



Traumatic INJURIES & Hyperbaric Oxygen

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Hyperbaric O₂ Therapy

DISCLAIMER

 I have *no financial interests* in *equipment* or *products* mentioned in this talk

 I do *receive royalties* and *honorariums* for *educational activities* including:



2010



2023

- Best Publishing Company, *MasterMinding Wounds* and *Diving Science...Revisited*
- Guest Speaker, National Baromedical Services
- Faculty Grand Rounds Presentations at Memorial Care Long Beach Medical Center

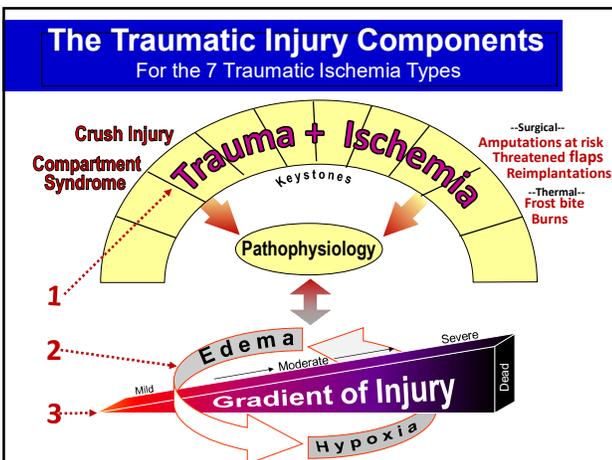
Objectives

By the end of this talk you will

- **Appreciate** the spectrum of the **Traumatic Injuries** with special emphasis on crush injuries & compartment syndromes
- **Become aware of** their unifying **pathophysiology** findings & **severity** classifications
- **Know** why & when **HBO** is indicated for their management

Introduction

- Trauma—a **great challenge** to our health care system \$672 billion spent in 2016 www.NatTrauma.Org
- **Predictable** complication rates ~50% in severe injuries
- HBO is a **logical adjunct** for **severe** traumatic injury care



Tissue Injury & Death

Acute

Damage proportional to **energy exchange** ($F = ma$)

	Fl-lbs	Factor
Fall	50	1
Ski	100	2
GSW	2,000	40
MVA	10,000	2,000

Tissue viability

1st component of the Traumatic Injury Triad

Acceleration (speed)

Speed (MPH)	Deaths (%)	Factor
20	5	
30	45	8x
40	85	17x

US Dept/Transportation; Nat HW Safety Administration

Tissue Death / Amputation

In Traumatic Ischemias



Time to tissue death

4 mins (brain)

- Heart
- Kidneys
- Eyes (retina)
- Viscera
- Bone

to >24 hr (skin & CTs)

Sub-acute Delay

Reperfusion injury

Infection

Hypoxia

↔ Edema

↔ Hypoxia

↳ Impaired function

↳ Non-healing

Late Delayed Amputations

Intractable pain

Uncontrollable deformities

Non-functional extremity

The "Big Bang"

At time of injury

O₂ Needs Greatest



O₂ Availability Lowest

For the

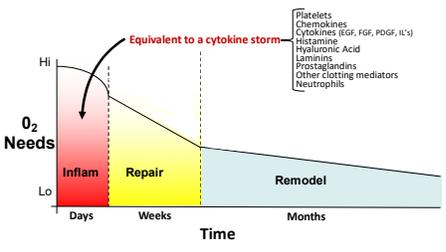
All oxygen dependent

- Inflammatory response
- Managing bioburden

Oxygenation Impediments

- Disruption of microcirculation
- Sludging, stasis
- Edema → compartment syndrome
- Hypotension

Metabolic Activity in Healing

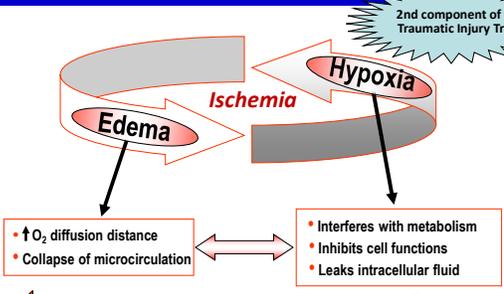


Equivalent to a cytokine storm

- Platelets
- Chemokines
- Cytokines (EGF, FGF, PDGF, IGF)
- Histamine
- Hyaluronic Acid
- Laminins
- Prostaglandins
- Other clotting mediators
- Neutrophils

Sub-acute Tissue Death

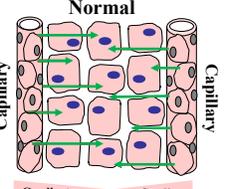
2nd component of the Traumatic Injury Triad



A Self-perpetuating Cycle

O₂ Diffusion & Gradients

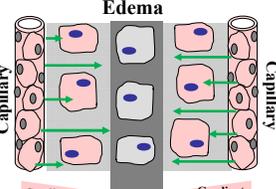
Normal



Capillary Capillary

Gradient Gradient

Edema



Capillary Capillary Capillary

Gradient Gradient

Zone of hypoxia

Edema Fluid = [shaded area]

→ = O₂ Diffusion

Tissue Injury & Infection

Halstead Circa 1890

Simple Incision



0% Infection

Inoculum (Bacteria)

↕

Incision + Crushing Tissues



100% Infection

• Injury to the microcirculation

• Sludging, stasis

• Edema

All components of the Traumatic Injury Triad

Similar effect with epinephrine

Stratford, Plastic Reconstr Surg, 2002

Inflammatory Response

C.F.U.'s to initiate infection after knee trauma in dogs
TK Hunt—UCSF presentation at a 1980's LBMC HBO Conference

Time	CFU → Infection	Factor
At time of inoculation	10,000	1
5-days after Injury	200,000	20

