Hyperbaric Medicine
The Depths of Healing

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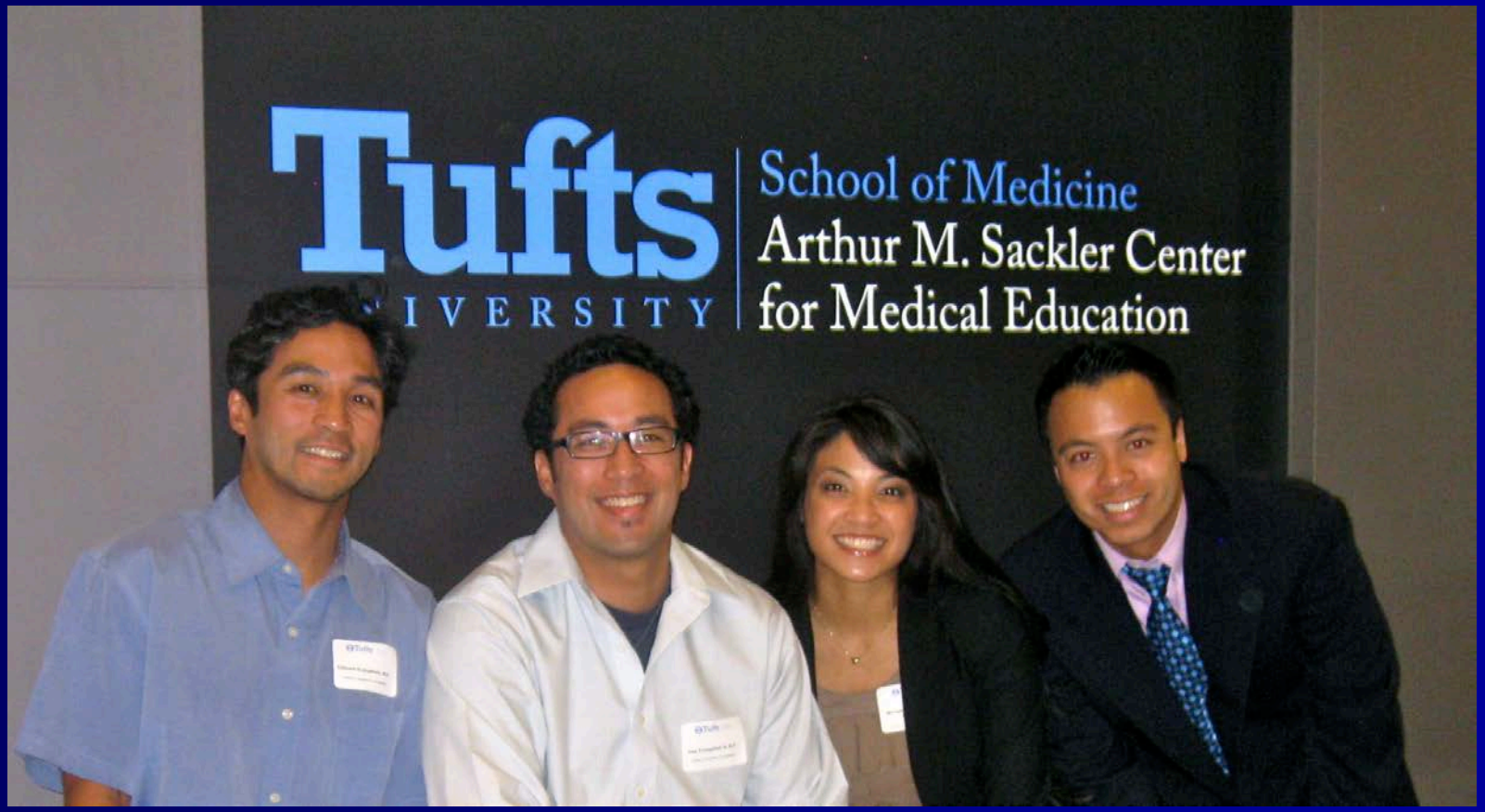
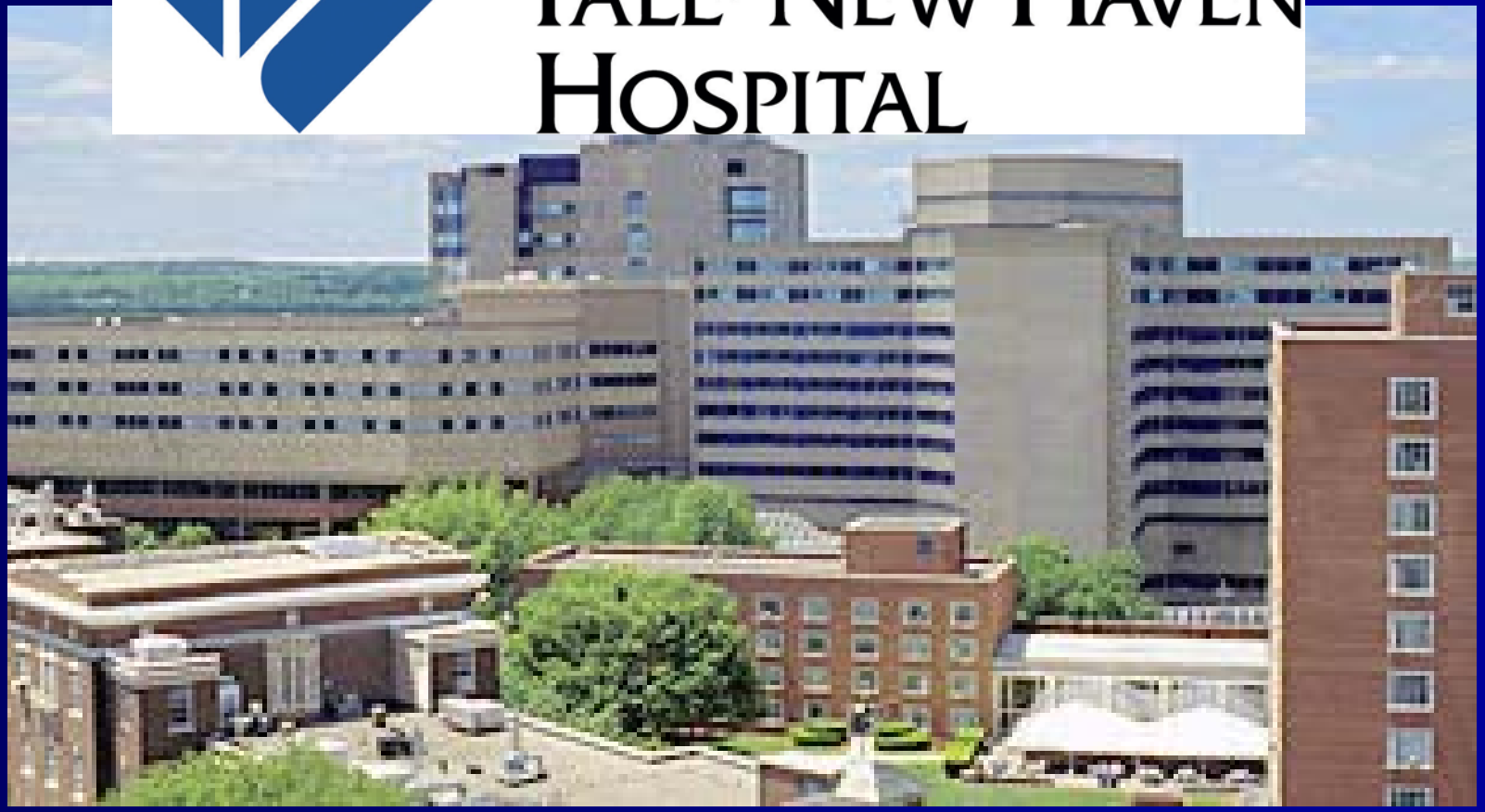
Pulmonary Critical Care Medicine
Director of Undersea and Hyperbaric Medicine

