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Title: Redundancy of Humidification at Upper Respiratory Tract, a Plausible Cause of Corona Pandemic - A Hypothesis Based on Thermodynamic Analysis-

Abstract:

The respiratory tract humidification transforms inspired air from whatever temperature and humidity it is, to alveolar air at 37°C at 100 % RH (relative humidity). This is a key thermodynamic and heat and mass transfer process and is as critical as the actual respiration. The normal body temperature of humans is also around 37°C.

A simple mathematical analysis is done by replacing figures of moisture content for 100% saturation level at 37°C in the alveolar partial pressure table, by those at 39°C and 30°C and then recalculating partial pressure figures of oxygen and carbon dioxide. The result is startling and deciphers the significance of 37°C. As of today, there is probably no place on the earth where one can have ambient air at 37°C concurrently with 100% RH. Such is the uniqueness of alveolar air parameters.

Apparently this uniqueness is threatened by climate change. We are ourselves infringing on this 'Natural Selection'. At certain places we have pushed ourselves, closer to 37°C at 100% RH, as an outcome of massive urbanization and industrialization. As a result the key critical process of humidification and conditioning of inspired air, essentially at the upper respiratory tract URT, has gone redundant. A process becomes redundant, when its primary purpose is achieved beforehand. The redundancy has weakened respiratory immune defense systems as well and allowed all viruses like Sars-Cov-2, an unchallenged access to reach alveoli and enter through ACE2 receptors. Free access meteorological data of places like Wuhan indicates that the average humidity at these places were higher than 75% and concurrently temperatures were above 30°C during later part of 2019. Wuhan acted as starting point to the pandemic, where some people had a weak or disabled immune defense due to the redundancy in upper respiratory tract (URT). Once the infections crossed a threshold, it escalated into a pandemic.

At 'Climate Change' meets, increase in ambient temperature concurrently with rising humidity due to massive urbanization and industrialization, and increased use of water for various industrial processes, needs to be on top of the agenda.

Enthalpy, a thermodynamic property of atmospheric air, becomes a good indicator of the concurrent effect of high temperature and high humidity. Enthalpy of air crossing 70 KJ/Kg level may be set as warning sign for impending viral attack.

Key Words: Relative Humidity, Alveolar Air, Natural Selection, Redundancy, Wuhan, Climate Change, Enthalpy

Basis 1: Partial Pressures of Alveolar Gasses

To begin with the uniqueness of alveolar air parameters are reviewed here. The alveolar air is at 37°C with 100% relative humidity (RH) irrespective of inspired ambient air ^{1, 2}. Generally nowhere on the earth, will you have human habitat with air naturally available for breathing at 37°C and 100% RH ³. These typical parameters are achieved by the body through its equally amazing air humidification and conditioning process in upper respiratory tract 'URT' and lower respiratory tract 'LRT' and partly by induced draft from oral salivary moisture. While most of humidification and conditioning is done at URT; LRT and induced draft from oral salivary moisture accounts for the saturation of the air ^{1, 2}.

This means that wherever one breathes, whatever place one inhabits or migrates to, the alveolar air shall be at 37°C at 100% RH. This 37°C also matches with normal body temperature. Comparative figures of partial pressures of atmospheric air and that of alveolar air are given below in the tables (Table 1 and 2). These tables are taken from science books ⁴.

Table 1: Partial Pressures of Atmospheric Gases(760mm)					
Gas	Percent of Total Composition	Partial Pressure (mm Hg)	Partial Pressures of O ₂ and CO ₂ in Pulmonary Capillaries(mm Hg)	Partial Pressure Difference Δp mm Hg	Remarks
Nitrogen	78.6	597.36			Partial Pressure Difference if Alveolar Air was same as Atmospheric Air
Oxygen	20.9	158.84	40	118.84	
Water	0.04	0.304			
CO ₂	0.004	0.0304	45	44.9696	
Others	0.456	3.4656			
Total	100	760			
Standard Figures Available in Science Books					

Table 2: Partial Pressures of Alveolar Gases(760mm)@37 Deg C 100%Rh					
Gas	Percent of Total Composition	Partial Pressure (mm Hg)	Partial Pressures of O ₂ and CO ₂ in Pulmonary Capillaries'(mm Hg)	Partial Pressure Difference Δp mm Hg	Remarks
Nitrogen	74.9	569.24			Values for Existing parameters of alveolar air temperature of 37 °C, @100% RH
Oxygen	13.6	103.36	40	63.36	
Water	6.2	47.12			
CO ₂	5.3	40.28	45	4.72	
Others	traces	0			
Total	100	760			
Standard Figures Available in Science Books					

The purpose of this exercise is to understand the significance of an alveolar air temperature of 37°C at 100% RH and why it is the best combination.

