

Exergy analysis of the respiratory system for different intoxication levels of carbon monoxide. Applications to pathology: anemia

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Abstract

The objective of this research was evaluate how people suffering from anemia are affected by different scenarios of carbon monoxide intoxication. Since CO is the main pollutant in big cities, that's an important issue. The study focused in destroyed exergy and exergy efficiency of lungs, which were evaluated under various percentages of carbon monoxide intoxication and in two different altitudes. Results indicate that the increase in the intoxication of carbon monoxide always decreases the exergy efficiency. Moreover, the higher the level of pathology associated with anemia the higher is the destroyed exergy.

Key words:

Bioengineering, anemia, carbon monoxide.

Introduction

The objective of the scientific initiation was evaluate by means of the Second Law of Thermodynamics the effect of carbon monoxide in respiratory system and in a person with anemia. For this aim it was used a multi-compartmental model proposed by Albuquerque (2005)¹ indicated in Figure 1. In order to carry out the simulations two different altitudes and eight severities of anemia (pathology) were evaluated. Figure 1 indicates the multicompartamental model used as basis for the simulations. In Figure 1, there are two control volumes: VC1 – Lungs, arterial and venous compartment; VC2 – Tissues (rest of body and its metabolism).

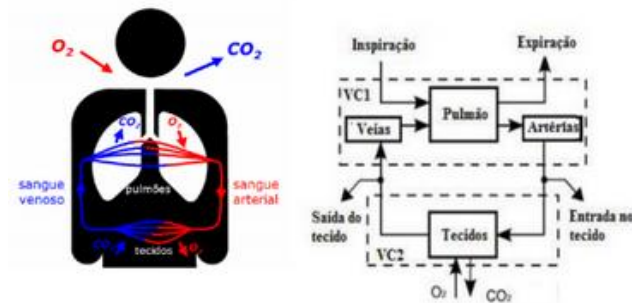


Figure 1. Respiratory system and control volume representation adopted by Albuquerque-Neto et al (2010)

Equation 1 indicates the destroyed exergy in the lungs and Equation 2 indicates exergy efficiency.

$$\dot{B}_{d,pul} = \dot{B}_{M,pul} + \dot{B}_{ag,ven} + \dot{B}_{ar,in} + W_{resp} - \dot{B}_{sg,arterial} - \dot{B}_{ar,ex} - \dot{Q}_{M,pul} \left(1 - \frac{T_0}{T_{corpo}}\right) \quad \text{Eq. 1}$$

$$\eta = \frac{\dot{B}_{sga} + \dot{B}_{a,exp} + \dot{Q}_{m,pul} \left(1 - \frac{T_c}{T_0}\right)}{\dot{M}_{pul} + W_{resp} + \dot{B}_{sgv}} \quad \text{Eq. 2}$$

Results and Discussion

Results showed that there is an inversely trend between lungs exergy efficiency and percentage of CO in environment (Figures 2a and 2c). As lower as the quantity of hemoglobin is, this relation is more evident. Also, higher altitudes decreases the efficiency for all concentrations of hemoglobin. Regarding destroyed exergy, it raises as CO percentage rises, and this directly proportional relation has

major influence for lower hemoglobin blood quantities (Figures 2b and 2d). For higher altitudes, exergy destruction, also, increases. Results showed that hemoglobin works as a facilitator for mass transfer in respiratory system, hence, enhancing efficiency and lowering exergy destruction. Therefore, these parameters may be a measure for the effectiveness of the lung. Another point to be discussed is for the same amount of hemoglobin there is an increase in the destroyed exergy with altitude.

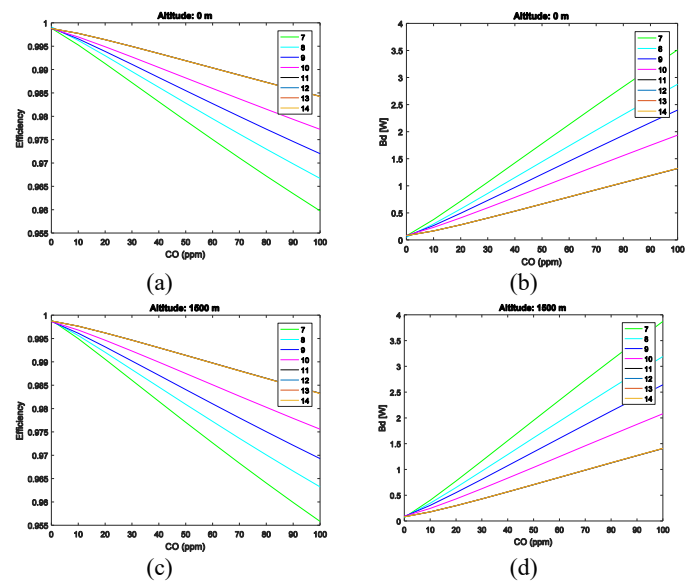


Figure 2. Simulation results for hemoglobin and altitude variations

Conclusions

The evaluation by means of the second law of thermodynamics of the effect of carbon monoxide intoxication in anemic people in different altitudes presented that the hemoglobin is directly related to destroyed exergy. An increase in this pathology increases the destroyed exergy of the lungs.

¹ ALBUQUERQUE-NETO, C. Um modelo do transporte de monóxido de carbono no sistema respiratório do corpo humano. Dissertação (Mestrado) — Escola Politécnica da Universidade de São Paulo, 2005.