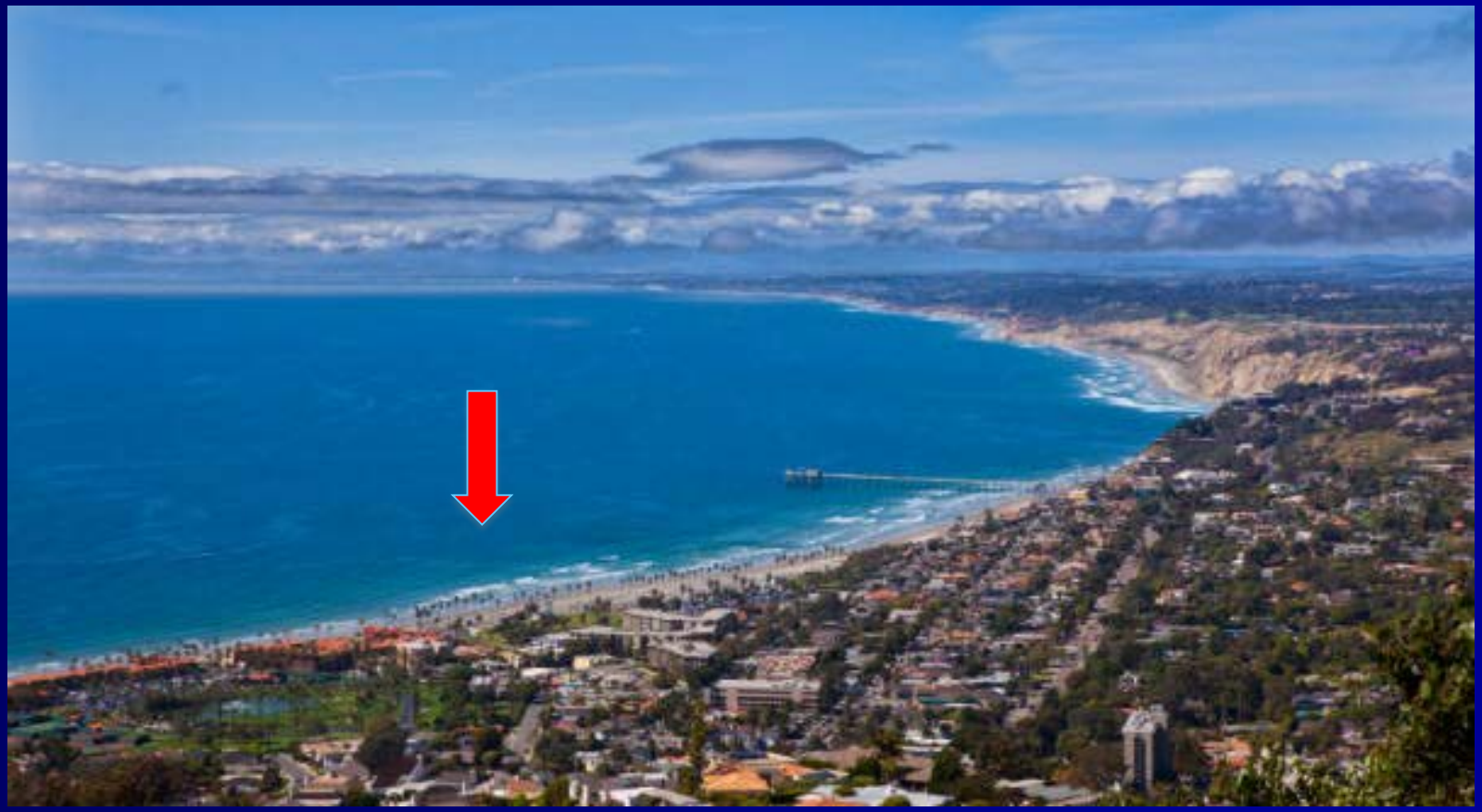
Outline

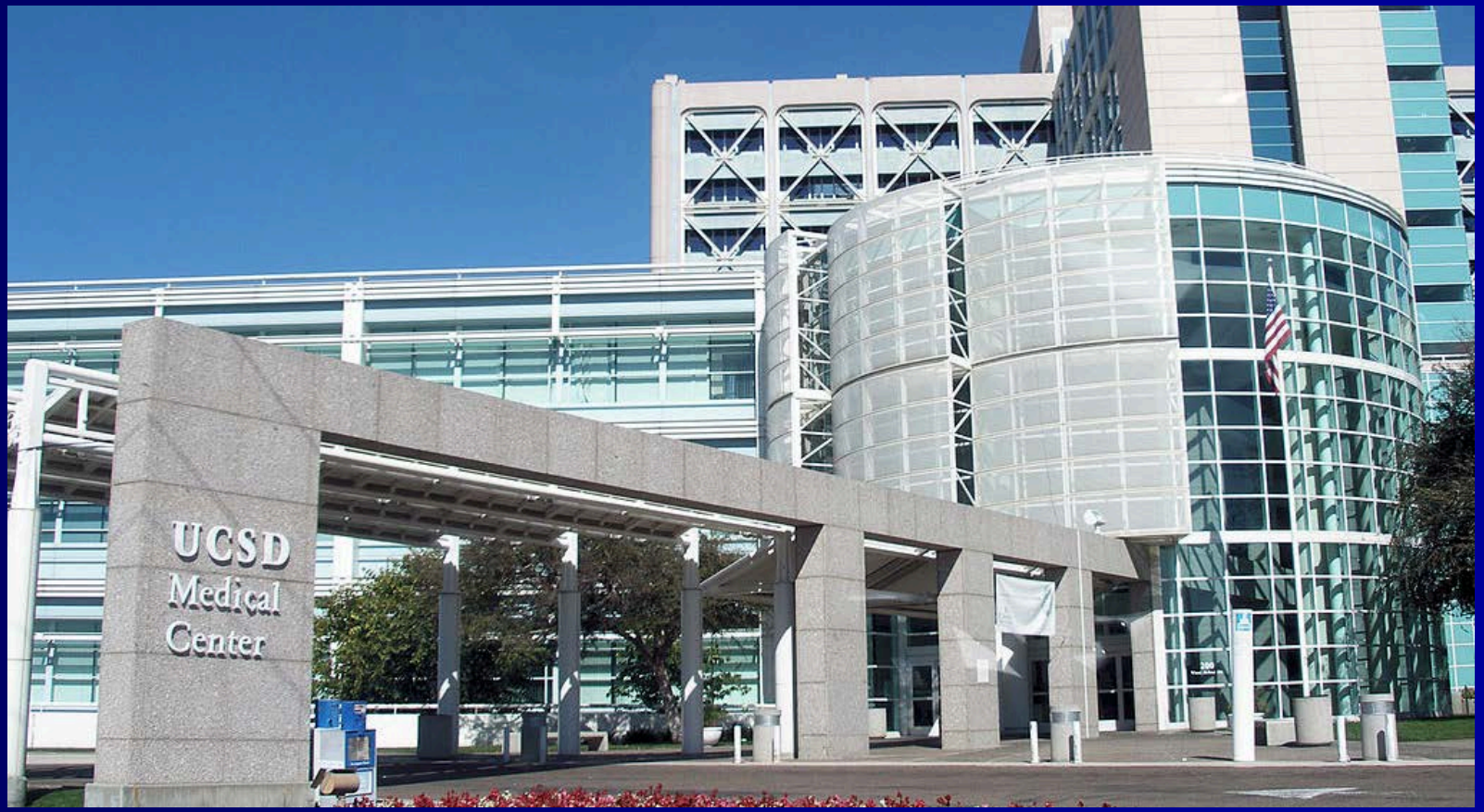
- History of Hyperbaric Medicine
- Pathophysiology
- Indications
- Contraindications
- Side Effects
- Current State of Affairs in HBO

