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The Underappreciated Role of Carbon Dioxide in Health

Analysis by Dr. Joseph Mercola | December 17, 2023

STORY AT-A-GLANCE

- CO_2 is typically thought of as nothing more than a harmful waste product of respiration, but it's actually a driver of mitochondrial energy production, and it improves the delivery of oxygen into your cells
- One of the simplest ways to optimize your CO_2 is by breathing properly. Most people tend to over-breathe, which causes you to expel too much CO_2. Proper breathing involves breathing less and breathing slower. Both of these allow CO_2 to build up, and that appears to be part of why breathwork has such wide-ranging benefits
- To have sufficient CO_2 production, you need healthy mitochondria because CO_2 is produced exclusively in the Krebs cycle in the mitochondria. If you have mitochondrial dysfunction, if you're hypothyroid or have high levels of inflammation, then you will not be producing enough CO_2
- When your CO_2 is too low, your body reverts to an "emergency" vasodilator, nitric oxide (NO). Drawbacks of elevated NO include peroxynitrite species formation and pseudohypoxia. NO also damages the polyunsaturated fats (PUFAs) in your cells, and inhibits energy production
- CO_2 combats cancer development by lowering the pH of the cell, thereby allowing extra water to be excreted. This is the opposite of linoleic acid (LA) and estrogen, both of which suck water in and cause the cell to swell. Cellular swelling is a feature of cancer cells

In this interview, repeat guest Georgi Dinkov reviews the role of carbon dioxide (CO_2) in health. CO_2 is typically thought of as nothing more than a harmful waste product of

respiration, but it's actually a driver of mitochondrial energy production, and it improves the delivery of oxygen into your cells.

While this may come as a shock to most people, of all the strategies I know of to increase life extension, CO_2 is one of the most effective longevity interventions available. There really isn't anything that comes close, other than a low linoleic acid diet and reducing estrogen dominance.

Unfortunately, virtually no doctors understand this. The now deceased Ray Peat, a biologist and physiologist who developed the bioenergetic theory of health,[1] was one of the few who understood it inside and out, and actually recommended its clinical use.

I wrote an **article** about this that featured his lecture on CO_2, which I watched six times as it catalyzed my interest in the topic. At the time I found his video there were fewer than 2,000 views on YouTube. You can find it by going to YouTube and typing in Ray Peat CO_2.

Proper Breathing Is Important for Optimal CO_2 Levels

One of the simplest ways to optimize your CO_2 is by breathing properly. Unfortunately, bad advice is rampant in the breathing arena as well. The problem is that most people tend to over-breathe, which causes them to expel (breathe out) too much CO_2, resulting in respiratory alkalosis. Chronic CO_2 deficiency will also contribute to premature death.

In a nutshell, "proper" or life-extending breathing involves breathing less and breathing slower. Both of these allow CO_2 to build up, and that appears to be part of why breathwork has such wide-ranging benefits.

> *"As it turns out, carbon dioxide, even though medically it's mostly viewed as a waste product of respiration, is actually the thing that protects us from oxygen's well-known toxicity,"* Dinkov explains.
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> *"In fact, if you speak to people who work in trauma or in the intensive care unit, when they have to revive people that are in shock or have suffered some kind of*

ischemic attack, they will tell you that the premature delivery of oxygen, or delivering too much oxygen ... is actually what kills most patients after they come out of the initial shock stage.

The introduction of too much oxygen too quickly creates this massive cytokine storm and inflammatory reaction, and one of the reasons [for that] is that the cells are hypermetabolic — they're not producing sufficient carbon dioxide, so they're not able to utilize the oxygen properly."

Forgotten Truths

It's rather surprising that the benefits of CO_2 have become forgotten considering its historical use. Asian cultures, for example, have a long history of using carbonated water for its health benefits.

The Romans recommended taking baths in naturally carbonated water for all kinds of ailments but especially arthritis, infertility and psychiatric ailments, and this practice extended well into the Middle Ages when monks prescribed it. To this day many visit natural hot springs, and the likely benefit in many of these springs is the CO_2 content of the water.

In the 20th century, Russian scientists did loads of research on CO_2, and to this day, many Russian clinics offer CO_2 baths and other CO_2 treatments. There's even a suit that can be filled up with CO_2, which then diffuses into your tissues. You'll start feeling hot very rapidly and this is a sign of vasodilation, which is one of the cardiovascular effects of CO_2.

It's been shown that CO_2 can, over the long term, even reverse arterial calcification. It can also reverse many other signs of and damage caused by the aging process.

Mitochondrial Dysfunction Inhibits CO_2 Production

The key, though, is that in order to have sufficient CO_2 production, you need healthy mitochondria, because CO_2 is produced exclusively in the Krebs cycle in the mitochondria. If you have mitochondrial dysfunction, if you're hypothyroid or have high levels of inflammation, then you will not be producing enough CO_2.

