



Disordered Decompression

An Explanation for Undeserved DCS

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Hyperbaric Medicine

Introduction

Prevention of decompression sickness (DCS) is a significant component of all compressed gas dive planning. It dictates the depths, durations and frequency of diving activities

Fortunately, DCS occurs rarely; about 1 to 3 times in every 10,000 ascents. When it occurs the explanation for its cause needs to be sought

We advocate 2 etiology categories of DCS

Deserved Identifiable Violations	Undeserved No "Apparent" Violations
Omitted decompression	Signs & symptoms of DCS without readily identifiable causes
Accelerated ascent rates	Information from the history may provide clues as to the cause
Missed 3 minute safety t stop	Disordering events (for off-gassing) often times identifiable
Multiple daily dives without a day's rest after sustained days of diving	A knowledge of the physiology of on- and off-gassing helpful in understanding why the undeserved DCS event occurred
Altitude excursions before off-gassing completed	

This presentation presents the science that explains why DCS occurred in six patients because of disordered decompression and identifies factor to account for the undeserved "hits"

Background

During over 60 years of accumulated diving medicine experiences we have helped to manage nearly 500 cases of DCS.

Although we are clinicians, we have much interest in the stress-reactions and pathophysiology events associated with the medical problems of diving

Our observations demonstrated a cohort of DCS patients who did not violate dive computer or safe ascent practices, but got "bent." In all the cases disordering events could be identified

Terminology

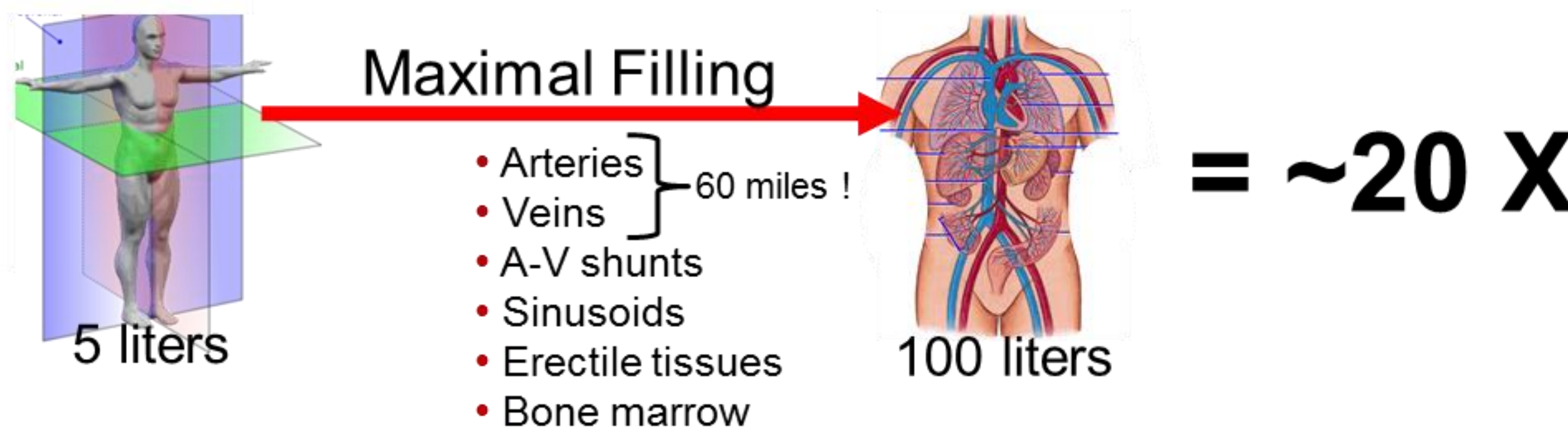
Diving academics have utilized the term "unexplained" when computer or ascent violations do not account for the DCS hit

We feel the terminology of "deserved" and "undeserved" is more appropriate.,

This presentation demonstrates why almost all cases of "unexplained" DCS have identifiable causes. With a careful history, almost all unexplained cases of DCS can be explained by the effects perfusion and gradients have on inert gas on- and off-gassing