Conclusion Once the **inflammatory response** is established, the better the tissue is **able to handle infection**

Repair Phase of Healing

Cellular Milieu Transitions to Monocytes

Signaling Mechanism

Reenstra, UHM Suppl. 25:51. #157 1998

Fibroblast Doubling Times

Age Group	Air (Hours)	HBO (Hours)
Newborns	~20	~18
Young Adults	~25	~18
Old Adults	~30	~18

$p < 0.05$

Doubling Times (Hours)

Reenstra's Premise: **O₂ a Signaling Mechanism**

HBO & Angiogenesis

Angiogenesis

Sheikh, Arch Surg. 2006; 135:1293

40% increase in vascular endothelial growth factor (VEGF) with HBO

Lin, et al (X-8). J Cell Molecular Med (open access) 2024, 28e70:310

→ Significant increase in angiogenesis w/HBO

→ Upregulated VEGF, HO-1, HIF-1 & Nrf2

→ Mitigated ROS & cell dysfunction

*Extra Cellular Matrix

Gradient of Injury

A tactic for classifying severity

Grading Systems for Acute Traumatic Peripheral Ischemias

3rd component of the Traumatic Injury Triad

Observational	Mild	Moderate	Severe
Crush	Gustilo 1 & 2	Gustilo 3 A	Gustilo 3 B & C
Compartment Syndrome	Precursor	Lag	Established
Burn	1 st Degree	2 nd Degree	3 rd Degree

Superficial Thickness ↔ Superficial Partial Thickness ↔ Deep Partial Thickness ↔ Full Thickness

In General...

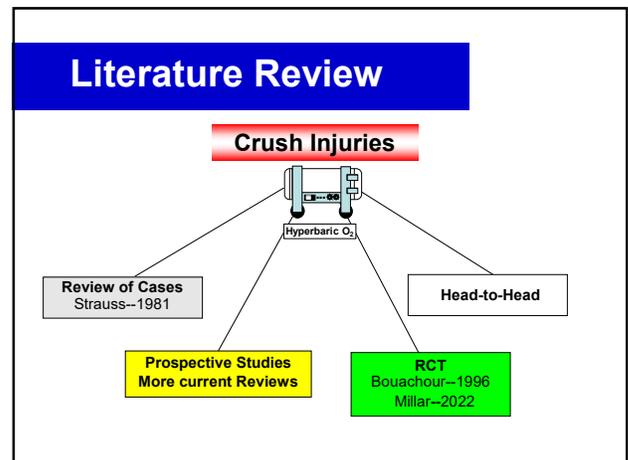
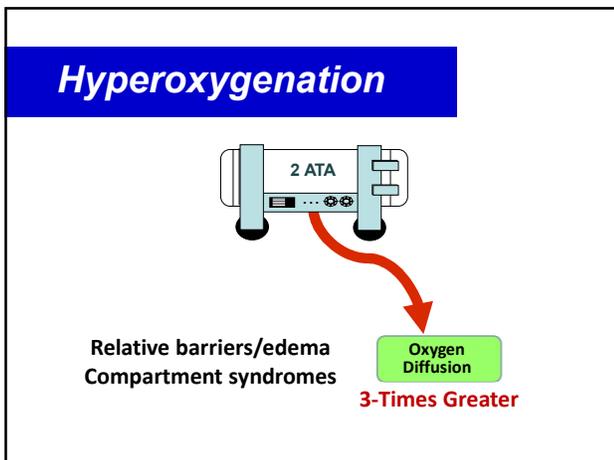
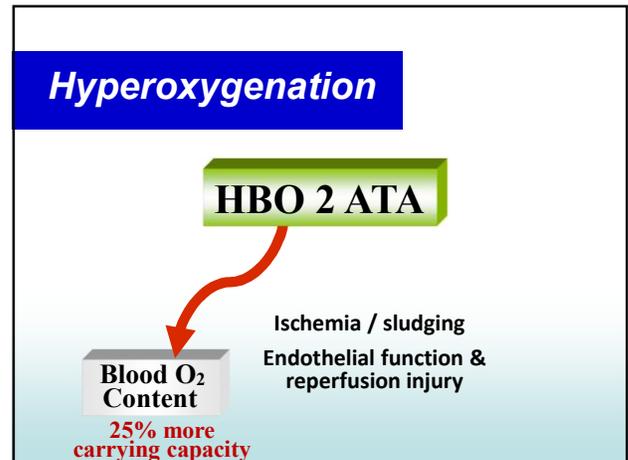
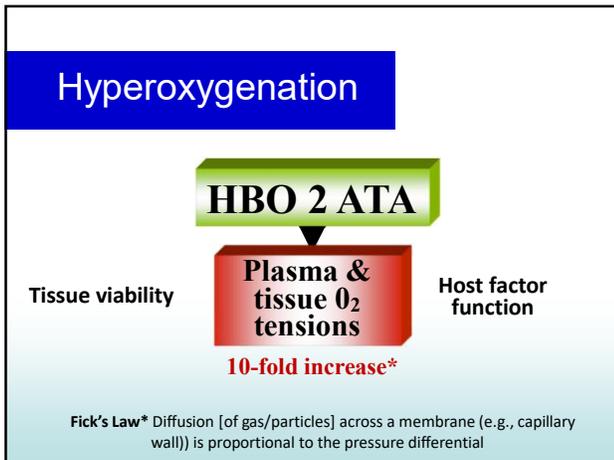
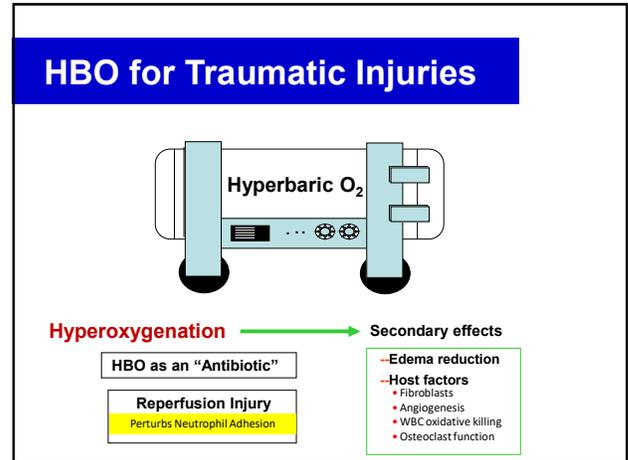
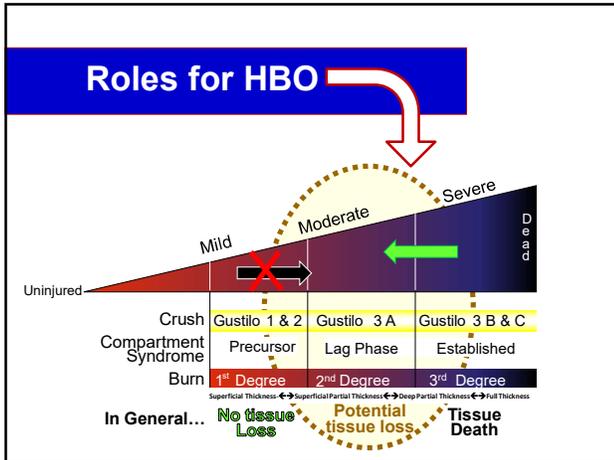
- No tissue Loss
- Potential tissue loss
- Tissue death

