusieurs aspects:

I. Influence du nez sur la fonction pulmonaire.
a. Réchauffement et humidification de l'aire inspiré.
b. Rapport ipsilatéral entre les cavités nasales et les deux poumons.
c. Réflexes naso-pulmonaires.
d. Influence de l'obstruction nasale sur le type de respiration.
e. Influence de l'obstruction nasale sur la fonction ventilatrice des poumons.
f. Influence de l'obstruction nasale sur l'inter-echange gaseux dans les poumons et sur la circulation pulmonaire.
g. Transmission des infections du nez et des sinus paranasaux aux poumons.
II. Influence des poumons sur la fonction nasale.
a. Type de respiration (nasale ou orale) chez des malades pulmonaires.
b. Effects d'une ventilation inadéquate de la conduction nasale.
c. Transmission des infections pulmonaires au nez et aux sinus para-nasaux.
III. Interaction entre les voies respiratoires supérieures et inférieures.
a. Allergie.
b. Infection.
c. Syndrome de Kartagener.