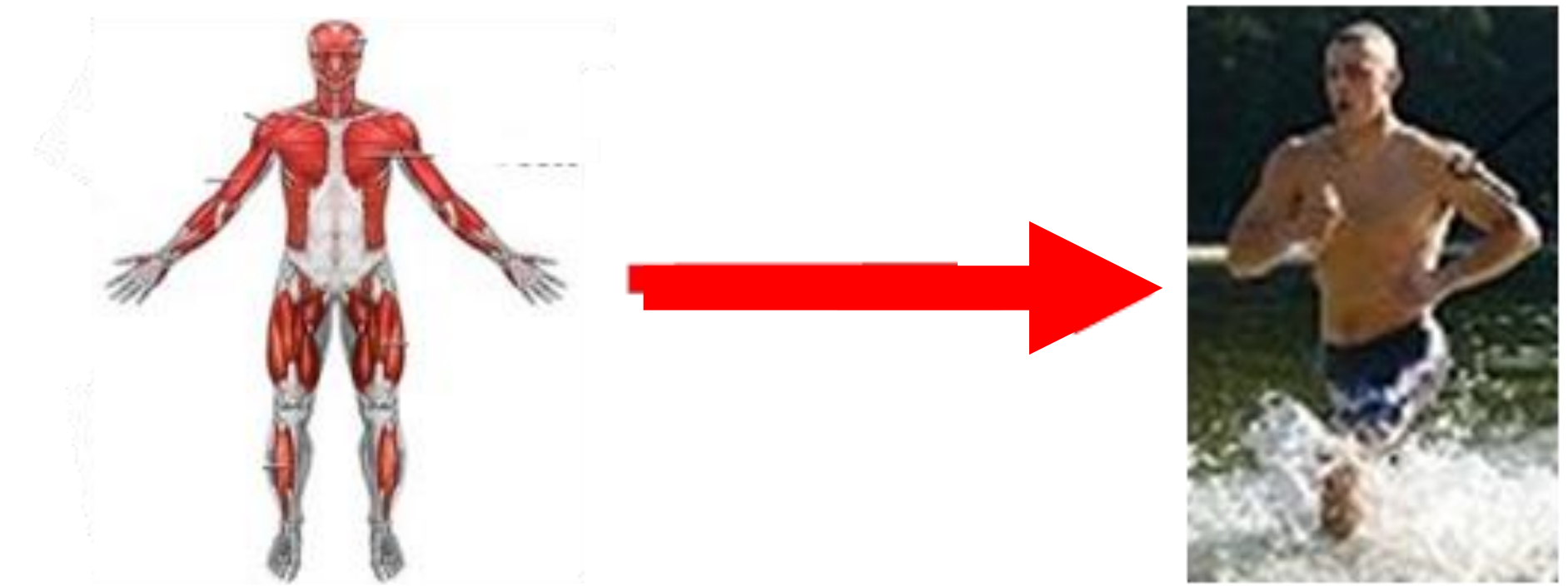
Pathophysiology of Disordered Decompression

There is an enormous difference between the blood volume & the summated capacity of the vascular system; at least 20-fold



Blood flow has to be carefully regulated so that it only goes to critical tissues and tissues that need them for activity (See our Wienke/Strauss poster)

Muscle blood flow



Baseline at rest = 1 Maximal activity = 40X

Don't swim after eating—it makes sense when blood volume & vascular system capacity are considered

