Updates in Prevalence, Prognosis and Management of Carboxyhemoglobin in Critically Ill Patients

An Essay

Submitted for Partial Fulfilment of Master Degree in General Intensive Care

Presented by

Mahmoud Sanad Ahmed Heussein

M.B., B.Ch.(Cairo University)

Supervised By

Dr. Azza Mohamed Shafeek Abdel Mageed

Professor of Anesthesiology, Intensive Care and Pain Management
Faculty of Medicine, Ain-Shams University

Dr. Ghada Mohamed Samir

Assistant Professor of Anesthesiology, Intensive Care and Pain Management
Faculty of Medicine, Ain-Shams University

Dr. Amal Hamed Abdel Hamid Rabie

Lecturer of Anesthesiology, Intensive Care and Pain Management
Faculty of Medicine, Ain-Shams University

Faculty of Medicine,
Ain-Shams University
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List of Abbreviations

ADP	Adenosine diphosphate
AF	Atrial fibrillation
ASA	Aminosalicylate
AST	Aspartate amino transferase
ATA	Atmospheres absolute
CaO2	O2 content of arterial blood
cGMP	Cyclic guanosine monophosphate
CK-MB	Creatine phosphokinase-MB
CNS	Central nervous system
CNS	Central nervous system
CO	Carbon monoxide
CO2	Carbon dioxide
COHb	Carboxyhemoglobin
COP	CO Poisoning
CoPP	Cobalt protoporphyrin
CORM	CO-releasing molecule
COX	Cyclooxygenase
CVDs	Cardio vascular diseases
CVS	Cardiovascular system
DM	Diabetes millatus
DNA	Deoxyribonucleic acid
DNS	Delay neurological seaquale
ECG	Electrocardiogram
ER	Endoplasmic reticulum
GMP	Guanosine monophosphate
GP	Globus pallidus
GTP	Guanosine triphosphate
H2O2	Hydrogen peroxide
HB	Haemoglobin
HbO2	Oxyhemoglobin dissociation curve
HBOT	Hyperbaric oxygen therapy
HIF-1α	Hypoxia-inducible factor 1 alpha
HO-1	Heme oxygenase-1
HO-2	Heme oxygenase-2

List of Abbreviations (Cont...)

I/R	Ischemia/reperfusion
IBD	Inflammatory bowel disease
IL,Na	Late current Na channels
IL-1	Interlukin-1
IL-6	Interlukin-6
iNOS	Inducible nitric oxide
Ipeak,Na	Peak inward current amplitude
KCA	Calcium-dependent potassium channels
LBW	Low birth weight
LD1	Lactate dehydrogenase 1
LD2	Lactate dehydrogenase 2
LDH	Lactate dehydrogenase
LDL	Low-density lipoprotein
LPS	Lipopolysaccaride
MAPK	Mitogen-activated protein kinase
MBP	Myelin basic protein
MCHC	Mean corpuscular hemoglobin concentration
MCV	Mean corpuscular volume
MDA	Malondialdehyde
MetHB	Methemoglobin
MPO	Myeloperoxidase
MPV	Mean platelet volume
MRI	Magntic resonance image
mRNA	Messanger ribonucleic acid
NADPH	Nicotinamide adenine dinucleotide phosphate
NAFLD	Non-alcoholic fatty liver disease
NF-κB	Nuclear factor kappa b
NMDA	N-methyl-d-aspartate
nNOS	Neuronal nitric oxide synthase
NO	Nitric oxide
NOX	Nitrogen oxides
NS	Neurological symptoms
OSI	Oxidative stress index
PAI	Plasminogen activator inhibitor

List of Abbreviations (Cont...)