Gustilo – 1979 & 1984

Open-fracture, Crush Injury

Grade	Findings	Outcomes
1	Puncture-type wound (inside to out) with fracture	Healing ~ 100% of cases
2	Laceration with fracture	~10% infection or delayed healing
3	"Crush" Injuries	Sub-classifications
A	Sufficient soft tissue to cover bone	Same as for Grade 2
B	Exposed bone remains after debridement	~50% infection, non-union complication rate >50% complication; amputations
C	Concomitant vascular injury	

J Bone JSurg. 1979; 58:453
 J Trauma. 1984; 24:742



Retrospective Review

Strauss **HBO** Reviews, 1981

- Anecdotal & small case series (>700 patients)
- Military applications (600 cases from Soviet Union)
- Patients **“did better”** with HBO

Fewer Complications

Fewer surgeries for equally severe injuries

Edema Reduction

Injuries of similar magnitude would have had bad outcomes

Survival of tissues that would have otherwise sloughed

Strauss--Retrospective

As subjective as the data was, **outcomes improved** as the **frequency of HBO** treatments increased

Author (Citation)	1 st day HBO Rx's	Good Outcomes
Schramek (1977 <i>J. Surg.</i> ; 64:644)	6	100%
Loder (1979, <i>Ann RC Surg.</i> ; 61:472)	3	80%
Slack (1966, <i>Proc 3rd Intl Cong HB Med</i> ; 621)	1	59%

HBO Rx's 1st 24-hours

Some Current Reviews

Ortho • 2005 Garcia-Covarrubias *Am Surg* 71(2):144-151
8 Of 9 (89%) of “qualified” reviews showed **benefits of HBO**

Plas Surg • 2014 Dauwe *Plast Reconst Surg* 133(2):208e-215e
8 studies showed **improved outcomes**-aided wound healing by improving graft survival, ecchymosis resolution and TCOMs

Hand • 2023 Chang *Wound Repair & Regen* doi:1111WRR.13134
72 patients (36 HBO 36 controls) with traumatic hand
Days for wound healing: 29.9 vs. 41 (p 0.03)
Benefits of early treatments (<72 hours)
--**Decreased hospital days**: 8.1 vs 15.5 (p 0.04)
--**Faster healing**: 28.7 vs 41.2 days (p 0.08)
--**Less surgeries**: 1.5 vs. 2.4 (p 0.06)

Most Recent...

- 2024 Kwee *Europ J Trauma & Emerg Surg*, Feb 2024
On-line: 10.1007/s00068-023-02426-2

7-Studies
229 Pts

HBO 138 (60%) Controls 91 (40%)

HBO in management of severe lower limb soft tissue injuries: a review

Considerations	Healing	Necrosis	Add'l Surgeries
HBO/Control Mean %	85/56 (20%)	14.5/43.8 (33%)	24.3/42.3 (28%)
Range (HBO)	62-100	0-29	0-67

Comments / Concerns { 2/7 (29%) RCTs; 5/13 elements (38%) had statistically significant findings
Quality of evidence mentioned, e.g., serious, low, moderate, or unclear
Deficient in pathophysiology / mechanism justifications for HBO

Caudle vs Matos

Gustilo 3-B & 3-C crush injury, fractures

Head-to-Head Contrasts

	Caudle-JBJS 1987 No HBO	Matos UHM-1999 With HBO
Amputation	13/62 (25%)	3/23 (13.8%)
Other unsatisfactory results	25/62 (40.3%)	0/23 (0%)
Complications	62.8%	13.8%

78% better outcomes with HBO

Bouachour--RCT

Gustilo grade 3 open fractures (Blinded, placebo)

Finding	HBO 18 Patients	Control 18 Patients	p	Improvement Factor
P ^o Healing	94% (17)	56% (10)	<0.01	38% better (Kwee 20%)
Add'l Surg's	6% (1)	33% (6)	<0.05	27% less (Kwee 28%)
Heal >40	88% (7/8)	30% (3/10)	<0.05	58% better

