Commentary

Editorial: The upper airway – the forgotten organ

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Abstract

The upper airway is an organ not often investigated. Relatively little is known about its complex functions, and misunderstandings abound. The paper by Thomachot *et al* in this issue provides an opportunity to ponder on this important organ. Although the main result seems to be negative, the study provides some interesting physiological information on the upper airway and how it works.

Keywords: humidification, filtration, upper airway, heat and moisture exchange

The upper airway is a no-man's-land. Whereas there is specialist interest in the nose and throat and in the lungs, the organ that connects the two is largely ignored. A failure to recognise this vital area as an organ has meant that its physiology and pathophysiology are often fundamentally misunderstood. This in turn might mean that dysfunction of this organ is not detected and is not adequately treated.

The upper airway acts as a countercurrent heat and moisture exchanging system. On expiration, heat and moisture are retained, only to be given up to relatively cool and dry inspired gases. Gases below the carina are 100% saturated at body temperature. Expired gases are also 100% saturated but at a temperature of about 30°C [1]. A gradient of heat and absolute humidity (the mass of water held in a given volume of gas at a particular temperature) thus develops down the upper airway, with most heat and moisture exchange occurring in the nose.

The functions of the upper airway seem simple: heat and moisture exchange, thermoregulation and filtration. However, the way in which the upper airway performs these functions and others is complex and poorly understood. Filtration will not be discussed further, because the subject of the paper by Thomachot *et al* in this issue is respiratory heat loss.

With changes in environmental conditions, the steepness of the heat and moisture gradient seems to change [2]. However, the existence of the gradient probably has an important role in thermoregulation. Individuals who live in tropical conditions, where the heat and moisture content of inspired gases approaches full saturation at body temperature, are unable to use their upper airway for thermoregulation and therefore develop compensatory mechanisms [2].

The amount of heat lost from the respiratory tract varies with the environmental conditions and with exercise. The upper airway seems to have a range of conditions to which it can adapt. The ability of the airway to function adequately depends on the ambient temperature, the ambient relative and absolute humidities, the state of the individual's airway and their tidal and minute volume [3]. There is probably a degree of adaptation to different environments over time, but this has not been studied. So, for instance, an individual living in a temperate climate could visit dry desert or tropical conditions and tolerate them. If they lived in either extreme for a period of time, their airway would probably change to adapt to its new environment. Some individuals find some extremes less comfortable. Their airways seem to have a smaller range over which they can compensate.

One way in which the limit of compensation of the upper airways is manifested is bronchospasm. As the demand for heat and moisture exchange increases with minute and tidal volume, so the limits of compensation are reached. For instance, many individuals are able to tolerate a cold, frosty morning with a low temperature and a low humidity. However, some cannot tolerate exercise in this environment without developing bronchospasm, which marks the limit of their upper airway to heat and moisturise an increased volume of inspired air [4].

The amount of heat lost from the airway depends on basic physical principles and therefore on the mass of expired gas, its specific heat and the change in its temperature. There is also the latent heat required to change the state of the water from liquid to vapour. The specific heat of dry air is relatively low and little heat is lost in dry air, even if the temperature change is large. This phenomenon also enables the airway to warm cold gases without injury because the absolute humidity of cold gas is low and relatively little heat is necessary to warm it [5]. However, the specific heat of water is much greater and it is the amount of water vapour in expired gases that contributes most to respiratory heat loss. More heat is lost from the airway when the absolute humidity of expired gases is high, and respiratory heat loss is more dependent on absolute humidity than on temperature.

The paper by Thomachot *et al* demonstrates that, although the measurement of tracheal temperature is simple, it does not provide an accurate indication of respiratory heat loss. In fact, information presented in the paper suggests that it is more closely related to absolute humidity.

The importance of respiratory heat loss probably lies in the ability that it gives us to adapt to different environments. The benefits of minimising respiratory heat loss have not been demonstrated. However, a benefit is often assumed in ventilated patients and hot-water humidifiers used in an attempt to minimise respiratory heat loss. In some patients, for example those with significantly damaged upper airways and a reduced body temperature, this can be useful. In other patients, the risks of over-humidifying inspired gases [6–9] are a real consideration. In addition, removing the normal upper airway gradient of heat and moisture can have important consequences. In patients with otherwise normal airways and thermoregulatory functions, minimizing respiratory heat loss is probably unnecessary.

We tend to simplify concepts so that we can obtain solutions to problems. This is generally a useful strategy. However, there are situations where it might not be useful; at the moment the upper airway is probably one. We are trying to solve problems without the information necessary to develop meaningful solutions. We need to know far more about the upper airway and the complexity of the countercurrent exchange mechanism, and how and when it changes. We also need to know far more about the relationship between the upper airway and the areas that it connects, the environment and the lungs. Only by knowing more will we be able to achieve really useful solutions to the problems we face.

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