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Does mucosa perfusion determine the exchange rate of CO₂ in the middle ear?

Y. Marcusohn¹, J.J. Dirckx¹, A. Ar², Antwerp; Belgium¹, Tel Aviv; Israel²

Purpose

To estimate if the exchange of CO₂ in the middle ear (ME) is mainly limited by perfusion or by diffusion.

Materials and Methods

Exchange of CO₂ in the ME of rabbits (a) and rats (b) was estimated using data obtained from iso-pressure measurements of total volume changes. After initiation of a long-term anesthesia protocol the tympanic membranes were perforated. The MEs were then flushed with ambient air before closing the system and starting measurements. The data obtained was normalized to cancel effects of other processes that took place during the experiments. The initial rising part of the curve was fitted to a first order exponential curve in the form of: $\Delta V_t = B \cdot (1 - \exp(-k \cdot \Delta t))$; ΔV_t - the ME gas volume change with time starting at the closure of the system, k - the rate constant of gas volume increase, Δt - elapsed time from system closure and B - the value of ΔV_t when Δt approaches infinity. It was assumed that the initial observed volume increase could be attributed mainly to the diffusive flow of CO₂ into the ME from the blood circulating in the ME mucosa with a maximal partial pressure gradient. It was further assumed that the first derivative of the equation at $\Delta t = 0$ represents the initial and maximal CO₂ flow rate into the ME which is $V(\dot{i})_{CO_2} (\Delta t=0) = k \cdot B$.

Results

It was found that $V(\dot{i})_{CO_2} (\Delta t=0)$ was ~13 times faster in rabbits than in rats. The mass specific (sp) cardiac output (calculated from (c)) was 0.154 mL/(min·g) in rabbits (~2800g) and 0.259 mL/(min·g) in rats (~179.1g). The sp $V(\dot{i})_{CO_2} (\Delta t=0)$ was 0.138 ± 0.117 microL/(h·g) in rabbits (n=16) and 0.170 ± 0.094 microL/(h·g) (n=9) in rats. Similar ratios were found when an allometric comparison was made between the ratio of sp $V(\dot{i})_{CO_2} (\Delta t=0)$ ($\sim 0.8 \pm 0.1$), and the ratio of sp cardiac outputs (~ 0.6) in rabbits and rats.

Conclusion

If the active mucosal surface areas of MEs of rabbits and rats are directly proportional to their masses as are the masses of their hearts (c) and mass specific cardiac outputs of rabbits and rats are proportional to the rates of blood flows in the ME mucosa, these results may support the assumption that the exchange of CO₂ in the ME of mammals is mainly perfusion dependent.

References

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