About 20% complication rate with HBO vs. 50% in controls

Bouachour—Outcomes

With Hyperbaric Oxygen

Healing >40-years of age* **58% better** than controls

*Chronological age is subordinate to **biological age** with respect to healing

HOLLT Study--2022

Hyperbaric Oxygen for Lower Limb Trauma

Millar, et al x-13., Diving and Hyperbaric Medicine, 2022; 52(3):164-174

Open Fracture (non blinded) RCT

Considerations	HBO	Controls	p-value
Tissue Necrosis <small>Within 12 days</small>	25/58 (29%)	34/59 (53%)	0.01
Late Complications <small>Up to 1-year infection, non union</small>	6/53 (11%)	18/52 (35%)	0.007
Quality of life	Significantly improved (based on 2 different scales) in HBO limb		

About 20% complication rate with HBO vs. 50% in controls

Quantifying Health

Ala Appgar 10-point Newborn Scoring

Wellness Score

Differentiating Biological from Chronological Ages

Factor	2-Points	1-Point	0-Points
ADLs	Full	Some	None
Ambulation	Community	Household <small>Minus 1/2 point if aids required</small>	None
Comorbidities <small>Other than neuro</small>	None Significant	Impaired	Decompensated
Inhibitors <small>Smoking, steroids, immunosuppressors</small>	None	Prior use	Current
Neuro Deficits	None	Mild-to-Moderate	Severe
Scoring	7.5-10 Points	4-7 Points	0-3.5 Points
Interpretation	Healthy	Impaired	Decomp'd

HBO for Crush Injuries

With consideration of Biological Age

	Healthy	Impaired	Decompensated
1	No HBO	No HBO	HBO
2	↓	HBO	↓
3-A	↓	↓	↓
-B	HBO	↓	??Amput
-C	↓	??Amput.	↓

Factor	2-Points	1-Point	0-Points
ADLs	Full	Some	None
Ambulation	Community	Household	None
Comorbidities	None Significant	Impaired	Decompensated
Inhibitors	None	Prior	Current
Neuro Deficits	None	Moderate	Severe
Wellness Score	7.5-10 Points	4-7 Points	0-3.5 Points

Wellness Score in Action

Nathe, K, et al., J Ft & Ankle Surg, 21 JUN 2024 (open access)

Multicenter Study (n = 162) **NO HBO**

Gustilo 2 (41%) & 3-A (39%) open ankle fractures

Literature: 10% complications
Older patients >60 chronological age vs. biological age

Gustilo Open Fx Outcomes	
1	Lowest grade fracture
2	Laceration with fracture
3	Crush fracture
A	Significant soft tissue to center
B	Minor soft tissue injury
C	Extensive soft tissue injury

Complications 34.6%

Superficial Infections
15.4%

Deep Infections
9.9%

Amputations
9.3%

Wellness Score: ADLs, Mobility, Comorbidities, Inhibitors, Neuro deficits

Mortality at 1-year: Age (p=0.021) & Diabetes Mellitus (p=0.005)

HBO for Traumatic Injuries

Treatment Protocols & Peer Review

Condition	HBO Rx's	Peer Review (# of Rx's)	Comments
Crush Injury, Other TI.	TID 1 st 24 Hrs BID 2 Days Daily 5 Days	12	If deterioration noted with step down Rx's, resume previous schedule Similarly, for threatened flaps, failing amputations, etc.

HBO for Traumatic Injuries

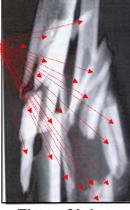
Treatment Protocols & Peer Review

Condition	HBO Rx's	Peer Review (# of Rx's)	Comments
Reperfusion Injury	1 or 2	2	Minimal tissue trauma; replantations, free flaps transient; ischemia, after revascularizations, etc.,
Compartment Syndrome	2 or 3	3	Impending stage fasciotomy not required

Clinical Correlations

Acute use of HBO

- 18 Year old male
- Mangled left leg (drum water extractor while working at a car wash)
- BKA proposed



Highly comminuted (30 fragments)

Time of Injury



Electrical bone stimulator

Incredible Remodeling

Solid Union

18 Months Later

Clinical Correlations

Delayed use of HBO

- 27 Year old male
- Crush/Fracture with septic nonunion after ~20 surgeries
- BKA requested by patient



Non-union site

1 year post injury

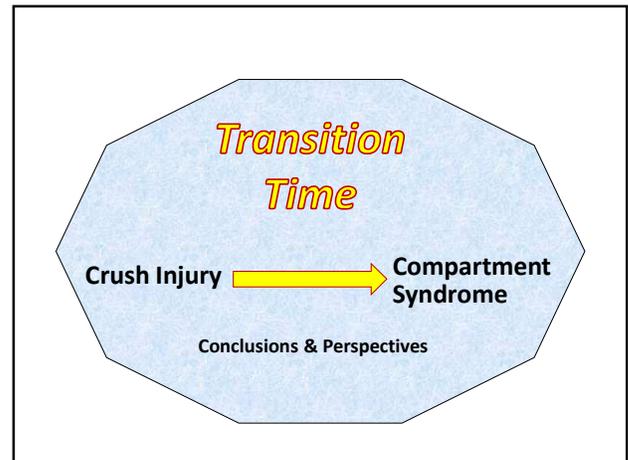


Bony union

Incorporation of bone graft

Pin from external fixator

18 months post-injury
After HBO + Surgery & Antibiotics



Compartment Syndromes

- **Inadequate perfusion** at the micro-circulation level—usually after trauma
- Excellent **justification** for the use of HBO



Muscles: Swell ~ 20% with activity & even more so with injury

Fascia: Encases muscles, **but does not stretch**—a relatively inelastic envelope

