Therapeutic Carbon Dioxide Literature

The scientific basis of our technology

Carbon dioxide gas is applied to the skin after enclosing the affected area with a plastic sleeve or the affected limb is placed in a carbon dioxide-rich bath. Multiple periodic applications are most effective to obtain the full response.

Clinical and Animal Studies

Helps tissue to heal

1. Improves blood flow and preserves tissue in peripheral vascular disease – human, rat (1-4)
2. Improves the vascular damage from diabetes – rat, human (5-7)
3. Improves acceptance of skin flaps – rat, equine (8)
4. Improves wound healing – human, equine (9,10)
5. Hastens fracture closure – rat (11,12)

Improves collaterals in the ischemic limb

1. Activates process for new blood vessels - rat (13)

Heals skeletal muscle

1. Improves muscle recovery after nerve injury – rat (14)
2. Reverses loss of oxidative capacity due to diabetes – rat (15)
3. Improves endurance – rat, human (16,17)

Reduces inflammation in lungs and peritoneum

1. Better than air or helium during laparoscopy (18,19)
2. Improves ARDS and Covid-19 lung inflammation (20)

Shrinks tumors

4. Reduces tumor growth – rat, mice (21-23)
5. Enhances the effectiveness of chemotherapy and radiation therapy – rat (24,25)

Physiological Actions of Carbon Dioxide

Anti-Inflammation

1. Moderates NF-kappa B (26)

Increases blood flow

1. Vasodilation (27)
2. Nitric oxide dependent (28)

Increases tissue oxygenation

1. Forces oxygen release from hemoglobin through the Bohr effect (27,29)

Activates normoxic angiogenesis

1. In resting skeletal muscle (30)
2. During fracture repair (11,12)
3. Muscle atrophy and contracture after nerve damage (14,31)
4. Muscle atrophy after fracture (32)
5. Hyperglycemia capillary preservation (7)
6. Releases VEGF in cultured endothelial cells (33)

Combats reactive oxygen species

1. Critical and potent anti-oxidant (34,35)

Oxygenates tumors

1. Moderates hypoxia inducible factor (HIF1) (22,36)

2. Moderates metalloproteases – MMP (21)
3. Increases tumor apoptosis (37)

Cell Biology of Carbon Dioxide

Facilitated diffusion

1. Aquaporin – allows for rapid diffusion of CO2 into the cells (38)
2. Carbonic anhydrase – maintains driving force by rapidly converting CO2 to bicarbonate (39)

Forces release oxygen from red cells

1. Bohr effect - (40)

Connexin 26 as sensor

1. Opens gap junction when detects CO2, and releases ATP. Astrocytes. Regulates neural blood flow and breathing (41)

Angiogenesis

1. Releases VEGF from endothelial cells (13,42)

Increases oxidative metabolism

1. Increases oxidative metabolism by mediating mitochondrial biogenesis through gene expression of peroxisome proliferator-activated receptor gamma coactivator 1-alpha (PGC-1a), sirtuin 1 (SIRT1), and VEGF, as well as in the number of mitochondria. (30)

Adenylyl cyclase

1. Evolutionarily conserved sensor (43)

Mitogen-activated protein kinase (MAPK) signaling pathways

1. Carbon dioxide sensor for many functions (20)

Therapeutic Elevations of Carbon Dioxide Concentration

Whole body by inducing hypercapnia (increased inspired concentration of CO2)

1. Improved blood flow and tissue oxygenation (36,44-49)

Localized external application of CO2

1. Gas is applied to the skin by filling a plastic sleeve covering the affected area
2. Gas readily diffuses through the skin, especially when the skin is wet (50-52)
3. Solubility in various tissues - 30x more soluble than oxygen in water (53)
4. Treat every 1-3 days for about 2 weeks (54)

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