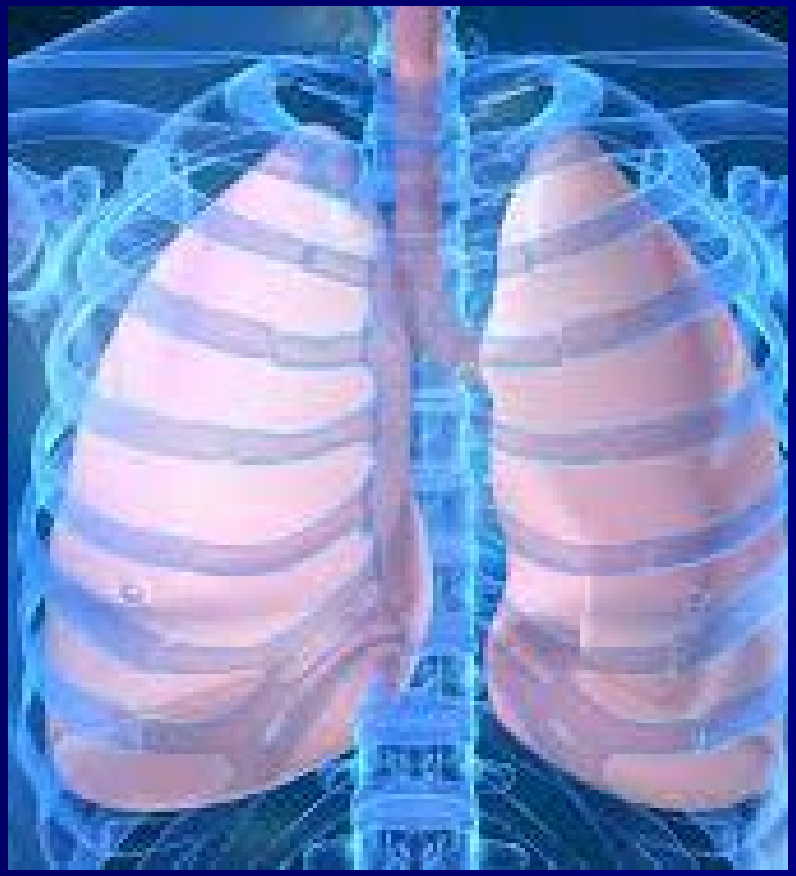

Tufts
IVERSITY
School of Medicine
Arthur M. Sackler Center
for Medical Education

Yale-New Haven Hospital






UCSD
Medical
Center



Call from the Emergency Dept…

- “56 y/o female diver presents in cardiopulmonary arrest while diving ‘the Yukon’ off the coast of San Diego and after >1 hour of CPR, we got a pulse back… We may need to dive her…”


Pacific Beach
Yukon
Mission Beach
NOSC Tower
Ruby "E"
El Ray
Waterhorse Charters
Ocean Beach


263

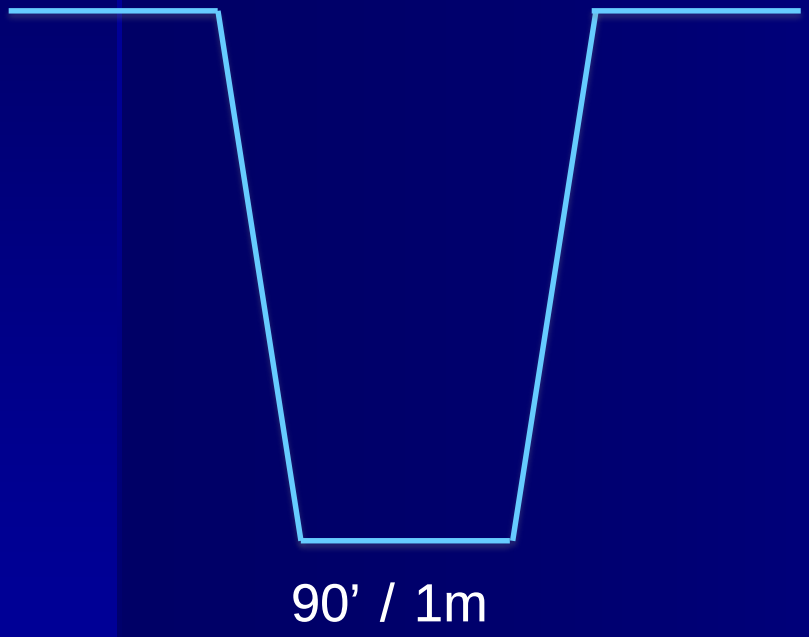

HMCS YUKON
Date
Depth
Time
(BACK)

Some More History…

- 56 y/o female diver
- PMHx: “adrenal fatigue”, obesity
- Allergies: NKDA
- Meds: None
- Dive History: Prior open water certification; 18 dives in her lifetime mostly in warm water, prepping for her advanced certification

Dive Profile

- Yukon Wreck Dive



Air tanks, Dive lasted total of 15 minutes, 1 minute of bottom time at 85’-90’, after which patient proceeds to surface ascending hand over hand on line, attempted to be held by divemaster to slow her ascent, spits out her regulator at 15’ with vomit and shoots for the surface…

“I can’t breathe” → LOC, Cardiopulmonary Arrest

Differential Diagnosis?

