Mathematic model of exhaled breath condensate forming

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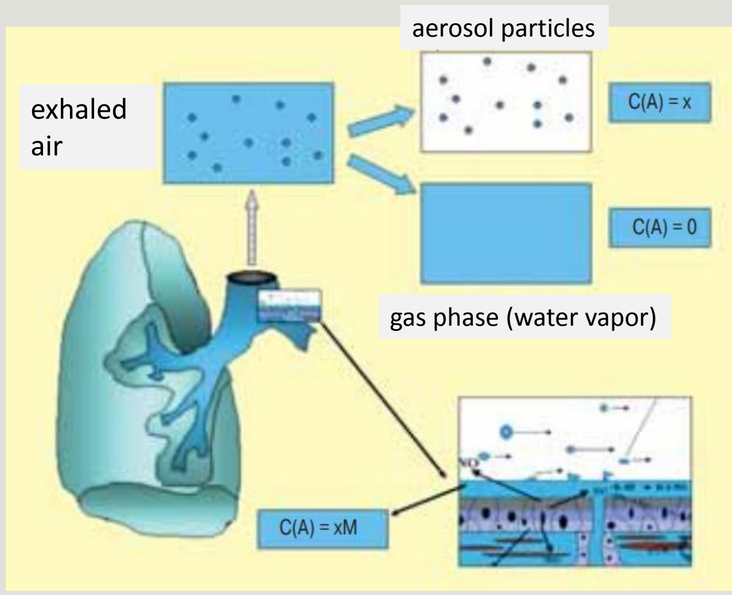
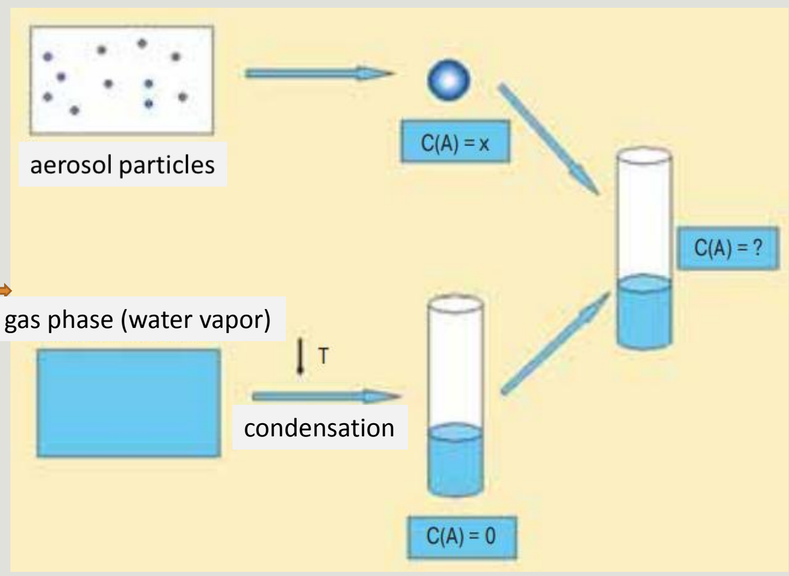
1. There are numerous problems regarding standardization of collection of exhaled breath condensate (EBC) and interpretation of results of its investigation despite the great interest to this field worldwide. Due to this, theoretical substantiation of standardizing the EBC preanalytic evaluation is important. This article proposes a standardizing technique for the EBC collection and evaluation of fixed components of epithelium lining fluid.
Considering several limitations, this technique could be used both for fundamental research and clinical practice.

2. The mechanisms of formation of aerosol particles in the respiratory tract and, accordingly, their appearance in the exhaled air are subject to general physical laws. So, from molecular physics, two methods for the formation of aerodisperse systems are known:
• condensation — formation of liquid droplets from supersaturated vapor molecules — method "from small to large";
• dispersive — grinding of solid and / or liquid bodies in the course of various processes — the "from large to small" method





3. It follows from the mechanisms of aerosol formation that dispersive particles, being a reflection of the fluid lining the bronchial epithelium, regardless of their size, contain X M of the substance we have considered, and condensation particles - 0 M. Water vapor in the exhaled air also does not contain the studied substance. non-volatile substance (0 M).

For our model, we will perform several mathematical transformations to calculate the concentration of the studied substance in the fluid lining the respiratory tract:

$$X_{изм} = \frac{\sum_{k=1}^{n} X_k * V_{аэчастk}}{V_{квв}}$$

$$X_1 = X_2 = \ldots = X_n = X,$$

$$X_{изм} = \frac{X * \sum_{k=1}^{n} V_{аэчастk}}{V_{квв}}$$

4. To simplify the model, we assume that:1. On the formed dispersive particles, which are in the amount of n in one exhalation, during their passage through the respiratory tract, water vapor condensation processes do not occur, i.e., these particles do not dilute.2. The concentration of condensation particles in the exhaled air approaches zero and they do not merge with dispersive particles.3. When the exhaled air passes through the tube system at a temperature of about 0 ° C or low negative temperatures from the gas phase of exhaled air, only water vapors are condensed, and aerosol particles, falling into condensed vapors, are merged and dissolved in the resulting liquid.4. All aerosol particles fall into the condensate of the exhaled air, i.e. the efficiency of the condenser for aerosol particles approaches 100%.5. The vapor of exhaled air is completely condensed by the condenser, i.e. the efficiency of the condenser for water vapor approaches 100%.

for j number of exhalations

$$X^{j}_{изм} = \frac{\left(\left(\frac{X * \sum_{k=1}^{n} V^{1}{}_{аэчастk}}{V^{1}{}_{квв}}\right) * V^{1}{}_{квв} + \left(\frac{X * \sum_{k=1}^{n} V^{2}{}_{аэчастk}}{V^{1}{}_{квв}}\right) * V^{2}{}_{квв} + \ldots + \left(\frac{X * \sum_{k=1}^{n} V^{j}{}_{аэчастk}}{V^{1}{}_{квв}}\right) * V^{j}{}_{rdd}\right)}{V^{1}{}_{квв}}$$

or

$$X^{j}_{изм} = \frac{\left(X * \sum_{k=1}^{n} V^{1}{}_{аэчастk} + X * \sum_{k=1}^{n} V^{1}{}_{аэчастk} + \ldots + X * \sum_{k=1}^{n} V^{1}{}_{аэчастk}\right)}{V^{1}{}_{квв}}$$

$$X^{j}_{изм} = \frac{X * \sum_{i=1}^{j}\left(\sum_{k=1}^{n} V^{j}_{аэчастk}\right)}{V^{1}_{квв}}$$

5. Thus, the proposed method for standardizing the procedure for collecting exhaled air condensate and assessing the non-volatile components of the fluid lining the epithelium of the respiratory tract, subject to the noted limitations, can be used in clinical practice.

$$X = \frac{X^{j}_{изм} * V^{1}_{квв}}{\sum_{i=1}^{j}\left(\sum_{k=1}^{n} V^{j}_{аэчастk}\right)}$$

X - the concentration of the substance of interest in the fluid lining the respiratory tract.
Хизмj- measured concentration of a substance for j-th exhalations.
Vlквв - total volume EBC for j exhalations
∑ (1-J) - sum of j-th exhalations
∑ (1-N) - sum of n-th respiratory particles
VаэчастJk - volume of k-th dispersion aerosol particle