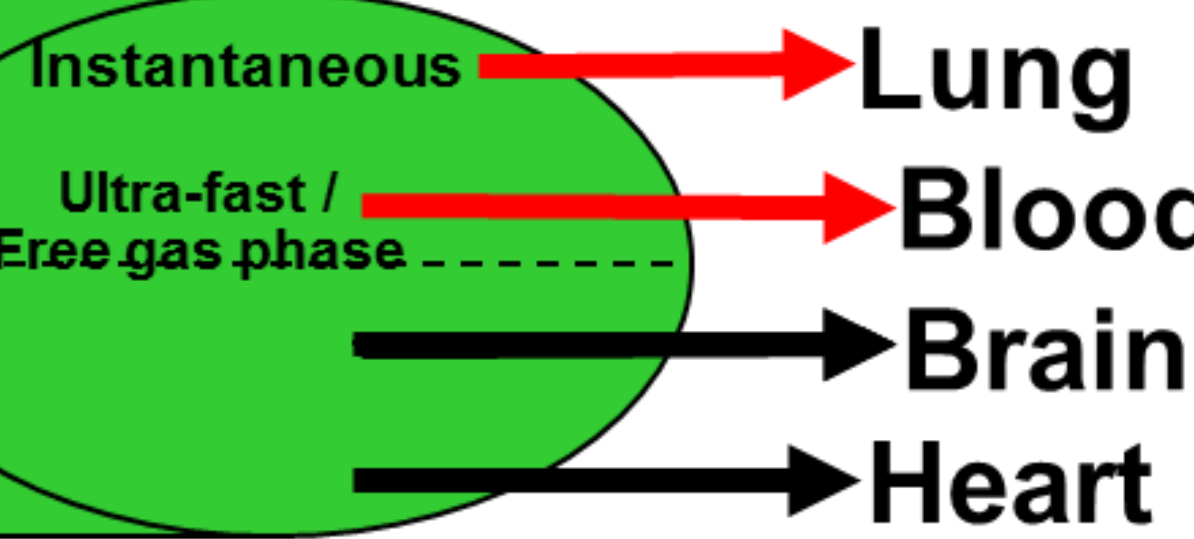
A Mother's Admonition

Critical tissues on-gas and off-gas almost instantaneously

Any interruption ("steal" syndromes) in blood flow to critical tissues can have catastrophic consequences

Fast Tissues

Continuous, optimal perfusion



Alterations in vasoactivity normally mediated by the sympathetic nervous system or obstruction in perfusion to tissues can have devastating consequences for the diver with a gas load in tissues. Such disordering events can lead to over-whelming gradients and be the cause of disordered decompression and undeserved DCS

Case Reports

Explosive Decompression

Two helmeted divers at a 180 depth lost communications with topside. The decision was made to surface the divers as fast as possible and decompress them with surface decompression. Upon reaching the surface the divers were unconscious and unresponsive to resuscitation efforts

Problem: Disordered decompression due to overwhelming gradients (far exceeding the ability of perfusion to off-gas the enormous inert gas load) with massive autochthonous bubbling in the lungs (chokes) and the blood stream from explosive decompression resulted

Traumatic Brain Injury

A commercial diver, previous Navy SEAL, completes a working decompression requiring dive without incident. While working topside, a cable parts, strikes the diver in the head & renders him transiently unconscious. After regaining consciousness, significant cognitive function impairment (4th grade equivalent mentation) plus narcotic requiring head & spine pain led to total permanent disability for the diver

Problem: Disordered decompression from loss of consciousness resulted in loss of sympathetic nervous system vasomotor control (perfusion impairment) and the "steal" syndrome (overwhelming gradients) with bubbling in critical brain and spinal cord tissues.

Transient Unconsciousness Upon Surfacing

An experienced female sports SCUBA diver experienced a severe headache after reaching a 96 foot depth. She aborted the dive and made a controlled ascent, but upon reaching the surface lost consciousness. Diffuse neurological injury including weakness, loss of balance, visual disturbances, speech impairment and difficulty with thought processes only partially improved with recompression treatments and time

Problem: Similar to the TBI scenario above; Presumably the headache and loss of consciousness on surfacing impaired vasomotor control and led to disordered off-gassing from the brain and the diffuse brain neurological injury

Interference with Extremity Off-gassing

A female dive instructor returned to the USA from a Caribbean vacation 48 hours after doing a couple of SCUBA dives to 40 foot depths. The diver fell asleep at altitude with her elbow flexed and her chin resting on her knuckle. Upon awakening she was unable to move her land. After landing a recompression treatment dramatically restored her hand function

Problem: Disordered decompression occurred because of obstruction of venous outflow from the flexed arm coupled with bubble enlargement while at altitude (8000 feet in commercial aircraft). Obviously, there was enough residual gas in her tissues even with the modest dives and 48 interval from flying to cause her DCS problem.

Perfusion Deficits from Dehydration

A relatively inexperienced female diver made a couple of 50 foot dives without incident although she felt thirsty after the dives. Later in the morning she climbs a local mountain, but negates hydrating herself. Diffuse left shoulder pain develops. It later resolves completely with a recompression treatment

Problem: Disordered decompression from dehydration that altered perfusion enough that off-gassing was insufficient to prevent autochthonous bubble formation in the shoulder tissues.

Conclusions

Disordered decompression resulting in overwhelming gradients and/or altered perfusion provides explanations for almost all cases of undeserved DCS

Undeserved rather than unexplainable DCS should be the preferred terminology. The history & confirming exam findings invariably disclose altered gradient/perfusion causes of DCS.