Pre-Hospital Care

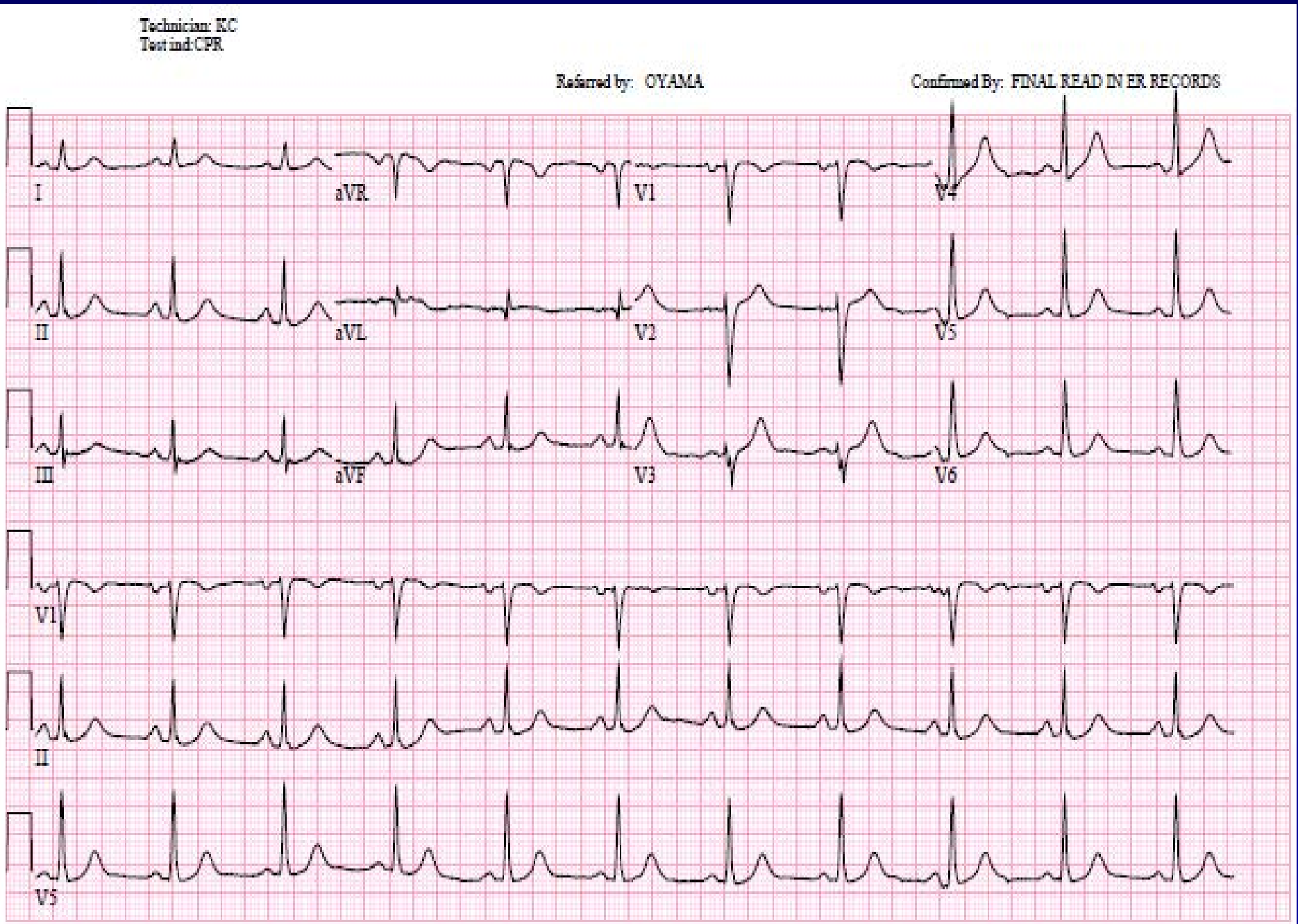
- Bystander CPR delayed, started on reaching Humboldt (dive boat) and O2 administered via NRBM
- Lifeguards alerted to boat in distress and dispatched to dive boat location
- Patient transferred to lifeguard boat, patient found to be in V-fib arrest, defibrillated twice, PEA noted, BLS CPR continued

Prehospital Care Continued…

- EMS arrives at shore with ALS ambulance to meet lifeguards
- IV started, patient receives epi x 3 en route to hospital
- CPR continued and PEA continues on monitor
- Intubation attempted by medics in the field unsuccessful, BVM ventilation continued until emergency department…
- Total transport time from water to ED is 45 minutes

ED Course

- Patient intubated on first attempt successfully
- ACLS meds of Epinephrine, Vasopressin, NaHCO3 administered
- ROSC with sinus rhythm
- Dopamine and Norepinephrine started to maintain BP
- Vitals: BP 91/68, P 79, R 16T, O2Sat 100%, Temp 96.9