Muscle Swelling



Fascia

Muscle Fibers

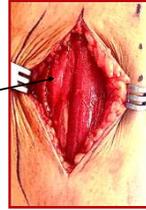
Tissue Fluid Normal Pressure

At Rest

20% Swelling of muscle fibers with activity

More so with trauma & bleeding

With Activity



Post Fasciotomy

Pathophysiology

Swelling causes **pressure to increase** in the compartment

When swelling **exceeds the capillary perfusion pressure**, capillaries collapse

Perfusion to the compartment **ceases**

Perfusion Pressures

Pressure	Site
120 mmHg	Artery
60 mmHg	Arteriole
30 mmHg	Capillary
10 mmHg	Intra-compartmental
8 cm H ₂ O / 5.9 mmHg	Venous

Compartment Syndrome Evolution

Precursor

Progression

Lag Phase

Progression

Established Phase
Surgical Emergency

Precursors

Index of Suspicion

Precursors

- Post-traumatic edema
- Obstruction of venous outflow
- Increased compartment contents (osteotomies, bone grafting)
- Decreased perfusion pressure (shock, arterial blockage)
- Snake bite
- Infiltrations
- Exercise

Management Observation

The 5 P's

- Pain (Magnified with passive stretch)
- Paresthesias
- Paralysis
- Pallor
- Pulselessness

Self-perpetuation

Precursor

Progression

Lag Phase

Edema → Hypoxia → Ischemia → Edema

Lag Phase

Impending / Manifest Stage Transition

Pressures (TORR)

Time (hours)

The Self-perpetuating Cycle

Edema → Hypoxia → Ischemia → Edema

Lag Phase

Wellness Score			
Factor	2-Points	1-Point	0-Points
ADLs	Full	Some	None
Activities	Community	Household	None
Comorbidity	None	Significant	Impaired
Insulin	None	Partial	Current
Neuro Deficit	None	Mild/Moderate	Severe
Scoring	2-10 Points	1-2 Points	0-3 Points

Findings

Progression →

Clinical

- Pain in muscle compartment
- **Worse pain** with passive stretch
- **Swelling / tautness** feeling of the compartment

2 or more

Plus 1 or more

- Hypesthesia
- Impaired or decompensated host
- Encephalopathy, myelopathy or neuropathy
- Hypotension
- Prolonged (greater than 4 hours) ischemia time

+/-

Manometrics

- Increasing pressures with serial repeats and / or
- **≥50 mmHg** in a **Healthy Host**
- **30-40 mmHg** in an **Impaired Host**
- **20-30 mmHg** in a **Decompensated host** and / or **hypotensive patient**

The Surgical Mentality!

No compartment syndrome

Lag Phase

Observe Manometrics

Established Compartment syndrome

Fasciotomy

The Surgical Mentality!

No compartment syndrome

Lag Phase

Observe Manometrics

Is there **anything** in between?

Established Phase

Fasciotomy

Hyperbaric Oxygen

Lag Phase

Progression → Stop

Plasma

Blood

Diffusion

Hyperoxygenation

↓

Vasoconstriction

20% ↓ Flow

Vasoconstriction with HBO

Normal Situation: Capillary In-flow (red arrows) = Capillary Out-flow (blue arrows). Filtration (Perfusion Pressure) and Resorption (Oncotic Pressure) maintain fluid balance. Lymphatics remove excess fluid.

Trauma / Injury: Capillary In-flow (red arrows) increases. Filtration (Perfusion Pressure) increases significantly, leading to **Fluid accumulation; i.e. edema**.

Hyperbaric O₂: Capillary In-flow (red arrows) is reduced. Filtration (Perfusion Pressure) is reduced, leading to **Fluid reduction**.