At any given instance, the diffusion of oxygen in the blood vessels accounts for fall in its partial pressure in alveolar air, whereas diffusion of carbon dioxide in the lung results in rise in its partial pressure. The solubility of each gas also affects the partial pressures and gas exchange ⁴.

Key words: Unique Physical Property, Humidification, URT & LRT, Partial Pressure, Diffusion

Method 1: Analysis of Parameters of Alveolar Gasses and Significance of its temperature and Relative Humidity

To evaluate this, further two tables are prepared for partial pressures of gasses; assuming that the body temperature and alveolar air with 100% RH were at 30°C and 39°C. These two tables (Table 3 & 4) are prepared based on, data of moisture content at 100% RH and vapor pressures at 30°C and 39°C respectively. These values are taken from standard tables on thermodynamic properties of saturated air ⁵. The values for partial pressures of oxygen and carbon dioxide are derived from table 1 and 2. The purpose of tables 3 and 4 is indicative only.

At 30°C and 100% RH the alveolar partial pressure of moisture shall be 31.82 mm Hg. Similarly partial pressures of oxygen shall be 121.37 mm Hg and that of carbon dioxide 27.15 mm Hg. Thus the partial pressures difference of oxygen and carbon dioxide shall be 81.372 mm Hg and 17.849 mm Hg respectively. The comparison of partial pressures in table 3 with those in table 2 indicates a condition of faster and larger gas exchange due to higher partial pressure difference, oxygen toxicity, oxidative damage, water filled alveoli etc ⁶. In short it will end up in a total lack of homeostasis and sustainability at 30°C and 100% RH.

Table 3: Partial Pressures of Alveolar Gases(760mm)@30 Deg C 100%Rh					
Gas	Percent of Total Composition	Partial Pressure (mm Hg)	Partial Pressures of O2 and CO2 in Pulmonary Capillaries'(mm Hg)	Partial Pressure Difference Δp mm Hg	Remarks
Nitrogen	76.10	578.37			Partial Pressures values, if alveolar air temperature @100% RH and body temperature were at 30 Deg C
Oxygen	15.97	121.37	40	81.372	
Water	4.19	31.82			
CO2	3.57	27.15	45	17.849	
Others	traces	0.00			
Total	100.00	760.00			
Figures for Moisture Content @30 Deg & 100% RH from standard tables on Thermodynamic Properties of Air. Rest all figures derived from likely diffusion of gases in case alveolar air temperature@100 RH and body temperature were at 30 Deg C					

Similarly, should the body temperature and alveolar air be at 39°C at 100% RH, just about 2°C higher than normal, the findings shall be just the opposite. In this case the moisture component shall be 6.9% and its partial pressure shall be 52.44 mm Hg, slightly more than that at 37°C saturation level. But it will result in a lower partial pressure difference of 57.09 mm Hg for oxygen, and a paltry and insufficient 0.236 mm Hg partial pressure difference for carbon dioxide. This would mean a poor carbon dioxide removal from blood which will lead to tiredness, irregular heart rate, convulsions, coma etc ⁷.

Table 4: Partial Pressures of Alveolar Gases(760mm)@39 Deg C 100%RH					
Gas	Percent of Total Composition	Partial Pressure (mm Hg)	Partial Pressures of O2 and CO2 in Pulmonary Capillaries(mm Hg)	Partial Pressure Difference Δp mm Hg	Remarks
Nitrogen	74.48	566.05			Partial Pressures values, if alveolar air temperature @100% RH and body temperature were at 39 Deg C
Oxygen	12.78	97.09	40	57.09	
Water	6.90	52.44			
CO2	5.89	44.76	45	0.236	
Others	traces	0.00			
Total	100.00	760.00			
Figures for Moisture Content @39 Deg & 100% RH from standard tables on Thermodynamic Properties of Air. Rest all figures derived from likely diffusion of gases in case alveolar air temperature@100 RH and body temperature were at 39 Deg C					

Report 1: It can be inferred that, at any combination of alveolar air just a few degrees above or below 37°C with 100% RH, life is not viable.

Thus apart from the generally understood role of providing protection to lungs from damage, the humidification plays an important role as a stabilizer of gas exchange and homeostasis⁸ and 37°C with 100% RH is the best combination for alveolar air. It is intriguing to know that there is no inhabited place on earth, where the atmospheric air can have 100% saturation at 37°C. This is clearly an example of the best ‘Natural Selection’. There are places as hot as 50°C, but the RH at such places is very low.