Technician: KC
Test ind:CPR
Referred by: OYAMA
Confirmed By: FINAL READ IN ER RECORDS
I
aVR
V1
V4
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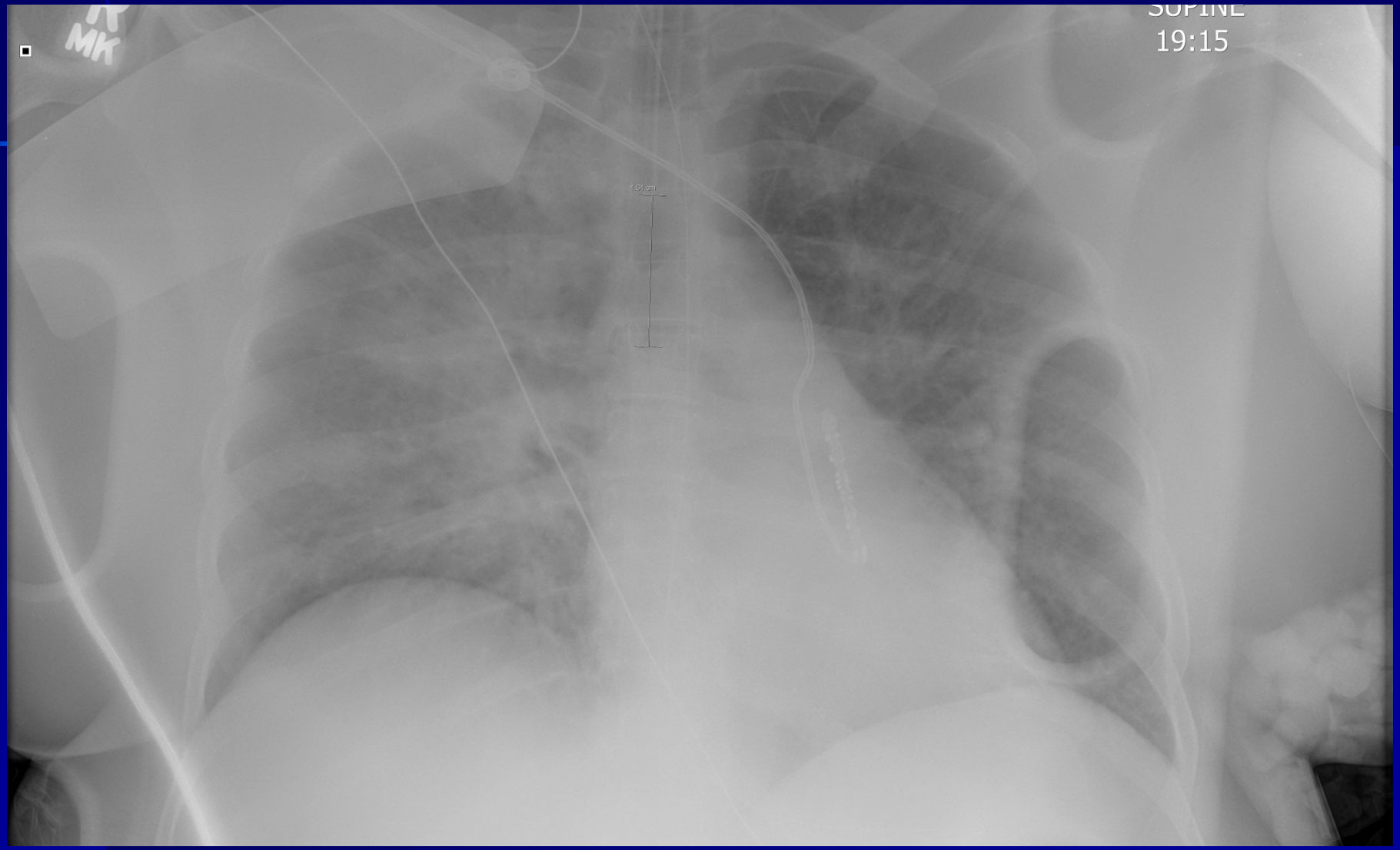
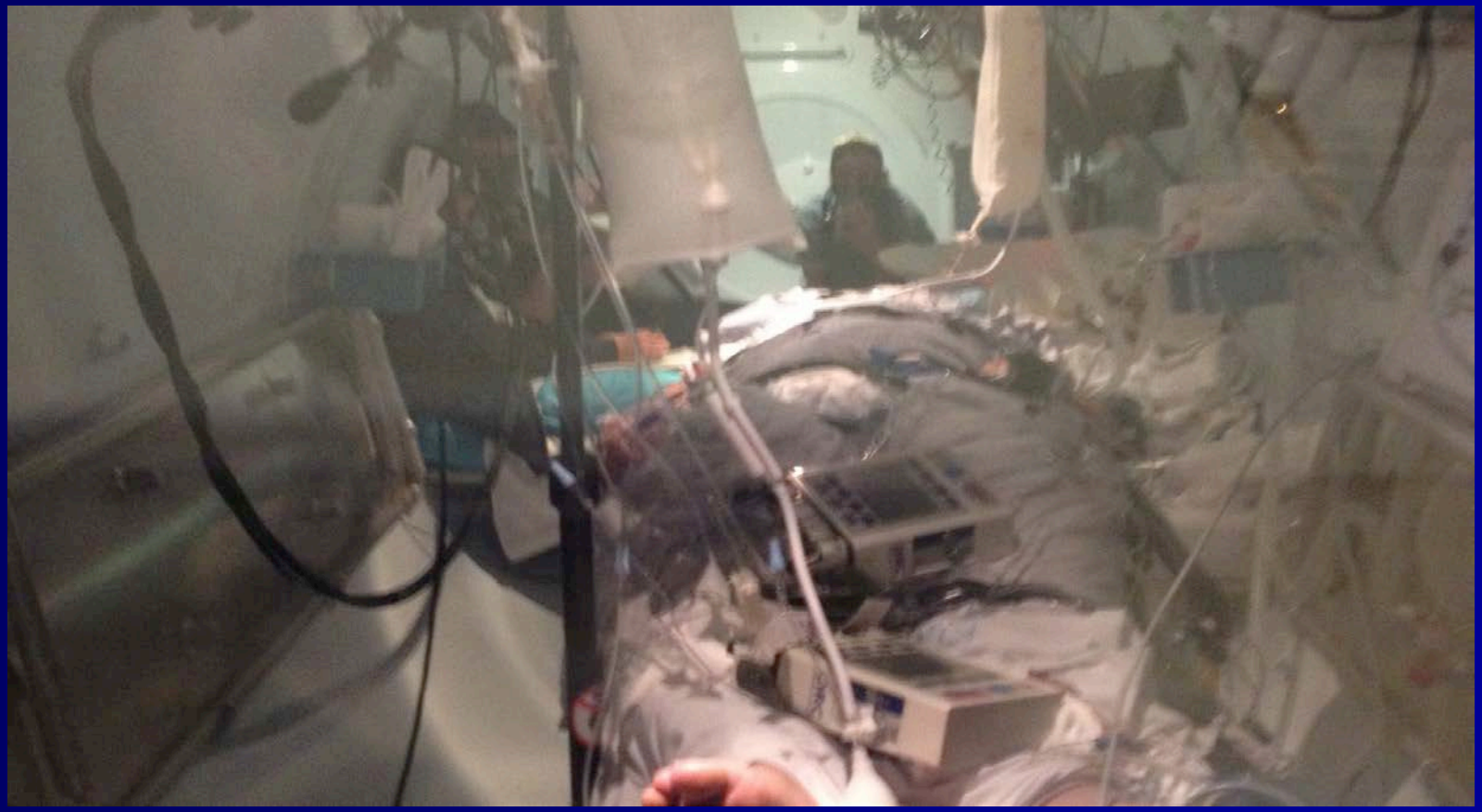
aVL
V2
V5
III
aVF
V3
V6
V1
II
V5


SUPINE
19:15

Critical Actions…

- How would you manage this patient?
- Would you dive such a patient?
- If diving, how many staff will you need for the dive/critical care?
- Any Other Concerns?



Hospital Course

- Patient completes TT6 therapy
- Transferred to ICU where patient is maintained on pressors, started on CRRT
- Multiple pressors added to regimen
- Albumin and IVF to maintain BP
- Patient never stable enough for transport to CT scanner for CT Head

Hospital Course Cont'd…

- Patient maintained in critical condition in ICU on multiple pressors
- Neurologically comatose, dilated pupils, no gag reflex, off all sedation
- EEG reveals no brain activity
- HD#3 patient is extubated and patient made Comfort care
- Patient expires the same day at 7:36am.