When your CO_2 is too low, your body reverts to an "emergency" vasodilator, nitric oxide (NO). There are three types of nitric oxide:[2] neuronal nitric oxide synthases (nNOS); endothelial NOS (eNOS); and inducible NOS (iNOS). Low CO_2 triggers iNOS. The problem with that is that now you're overproducing NO, which is not ideal. Dinkov explains:

> *"Most of the eNOS ... stays in the actual blood vessel. iNOS also spills into the blood. That's kind of the purpose of iNOS because the primary purpose of nitric oxide in the body is to fight pathogens. It's a reactive nitrogen species.*
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> *It's produced for only two reasons, either as an emergency vasodilator, or if the immune system senses an invasion from pathogens, specifically bacteria and viruses, in which case iNOS is activated.*
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> *The reason iNOS is bad is because the nitric oxide does not stay localized. It's made available systemically because you want to affect all blood vessels, and that's what happens when you don't have sufficient amounts of carbon dioxide production. So, if you don't have [enough] CO_2, you will have elevated NO.*
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> *But with NO, nitric oxide, you have a lot of other bad things happening. It's a highly reactive molecule. It can form peroxynitrite species. It can damage the polyunsaturated fats (PUFAs) in the cells, no matter where they are.*
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> *Nitric oxide itself can form a covalent bond with something called cytochrome c oxidase [Complex 4 in the electron transport chain], which is the rate limiting step of the oxidative phosphorylation ...*
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> *You want to break that bond because otherwise your oxidative phosphorylation is inhibited. Methylene blue can do it, magnesium can do it, carbon dioxide can do it, near-infrared light and some quinols."*

Another significant problem associated with elevated NO is pseudohypoxia, because you have oxygen in the cells but it cannot be utilized because No impairs Complex IV in the electron transport chain.

CO_2 prevents this by dissociating the covalent bond between NO and Complex IV. Hence, oxygenation is optimized when sufficient CO_2 is present. So, to summarize, CO_2 keeps your blood vessels supple without the drawback of blocking Complex IV.

The Bohr Effect

Needless to say, optimal delivery of oxygen is crucial for good health. Oxygen from the air binds to hemoglobin when you inhale and enter your blood circulation. This bond is relatively strong. To break that bond and deliver the oxygen where it's needed, you need CO_2. This is known as the Bohr Effect.

Basically, the Bohr Effect describes the process in which CO_2 weakens the bond between oxygen and hemoglobin so that the oxygen can separate and enter into the tissues.

As the hemoglobin releases the oxygen, it binds to the CO_2 instead. The CO_2 is then expelled through your outbreath. Without enough CO_2, you will not be able to liberate sufficient amounts of oxygen from hemoglobin.

A Note on Oxygen Saturation

On a side note, a pulse oximeter measures the amount of oxygen in your blood. However, if your CO_2 is extremely low, it could still read 100% saturation because you're not dissociating the oxygen. It's circulating in your bloodstream but cannot be used.

The major factor that determines your tissue oxygenation is how much CO_2 you're producing. If you're hypermetabolic, if your mitochondria are not working, then you're oxidizing mostly fats, which produces less CO_2 per molecule, so you'll be deficient in CO_2.

In the past (going back 100 years ago or so), the test for seizure susceptibility was hyperventilating. The doctor would instruct you to breathe through your mouth very quickly for 30 seconds, and if seizure symptoms emerged, it was a sign that you have insufficient CO_2, as that's what's causes the seizure activity.

How CO_2 Can Combat Cancer

Another important aspect of CO_2 is that it lowers the pH of your cells, thereby allowing extra water to be excreted. This is the exact opposite of linoleic acid (LA) and estrogen, both of which suck water into your cells which causes the cells to swell. Cellular swelling, aside from being the cause of edema, is also a feature of cancer cells. So, you don't want your cells to retain excess fluids. Dinkov explains:

> *"Because carbon dioxide is a Lewis acid, it's an electron withdrawing agent, even though it doesn't directly bind them like a quinol. If you look at the structure, it's very similar to a quinol. It's a carbon atom with two carbonyl groups, and the quinol is very similar. They usually have a ring and two or more carbonyl groups.*
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> *Lewis acids drop the pH of the cell, which automatically decreases the cell's affinity for water. Which means you're going to be excreting some of that extra water of the cell.*
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> *It's not a coincidence that linoleic acid has multiple double bonds. It's much more hydrophilic than the saturated fats, which lack the double bonds. Any time you have an increase of intracellular pH, you have increased affinity for water. The moment water streams in, that's a signal for de-differentiation and metosis (division). If this process continues uncontrollably, we basically get cancer.*
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> *Conversely, when you excrete water, the cell becomes acidified and a little bit dehydrated, so to speak. Then you're getting high amounts of differentiation. You're also increasing the affinity of the intracellular proteins for potassium and magnesium, while decreasing their affinity for sodium and calcium. In fact,*

when carbon dioxide is produced and streams out of the cell, it draws calcium and sodium with it.