Canine Model

Hargins / Mubarak—San Diego

Impending

 Hyperbaric O₂

THE MODEL

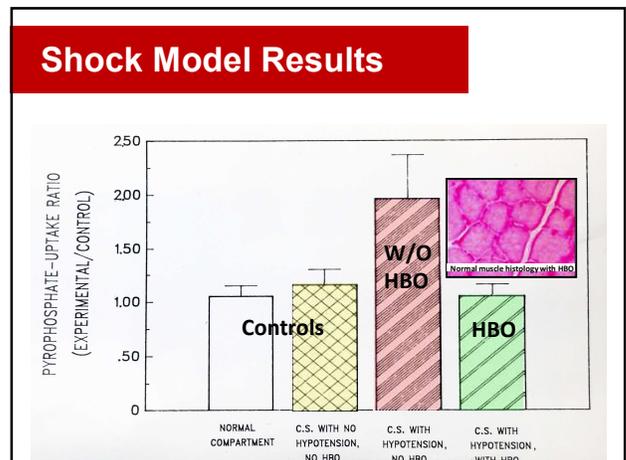
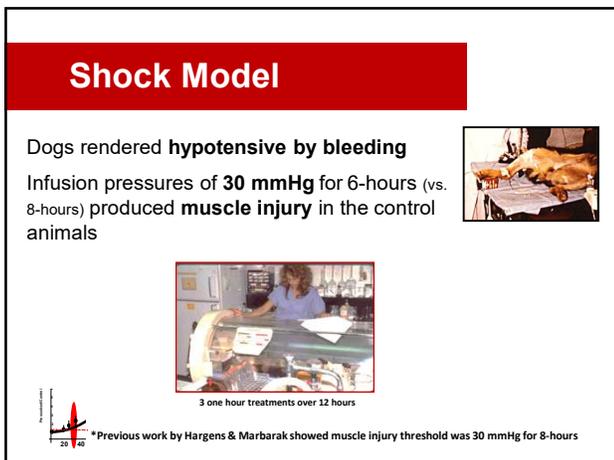
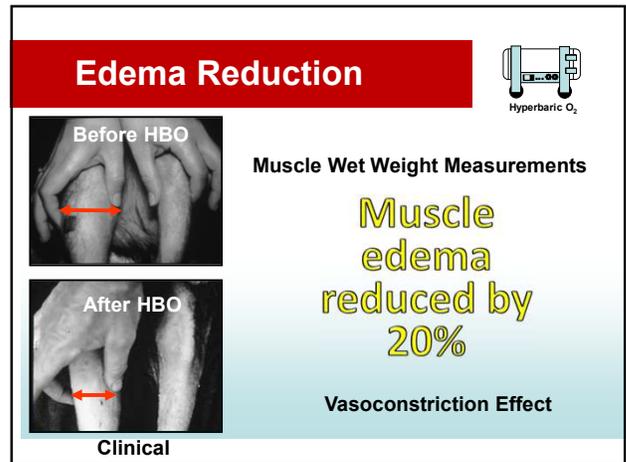
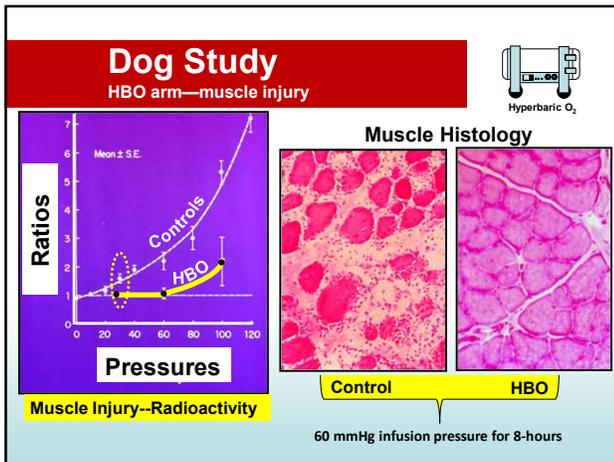
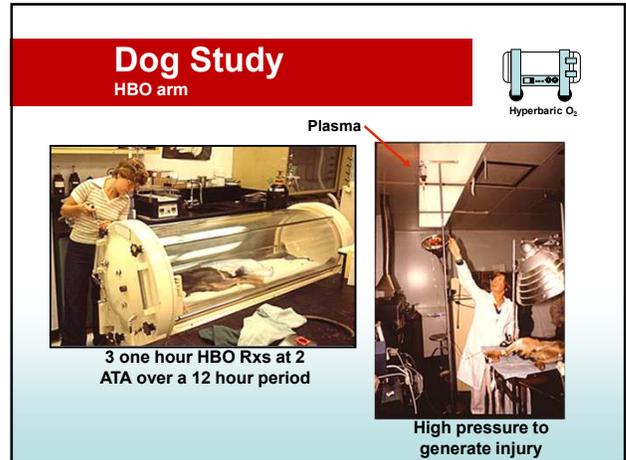
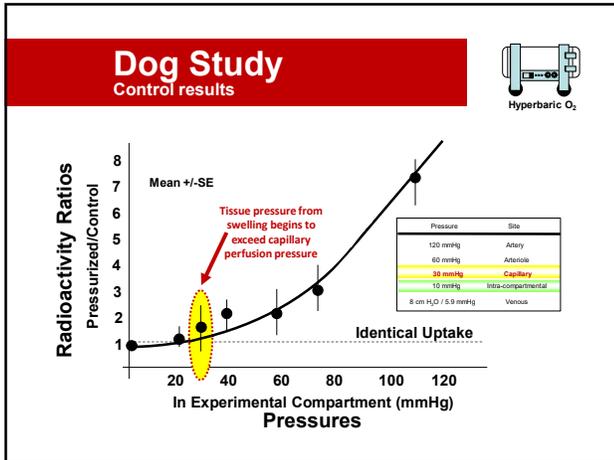
INJURY	NONE	MILD	SEVERE
HISTOLOGY			
CALCIUM RELEASE	Minimal Ca ²⁺	Moderate Ca ²⁺ Ca ²⁺	Marked Ca ²⁺ Ca ²⁺ Ca ²⁺ Ca ²⁺ Ca ²⁺ Ca ²⁺
TECHNIUM UPTAKE	Small 	Intermediate 	Large

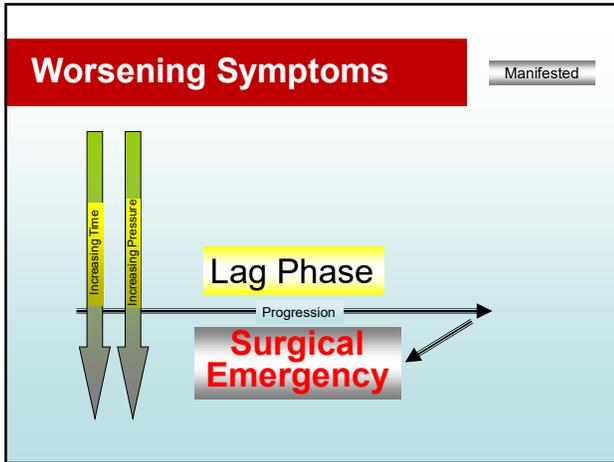
The Model

8 Hour Infusions

Documenting Injury

4 Days Later





Pressure Dilemmas

Criteria for fasciotomy

Established Stage

Author (year)	Pressure for Fasciotomy
Whiteside(1975)	Less than 10-30 mmHg of diastolic blood pressure (DBP)
Matsen (1976)	40 mmHg
Mubarak (1978)	30 mmHg
Matsen (1980)	45 mmHg
Heckman (1993)	< 10-20 mmHg of DBP
Mateva (1994)	< 20 mmHg of DBP
McQueen (1996)	< 30 mmHg of DBP

Absolute Delta 40%

Surgical Emergency

Findings

Wellness Score			
Factor	2-Points	1-Point	0-Points
ADLs	Full	Some	None
Ambulation	Community	Household	None
Comorbidity	None Significant	Impaired	Decompensated
Inhibitors	None	Past	Current
Home Details	None	Mild/Moderate	Severe
Scoring	2-10 Points	4-7 Points	0-3 Points