PO2	Partial pressure of oxygen in the blood
Ppmv	Parts Per Million By Volume,
PROM	Premature rupture of membranes
PVCs	Premature ventricular complexes
ROS	Reactive oxygen species
SaO2	O2 saturation
SRCA	Sarcoplasmic reticulum ca2+ atpase
sGC	Soluble guanylate cyclase
SMCs	Smooth muscle cells
SPCO	Carboxyhemoglobin saturation
STAT3	Signal transducer and activator of transcription 3
TAS	Total antioxidant status
TBA	Thiobarbituric acid
TGF-β	Tuomer growth factor
TNF-α	Tumor necrosis factor-α [])
TOS	Total oxidant status (tos)
t-PA	Tissue-type plasminogen activator
UC	Ulcerative colitis
UPR	Unfolded protein response
UW	University of wisconsin solution
VECs	Vascular endothelial cells
VEGF	Vascular endothelial growth factor
WM	White matter
XD	Xanthine dehydrogenase
XO	Xanthine oxidase

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Introduction

Carbon monoxide (CO) is a poisonous, colorless, odorless and tasteless gas. It is a poisonous gas and is a common, yet preventable, cause of death from poisoning worldwide**.** Carbon monoxide has exogenous sources like coal gas, iron smelting, volcanoes and forest fires and also has endogenous sources through normal heme catabolism by heme oxygenase so it increased in hemolytic anemia and sepsis going**.** Carbon monoxide had approximately 250 times the affinity of oxygen. Despite the known toxicity of CO at high concentration, low concentrations of CO can exert vaso -regulatory properties, as well as modulate inflammation, apoptosis, and cell proliferation. So CO can be used in preventing and treating some diseases as vascular insufficiency, graft rejection, atherosclerosis, malaria and immunologic diseases **(Rodriguez et al., 2010).**

Because of their high metabolic rate, the brain and the heart are most susceptible to CO toxicity. The severity ranges from mild flu-like symptoms to coma and death. Carbon monoxide poisoning causes 1.6 million deaths worldwide every year. CO toxicity causes multiple cardiac diseases including arrhythmias and ECG alteration suggesting an ischeamic like syndrome and may be associated with elevation of cardiac enzymes **.**carbon monoxide

poisoning produces both immediate and delayed neuronal injury o during and after CO poisoning which is related to hypoxia and production of reactive oxygen species (ROS) by the brain. Carbon monoxide poisoning increase thrombotic tendency and induce platelet activation , aggregration and stickiness with alterations in the fibrinolytic pathway causing cardiovascular diseases including myocardial infarction **(Wu and Juurlink, 2014).**

Diagnosis of CO poisoning is mainly based on exposure to CO and clinical picture. CO poisoning can be diagnosed and monitored by the Co pulse oximeter and serum S100B and neoron specific enolase. CO poisoning treatment begins with supplemental O_2 and aggressive supportive care, including airway management, blood pressure support, and stabilization of cardiovascular status.high-flow O_2 therapy should be administered immediately to treat hypoxia due to CO poisoning and also to accelerate elimination of CO from the body. Oxygen can be given under increased pressure with hyperbaric oxygen therapy (HBOT). HBOT is indicated in comatosed patients or with neurological abnormalities **(William and Lewis, 2011).**

Aim of the Essay

The aim of this essay was to highlight the chemical, physical properities and uses of carbon monoxide gas, the clinical picture of carbon monoxide poisoning in intensive care patients and to demonstrate the updates in diagnosis, treatment and prognosis of carbon monoxide poisoning in intensive care patients.

Carbon Monoxide Gas

Carbon monoxide(CO) gas is produced from the partial oxidation of carbon-containing compounds; it is formed when there is no enough oxygen to produce carbon dioxide (CO2). in the presence of oxygen, carbon monoxide burns with a blue flame, producing carbon dioxide. carbon monoxide is slightly lighter than air, it is also produced in normal metabolism in low quantities, and is thought to have some normal biological functions. In the atmosphere however, it is short lived and spatially variable, since it combines with oxygen to form carbon dioxide and ozone. **(*Williams and Lewis, 2010).***

Properties of Carbon monoxide:

Carbon monoxide consists of one carbon atom and one oxygen atom, connected by a triple bond that consists of two co- valent bonds as well as one dative covalent bond Fig(1). ***(Prockop and Chichkova,2007).***