Key Words: Homeostasis, Partial Pressure, Thermodynamic Property, Stabilizer, Natural Selection

Basis 2: Humidification of Inspired Air ^{1,2}

Now let us review how the humidification happens in the upper and lower respiratory tract. Whatever is the temperature and relative humidity of air inspired; it passes through the convoluted air passages of the naso-pharynx and pharynx. This generates turbulence which increases contact area for heat and mass transfer between air and the mucosa. Thus humidification of inspired air is a key thermodynamic and heat and mass transfer process where depending on inhaled air parameters an evaporative heating takes place and some IgA laden water molecules of mucosa mix with inhaled air⁹. This air attains relative humidity between 80% to 85% and temperature nearly up to 33°C. While traveling to the lower respiratory tract it

creates an induced draft for oral salivary moisture⁹ and at the isothermal saturation boundary, beyond the Carina, the inspired air reaches 37°C at 100 % RH.

During exhalation the hot air at 37°C, heats up mucosa which has lost heat during inspiration. A small amount of vapor also gets condensed^{1, 2, and 9}.

At places where ambient air is dry and hotter than 37°C, humidification by evaporative cooling takes place.

It is evident that the humidification process is as critical as actual breathing, and is linked with immune defense response. All the defense mechanisms comprising IgA, which is part of mucosa, shall also be part of its evaporated component while it travels through to alveoli with inhaled air⁹. Immunoglobulin A (IgA) is the first line of defense.

Key Words: Turbulence, Contact Surface Area, Evaporative Heating, Induced Draft, Salivary Moisture, Isothermal Saturation, IgA, Evaporative Cooling,

Report 2 a:

Humidification Redundancy Effect:

However there are many locations across the world, where the humidity has gone past 75% while temperatures are also concurrently beyond 30°C to 33°C, for a period it would ultimately matter. There will be a situation when the humidification and associated immune defense⁹ in URT will become almost redundant, as the inhaled air will have parameters the same as what it is expected to achieve. Neither will there be any reverse heat transfer and condensation during exhalation. In short a case of “URT Humidification Redundancy”. A process becomes redundant, when its purpose is achieved beforehand. A schematic of the redundancy point is shown in Figure 1. If the inspired air is at Redundancy Point, or beyond, then the humidification, conditioning and immune defense at URT shall be redundant and disabled⁹.

Thus exposure to such ambient conditions can give an unchallenged access to all viruses, pathogens, and bacteria to the alveolar space and the period of such exposure shall be critical in severity of the infection.

Report 2 b:

A Statistical Record of Atmospheric Parameters Bringing About URT Redundancy:

From free access meteorological data of Wuhan, it can be noted that average humidity of Wuhan in 2019 was 78% while concurrently maximum temperature was in the range of 30°C to 34°C in the months of June to September and part of October 2019^{10, 11}. Thus it can be inferred that Wuhan’s ambient air parameters resulted in “URT Humidification Redundancy” and then acted as a starting point to the Sars-Cov-2 infections. Once the infections crossed a threshold, it escalated into a pandemic.

Based on similar data available as a free issue, concurrent occurrences of temperatures in the range of 29°C to 37°C and relative humidity of 75% and above were checked for various cities throughout world^{12, 13}. Wherever and whenever concurrent occurrences of atmospheric conditions of 29°C to 37°C and RH

75% and above prevail for a longer period, it may be seen as a warning sign for likely emergence of a variant or increase in cases related to existing viral infection.

Figure 1: Redundancy Point (Schematic & Not to scale)

Discussions:

A Little Climate Change Makes Big Impact

In the earlier paragraphs of mathematical analysis, we have noted how a small change in alveolar temperature and partial pressures can impact viability of life. It can also be inferred that, climate change with respect to even a small rise in temperature and humidity near these critical values of 33°C and 75% RH can impact human lives severely.

80% RH concurrently with temperatures reaching 33°C is an alarming condition. The enthalpy of air is 97 KJ/Kg at this stage. Enthalpy¹⁴, a thermodynamic property of atmospheric humid air, is a good indicator of the combined effect of high temperature and high humidity. It is calculated according to following formula¹⁵

$$h=1.005* t + x (1.88 * t + 2501)$$

‘t’ is the temperature in °C, ‘x’ is Weight (mass) fraction of water (Kg/Kg) and ‘h’ is the enthalpy.

All weather reports should include daily maximum and minimum enthalpy figures. Enthalpy crossing 80 KJ/Kg of air, representing 30°C at 75%RH, should be used as a warning sign for forecasting viral attack.

Key Words: URT Redundancy Effect, Climate Change, Enthalpy

Conclusions:

Body temperature of 37°C and alveolar air parameters of 37°C with 100% RH are most critical in Natural Selection of human evolution.

Humidification plays an important role as a stabilizer of gas exchange and homeostasis.

If the quality of inspired air is consistently at or above 30°C and 75%RH concurrently, irrespective of location, it can cause redundancy in upper respiratory tract humidification process of many people and allow unchallenged access to viruses like Sars-Cov2 or its variant and then result into wide spread infections and pandemics.

Enthalpy, a thermodynamic property of ambient air should be used as part of daily weather report and marker for possible viral attack.

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