Progression

Clinical

- **Extreme** pain
- **Severe** pain with passive stretch
- **Marked** swelling / tautness of the compartment
- Compartment muscle **paralysis**

Plus 1 or more

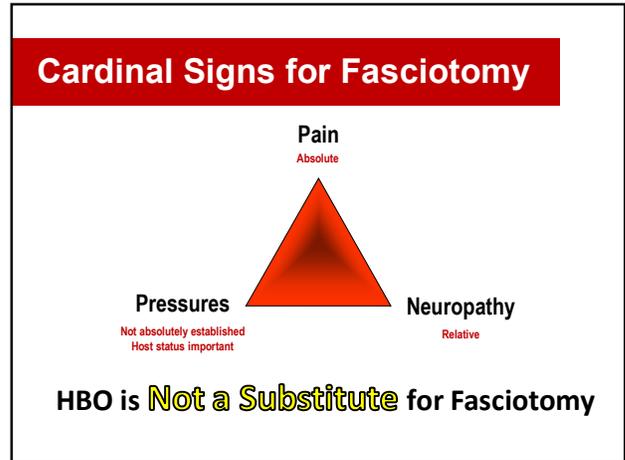
- Anesthesia
- Impaired or decompensated host
- Encephalopathy, myelopathy or neuropathy
- Hypotension
- Prolonged (greater than 4 hours) ischemia time

Manometrics

- >50 mmHg in a **Healthy** Host
- >30 mmHg in an **Impaired** Host
- >20 mmHg in a **Decompensated/Hypotensive** Host

1 or more

+/-



HBO after Fasciotomy

One or more of the following

- **Ischemic** muscle
- **Demarcation** between viable & non-viable tissue is indistinct
- Major **swelling**
- Prolonged **ischemia time**
- **Threatened** skin flap or graft
- Residual **neuropathy**
- Markedly **impaired** and / or **decompensated** patient

Acute Compartment Syndrome

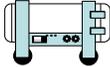
Edema Hypoxia

- 17-Y/O **heathy** male
- Water skiing injury to left calf
- **24 hour "lag"** period
- HBO while awaiting OR availability

Pressure Measurements

Maxims about Compartment Syndromes

- HBO is **not a substitute** for fasciotomy in the **when urgent surgery required**, but may be considered while awaiting OR being available
- No other interventions except for HBO mitigate rising compartment pressures** before a fasciotomy is required (i.e., during the lag phase)



Post-fasciotomy Residuals



Manifested
Post Fasciotomy



Immediate Post-op



After 10 days of HBO

- 5 year old male
- Sliver in elbow
- Clostridia in wound
- Compartment syndrome



Delayed Closure

SMCS-HBO Literature



7 "strong" studies

>50 "reports" ≠ Oriani

Laboratory Studies

- Strauss, Hargens, et al., Canine studies...very conclusive, *J Bone Joint Surg*, 1983, 1986, *J Ortho Res* 1986
- Nylander, et al., Edema reduction, muscle preservation, *Plast Reconstr Surg*, 1985, Ibid, 1988, *Scandi J Plast Recon Surg*, 1989
- Bartlett, et al., Rabbit model...neuro recovery, *UHM*, 1998

Clinical Reports

- Strauss, Hart, Clinical series in lag phase with no subsequent fasciotomies, *Contemp Orthop*, 1989
- Oriani, several hundred clinical experiences without elaboration, *Handbk Hyperb Med* (Springer), 1996
- Fitzpatrick, et al., adjunctive treatment, case rept., *Mil Med*, 1998
- Kosugi, et al., 49 SMCS cases, 45 in lag phase before fasciotomy; good results when HBO used as soon as clinically diagnosed, *UHM*, 2014

Some
Concluding
Remarks

RBI (Rational based indications) for HBO



Hyperbaric O₂

Another 10-Point Scoring System!!!

Criteria	Strong Evidence (2 Pts)	Information is consistent with the assessment (1Pt)	No information, no benefit or possible harm (0 Pts)
Clinical experiences		1 1	
Mechanisms/Lab	2 2		
Literature / outcomes		1 1	
No other Rx's available	2	1 1/2	
RCT's; Head-to-head studies	2		0

Crush Injury = 7 ½ Points

Compartment Syndrome = 6 points

5 Points meets HBO criteria for a RBI

My New Perspectives



The **bone problem** is invariably **subordinate to the soft tissue injury**

Orthopaedic techniques & hardware is so advanced that rarely does bone management lead to less than adequate alignment & stability

The **seriousness of the soft tissue injury** is the **crucial consideration**

SURGICAL JUDGEMENT !!!

- ✦ ~ 30% better out comes with HBO
- ✦ Biological vs. chronical age factors into decision making

Comments & Frustrations

Strauss & HBO

Traumatic Injuries



- Great potential
- Good evidence
- Major Logistic Challenges

Traumatologists

Que sera' sera'

Nothing in between

Egos, reluctance & lack of knowledge

HBO can nearly half the 50% complication rates

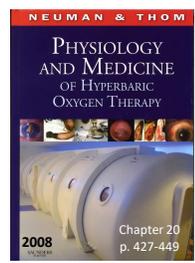
The *mechanisms* of HBO *mitigate the pathophysiology* of the traumatic Injuries

Additional Resources



2025

"Preaching" to the Choir



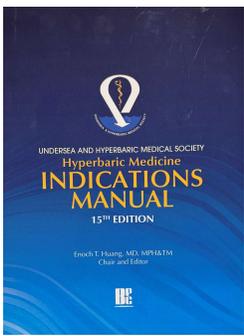
2008

Chapter 20
p. 427-449

For the "Skeptics"

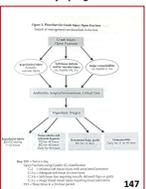
Crush Injury Chapters
Similar subjects; different perspectives

HBO Committee Report



Part I. Chapter 6
Pages 137 -154

Crush Injury Algorithm



147

Compartment Syndrome Algorithm



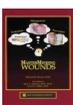
148

For those who like algorithms...