If you're not producing sufficient amounts of carbon dioxide, you're also probably not producing sufficient amounts of ATP, because carbon dioxide and ATP go hand in hand; they're signs of good mitochondrial function. ATP has affinity for magnesium, but if you don't have sufficient amounts of ATP, you'll have more ADP, which is the degraded version.

ADP has an affinity for calcium. So low metabolic rate, by definition, means cellular excitotoxicity, cellular alkalinity and cellular division, because of the lack of carbon dioxide and the lack of the ATP. ATP always exists in the body in a complex with magnesium. So, if you're taking magnesium but not producing sufficient amounts of ATP, it will not become bioavailable. But the production of ATP is tied to the production of carbon dioxide.

Carbon dioxide also increases the uptake of serotonin into the platelets, so producing sufficient amounts of carbon dioxide will lower your extracellular levels of serotonin.

It also increases the uptake of histamine, a very highly inflammatory mediator. Its transport also depends on carbon dioxide and on sodium as well, just like the serotonin ... So, almost everything that you do metabolically, in terms of health, depends on the production of CO_2. It's not a waste product."

Respiratory Alkalosis and Cancer

Cells can only produce a certain amount of CO_2 per unit of time, so when you breathe too fast, you overwhelm your cells' ability to maintain an appropriate level of CO_2. As a result, you'll have excess oxygen circulating in your blood stream, but because the CO_2 production cannot keep up with the amount of CO_2 you exhale, you end up with respiratory alkalosis.

Respiratory alkalosis also increases intracellular water uptake, as just described, and as the pH of the cell increases, it causes overproduction of several inflammatory mediators, including lactate, which is another hallmark of cancer cells.

> *"Cancer cells are highly alkaline, they're overproducing a lot of lactate and they have a very high uptake of water,"* Dinkov says. *"In fact, I think the word tumor is a Latin word which meant swelling.*
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> *You can reduce the swelling of the tumor to a tremendous degree simply by either increasing delivery of CO_2 around the tumor, if it's on the surface, or increasing uptake of CO_2 through a CO_2 bath or drugs that increase the levels of CO_2 in the blood."*

Drugs that increase CO_2 include carbonic and hydrate inhibitors such as acetazolamide, which decrease the degradation of CO_2, allowing more CO_2 to build up in your blood.

CO_2 Benefits Your Entire Body

A nearly 150-year-old medical book describes the many uses and health benefits of CO_2 that were known at the time. It basically included the entire body, and an extensive list of ailments of the day, including:

Dementia	Psychiatric disorders like mania
Dysentery	Fistulas
Fibrotic conditions	Whooping cough
Tuberculosis	Rhinitis

"Really, every condition you can think of, both physiological and mental, can be remediated, and in many cases cured, by increasing endogenous CO_2 production and decreasing degradation," Dinkov says. Migraines, are another common ailment that can

be addressed with CO_2. In many cases migraines are due to overbreathing causing a lack of CO_2 that constricts the blood vessels in your brain.

Exogenous CO_2 Delivery Methods

While it's obviously important to optimize your endogenous (internal) production of CO_2, exogenous delivery or supplementation will definitely produce the greatest benefits, as you can deliver far greater amounts than your body can produce. Such strategies include:

Breathing into a paper bag	Drinking carbonated water and other carbonated beverages
CO_2 baths	A special suit into which CO_2 is pumped
Hyperbaric administration	Taking small amounts of baking soda in your drinking water

A book written in 1905 by Achilles Rose, M.D. discusses delivery by rectal insufflation. It contains dozens of case reports of it being used for asthma, whooping cough, dysentery, colitis, rectal fistulas, rhinitis and ear infections. It is a fascinating read. There are three grades of CO_2 gas:

- Industrial-grade, used for cryo chambers, welding and a variety of other typically commercial applications
- Food grade
- Beverage grade, which is 10 times cleaner and purer than food grade, and it's the kind used in restaurants

If you are going to use CO_2 therapeutically, the grade you will want to use is the beverage grade. Commercially, it's typically sold or rented in 20-pound cylinders. There's enough CO_2 gas in one cylinder that if you're using 1 liter a day therapeutically, it will last you 250 years.

However, there are smaller units like SodaStream that can provide CO_2 gas. The problem is that you need to use those CO_2 cylinders with SodaStream equipment and there is no easy way to put the gas into a container or bag.

I hope to go into greater detail of how you can use CO_2 therapeutically when I interview Anders Olsson, breathing instructor and the founder of Conscious Breathing, soon.

Sources and References

- [1] Umzu. Who Is Ray Peat?
- [2] Frontiers in Physiology June 2, 2016; 7