And the Autopsy Shows…

- Normal coronary arteries
- No bullous / emphysematous changes of the lungs
- No significant pathology seen on autopsy

Summary Points

- Patient likely suffered from IPE at depth and had an AGE near the surface
- Risk vs benefit?
- Should we have dove her at all?
- Would you have done anything differently?

Duke Research - IPE

Katherine Calder-Becker.
“Kat”

Kat Re-tells her story of IPE

- In my case, the first occurrence of SIPE was at the Mooseman ½ Iron race in June 2007. I began experiencing shortness of breath at 750m into the swim. I felt tightness in my chest – almost like an asthma attack, or that my wetsuit was too tight. Then, fluid began to build in my lungs and I developed a slight 'cough'. I ended up doing the 'backstroke' for the last 750m of the swim in order to get to shore. At that point, tried to keep racing and pushed through the complete bike leg, then had to stop at the beginning of the run as I was completely unable to get oxygen and was wheezing. That was 4 hours and 17 minutes into the event. I ended up in an ambulance on oxygen, and was released on site once my breathing improved....

Immersion Pulmonary Edema

- 1st reported in SCUBA divers in 1984
- Also seen in Long Dist Military swimmers, Breath Hold Divers, Tri-athl
- Incidence is low - up to 1.8%
- Risks incl
  - HTN, Fish oil supplements, Wet suit use, Long distance swims, cold h2o, prev hx of IPE, increasing age, Women

IPE cont

- Sx incl DOE, Hemoptysis, Frothy sputum, Cough, fatigue, chest tightness, hypoxemia. No CP
- Onset Rapid (Less than 10-30+min), exac by exertion, resolves rapidly

- Treatment
  - remove from water, normobaric oxygen, bed rest
  - diuretics, continuous positive airway pressure (CPAP), inhaled beta 2 agonists
- Return to diving?
  - some flexibility for single incident
  - less favorable for repeated insult

EFFECTS OF IMMERSION

- Intrathoracic blood volume ↑ 0.7 L
  - Arborelius et al. (1972)
- Forced vital capacity (FVC) ↓ ~9%
  - Liner and Andersson (2008)
- Forced expiratory volume in first second (FEV_1) ↓ ~12%
  - Liner and Andersson (2008)
- Residual volume (RV) ↓ ~40%
- Total lung capacity (TLC) / RV increases ~40%

IPE - Pathophysiology

- Inc C.O. and inc PAP / PCWP
  - If PAP/PCW high enough→ Cap leak / CHF
  - Immersion – Inc Hydrostatic pressure
    - redistributes blood
    - 700cc inc in intra-thoracic vol
      - Inc PAP 12mmhg
    - Cold redistributes blood centrally
      - Inc preload
    - Tight wet suit – inc hydrostatic pressure

Search this site Search

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Clinical Trials

Screening Tests for Susceptibility to Immersion Pulmonary Edema

Subjects are needed for a U.S. Navy-funded research study at Duke University Medical Center's Center for Hyperbaric Medicine and Environmental Physiology.

Volunteers are needed for a research study of the effect of exercise while immersed to the neck in water on cardiac (heart) function.

Related Content

Health Articles

Understanding Clinical Trials: A participants' guide

Compensation

Subjects will be paid $25 for the pre-screen and $150 for completion of the entire study.

For more information, contact Mike Natoli at 919-668-0017 or michael.natoli@duke.edu.

Good Reference

Concise Definitive Review — Section Editor, Jonathan E. Sevransky, MD, MHS

Hyperbaric oxygen in the critically ill

Lindell K. Weaver, MD, FACP, FCCP, FCCM

Definition of HBO:

The inhalation of 100% oxygen while at increased atmospheric pressure

1 ATA = 14.7 PSI = 760mmHg = 33 fsw

Air = 21% o2 → 100% w supplemental o2

This is Hyperbaric Oxygen

This is Hyperbaric Oxygen

Even this is Hyperbaric Oxygen

This is NOT Hyperbaric Oxygen Therapy!!

What we are battling…

RIP

YOUR LUCKY LOTTERY HOROSCOPE FOR FALL

Numbers that will make you a fortune

NATIONAL Examiner
AMERICA'S FAVORITE FAMILY WEEKLY

PAULA UILTS UICE

Bride to be runs away with new love

HOCKING CRET IN Z'S PAST

AMAZING NEW OXYGEN CURE

- Unclogs arteries
- Ends allergies
- Beats migraine

DI FRAMED IN SEX SCANDAL

How gals use ESP to make guys look dumb

Non-approved uses

- Brain injury
  - Cerebral palsy
  - Stroke
  - Chronic brain injury
- Chronic fatigue
- Multiple sclerosis
- Anti-aging