Thank You

For inquires and/or suggestions

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Inquiries: USA Phone 562 933-6960



Wound Care



Hyperbaric Medicine Program



Dive Medicine

Questions



Hyperbaric O₂

What situations justify using HBO for traumatic injuries?

What are the similarities and differences between crush injuries and the other traumatic injuries?

Why is HBO not more utilized for traumatic injuries?

Additional Questions

- T F 1. Information from the following 7-supplement slides has been SPECIFICALLY DISCUSSED in today's presentation (Slide -79)
- T F 2. Oxygen availability for cell functions IS ONLY NEEDED for the inflammatory phase of wound healing (S-80)
- T F 3. Bouachour showed that tissue oxygen tensions DID NOT INFLUENCE healing rates of crush injury-fractures (S-81)
- T F 4. It is not possible for an exertional compartment syndrome to coincide with a "full-blown" skeletal muscle-compartment syndrome (S's-82 & 83)
- T F 5. Almost ALL ORTHOPAEDIC SURGICAL DECISIONS are based on randomized control trials (S-84)
- T F 6. RATIONAL BASED DECISIONS for using HBO in traumatic injuries is based entirely on experimental evidence (S-85)
- T F 7. The use of Medicare DRGs (Diagnostic Related Groups) HAS BEEN A BOON for using inpatient HBO services (S-86)

ANSWERS

The following slides explain why each of the seven TRUE, FALSE questions answers are "False"

However, each warrants discussion and could be the subject for entire talks or papers (as in slides 82 & 83) on the topics



A little Additional...

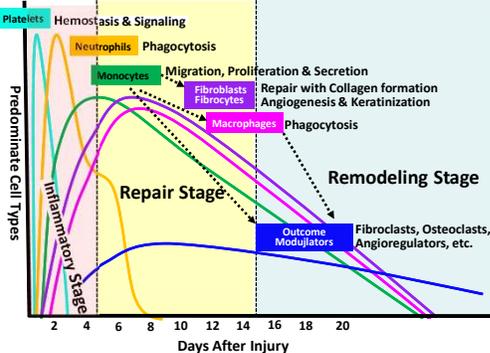
A large amount of information has already been presented.

The following 7 slides supplement information presented in today's talks

They have been used in previous Traumatic Injury presentations

The Message

Specific cell types predominate for each stage of healing
Oxygen is essential for the function of each cell type



Bouachour TCOM Indexes

Ratios of Injured vs. Uninjured Legs

Healed Legs
(vs Non-healed)

>0.9 (p = 0.05)

HBO Legs
(vs Controls)

>0.9 (p = 0.05)

Deductions: The **adequately oxygenated** fracture is the one that heals
HBO is an adjunct to oxygenating the fracture site

Neurological Residual & HBO

- 13-year-old ballet dancer & gymnast
- **Severe leg pain** plus **unilateral "drop foot"** (i.e. peroneal nerve palsy) after a strenuous combination of above activities.
- Pain resolved, but seen in ED 2-days later with on-going foot drop. **Pressures normal**; patient told she **did not have** a compartment syndrome
- **2nd opinion** delayed HBO consultation obtained.
- Foot drop resolved with a single HBO treatment

...A Case report paper in press

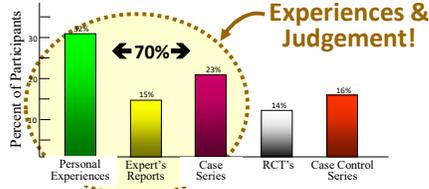
After Thoughts...



- **Combination Problem**
 - Exertional compartment syndrome pain resolved spontaneously
 - **Acute compartment syndrome (ACS)** residual with peroneal nerve palsy...i.e. drop foot
- **Serendipity**
 - If the ACS had been recognized initially, a fasciotomy would likely have been done
 - The single HBO treatment **resolved** residual neuro problem
- **Later-on...**
 - Bilateral leg fasciotomies done
 - Patient able to resume activities without recurrent ECSs

Making Decisions

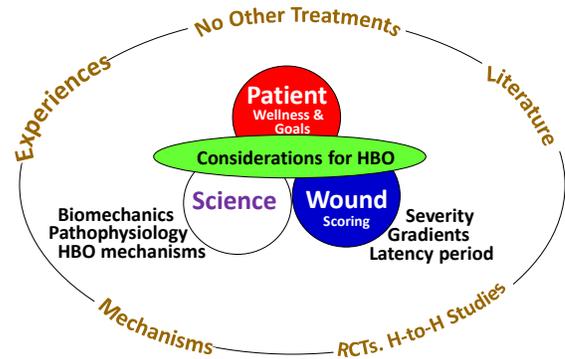
Evidence Used for Clinical Decision Making* (American Orthopaedic Association)



What is the primary type of evidence you use in your clinical decision-making?

*Schemitsch, EH, M Bhandari, MD McKee, et al., Orthopaedic surgeons: artists or scientists?, *J Bone Joint Surg*, 2009; 91:1264-73

Rational Based Decisions



Frustrations!

1977: ~30 HBO units in the USA; all treating wounds, emergencies & medical problems of diving

Reimbursements: Fee for service; cognitive & support

Today: Estimated 1500 HBO units in the USA; **but only +/- 70 (~5%!!!)** are treating emergencies & medical problems of diving

Reimbursements: Out-patient facilities only
DRGs (Diagnostic Related Groups) limit **IN PATIENT** payments for HBO