Hirose's column

In the process of developing the Hero Inner-Mask, I have answered the following questions:

'Why do people inhale and exhale air through their noses'?

'Why has the nasal cavity evolved so thin that it can get clogged by empyema'?

When we were aquatic animals such as fish in ancient times water flowed through our mouths and exited through our gills; therefore, freshwater (oxygen) was pumped into the gills.

However, our ancestors that emerged to the ground began to inhale and exhale air through their noses. This structure forced the re-inhalation of exhaled air composed of a low oxygen concentration through the same hole. In particular, I have never questioned the structure related to pulmonary respiration. This structure appears to be similar to eating and defecating from the mouth, which is very irrational.

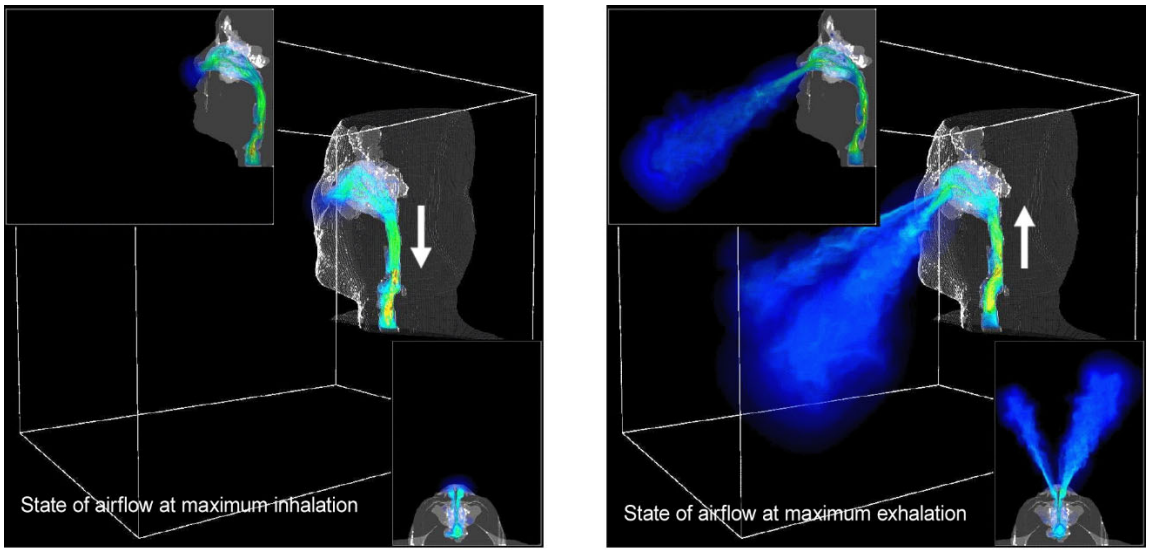
Why have we evolved in this manner? To answer this question, I conducted a literature review on physiology and observed that the major issues with animals that were once aquatic were related to their living tissues, which had to be preserved in a wet state (similar to that in water) after they emerged from the water and reached the ground. I, therefore, speculate that the process of evolution from gill respiration to lung respiration is as follows:

Our ancestors who emerged from the water and reached the ground had a gill-breathing mechanism, which led them to create a one-way airflow, similar to gill breathing, that would allow them to breathe efficiently. However, the trachea, which is the passageway into the respiratory tract, became dry due to the outside air; therefore, it was difficult to maintain the wet state. At that time, there was a species that breathed through lungs with the same air inlet (trachea), which was always maintained wet by exhalation. As a result, this species easily adapted to environments composed of dry ground.

However, species that had a large hole (nostril) slowly exhaled air drifts around the hole. Subsequently, during inhalation, the drifting exhaled air was inhaled again. In this case, the oxygen intake efficiency in respiration was poor.

In contrast, species that had small nostrils exhaled from the narrow nostrils far away at a high speed, improving their breathing efficiency, as the inhaled air was not mixed with the exhaled air floating around the nose. This resulted in a higher survival rate.

We inhaled and exhaled air through the same nose; therefore, the nostrils became narrower to avoid the exhaled air being mixed with the inspiratory air. Problems would arise if the only nasal cavity of the species would become clogged; therefore, they had two nasal cavities. The nasal structure evolved similar to that observed in our study.



Visualization of respiratory reciprocating flow with a supercomputer
Source: 2009 RICC Usage Report Toshihiro Sera "Calculation of Airflow in the Human Upper Respiratory Tract"

The figure above is a simulation material reported by Professor Sera of Kyushu University. During inhalation, the stationary air around the nose is slowly inhaled into the nasal cavity, whereas, during exhalation, the air is vigorously blasted from the nasal cavity, even if the airflow (trachea) is the same. Although the flow of inhalation from the nostril and that of the exhalation are different, the process prevents the mixing of inhaled and exhaled air, improving the breathing efficiency, which appears to have never been interpreted.

This discovery is an example of my understanding of the natural respiratory mechanism to try to create an industrial product based on the respiratory mechanism. This is a typical example of 'analysis by synthesis' process in the field of robotics.

The mask we currently wear interferes with the exhalation-inhalation separation mechanism that the nose originally had, therefore preventing the exhaled air from being blown far away. This is considered the fundamental principle of discomfort.

In contrast, the HERO Inner-Mask guides the exhaled air from the nose to the lower part inside the mask. This air is filtered from the lower non-woven fabric and then assists inhalation from the upper non-woven fabric.

This unique device considers the exhalation-inhalation separation mechanism of the human nose, allowing easier breathing even when wearing a mask.

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