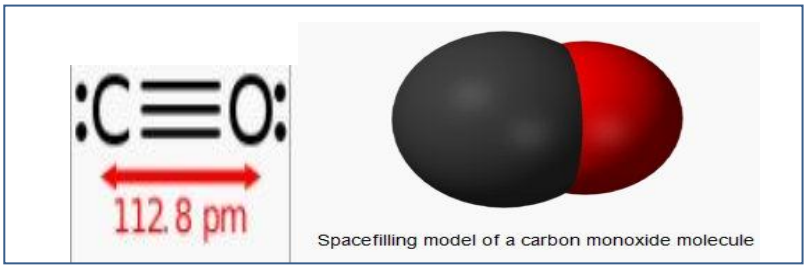

Fig.(1): Physical properties of carbon monoxide ***(Ayres, 2009).***

Table (1): The physical properties of carbon monoxide**.** ***(Ayres, 2009)***

Molecular formula	
Molar mass	28, 010g/mol
Appearance	Colorless
Odor	Odorless
Density	789 kg/m^3liquid 1.250kg/m^3 at 0 °C, 1 atm 1.145 kg/m^3at 25 °C, 1 atm
Solubility in water	27.6mg/1liter
Boiling point	-191.5°C, -313 °F
Melting point	-205.02 °C, -337 °F
Refractive index	1.0003364
Flash point	−191 °C, −311.8 °F
Solubility	soluble in chloroform, acetic acid, ethyl acetate, ethanol, ammonium hydroxide, benzene

Carbon monoxide is absorbed through breathing and enters the bloodstream through gas exchange in the lungs. Normal circulating levels in the blood are 0% to 3%, and are higher in smokers. Carbon monoxide levels cannot be assessed through a physical exam. Laboratory testing requires a blood sample (arterial or venous) and laboratory analysis on a CO-Oximeter. Additionally, a noninvasive carboxyhemoglobin (SpCO) test

method from Pulse CO-Oximetry exists and has been validated compared to invasive methods ***(Roth et al., 2011).***

Sources of carbon monoxide

It may be exogenous or endogenous sources (table 2).

I -Exogenous sources of carbon monoxide

Coal gas, which was widely used before the 1960s for domestic lighting, cooking, and heating, had carbon monoxide as a significant constituent. Some processes in modern technology, such as iron smelting, still produce carbon monoxide as a by product.The largest source of carbon monoxide is natural in origin, due to photochemical reactions in the troposphere that generate about 5 x 10^{12} kilograms per year (table 3). Other natural sources of CO include volcanoes, forest fires, and other forms of combustion

(Ayres, 2009).

2-Endogenous sources of carbon monoxide

In biology, carbon monoxide is naturally produced by the action of heme oxygenase 1(HO-1) and heme oxygenase2 (HO-2) on the heme from hemoglobin breakdown. This process produces a certain amount of carboxyhemoglobin in normal persons, even if they do not breathe any carbon monoxide. Following the first report that carbon monoxide is a normal neurotransmitter in 1993, as well as one of three gases that naturally modulate inflammatory

responses in the body (the other two being nitric oxide and hydrogen sulfide), carbon monoxide has received a great deal of clinical attention as a biological regulator. In many tissues, all three gases are known to act as anti-inflammatories, vasodilators, and promoters of neovascular growth. Clinical trials of small amounts of carbon monoxide as a drug are on-going ***(Li et al., 2009).***

Table (2): Sources of carbon monoxide. ***(Louise and Kristine, 2004)***

Exogenous
-Incomplete combustion of carbonaceous fossil fuel -House fires -Automobile exhaust -Propane-powered vehicles (forklifts, ice skating rink resurfacers) -Gas-powered furnaces, ovens, fireplaces -Heaters -Indoor grills -Camp stoves -Boat exhaust -Cigarette smoke -Methylene chloride (solvent found primarily in paint remover) endogenously converted to carbon monoxide after exposure
Endogenous
-Normal heme catabolism by heme oxygenase -Increased in hemolytic anemia, sepsis