HISTORY OF HBO

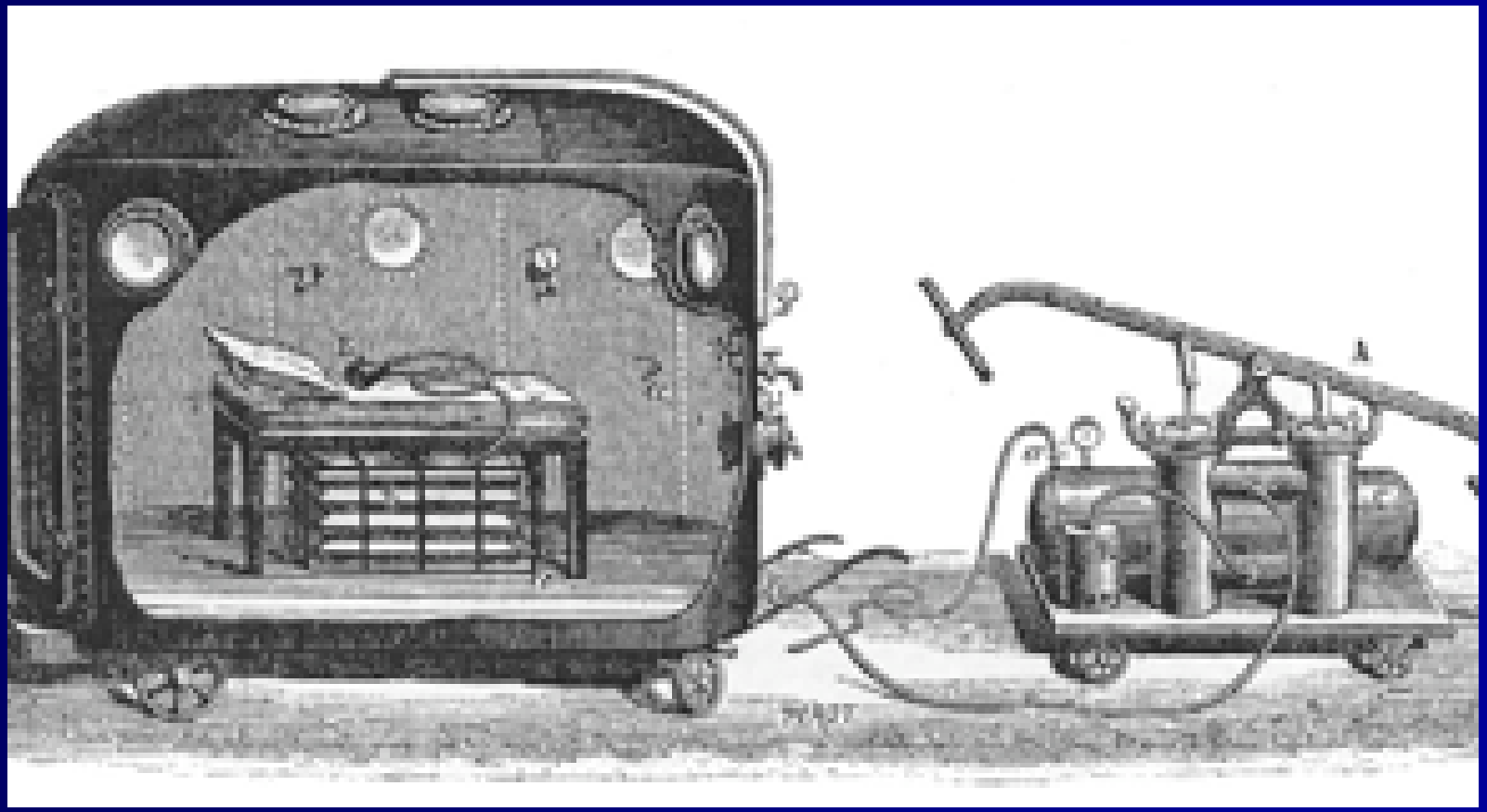
- 1662 – British clergyman / MD (Henshaw) built the “Domicilium”.
- Chamber pressurized with bellows.
- Oxygen has not been discovered yet.
- Seemed like a good idea. Attempted to treat broad array of ailments.

Kindwall, 1999

“Domicilium”

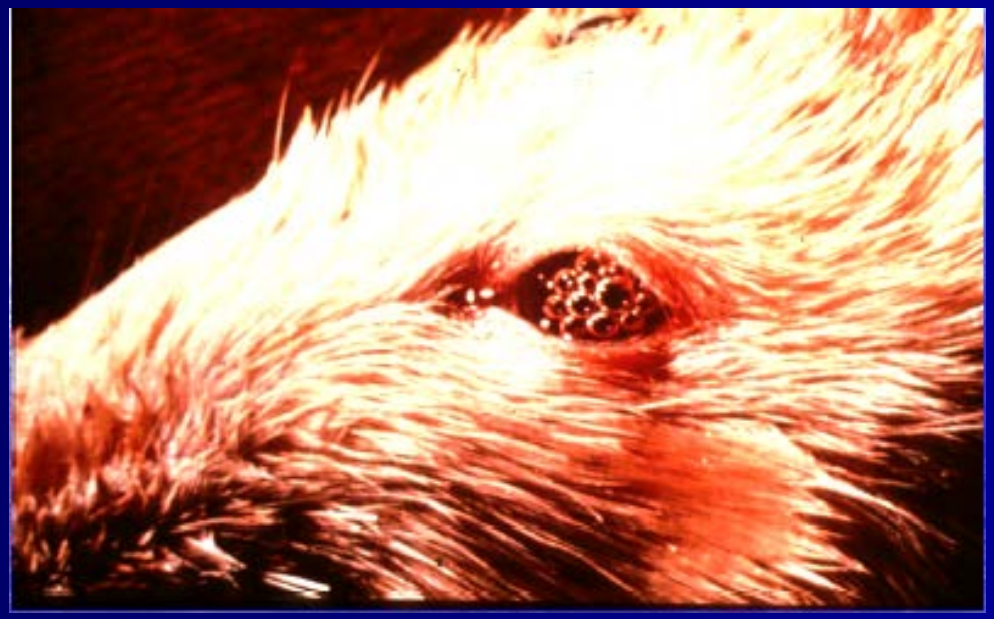
- *“In times of good health this domicilium is proposed as a good expedient to help digestion, to promote insensible respiration, to facilitate breathing and expectoration, and consequently, of excellent use for prevention of most affections of the lungs”*

Domicilium

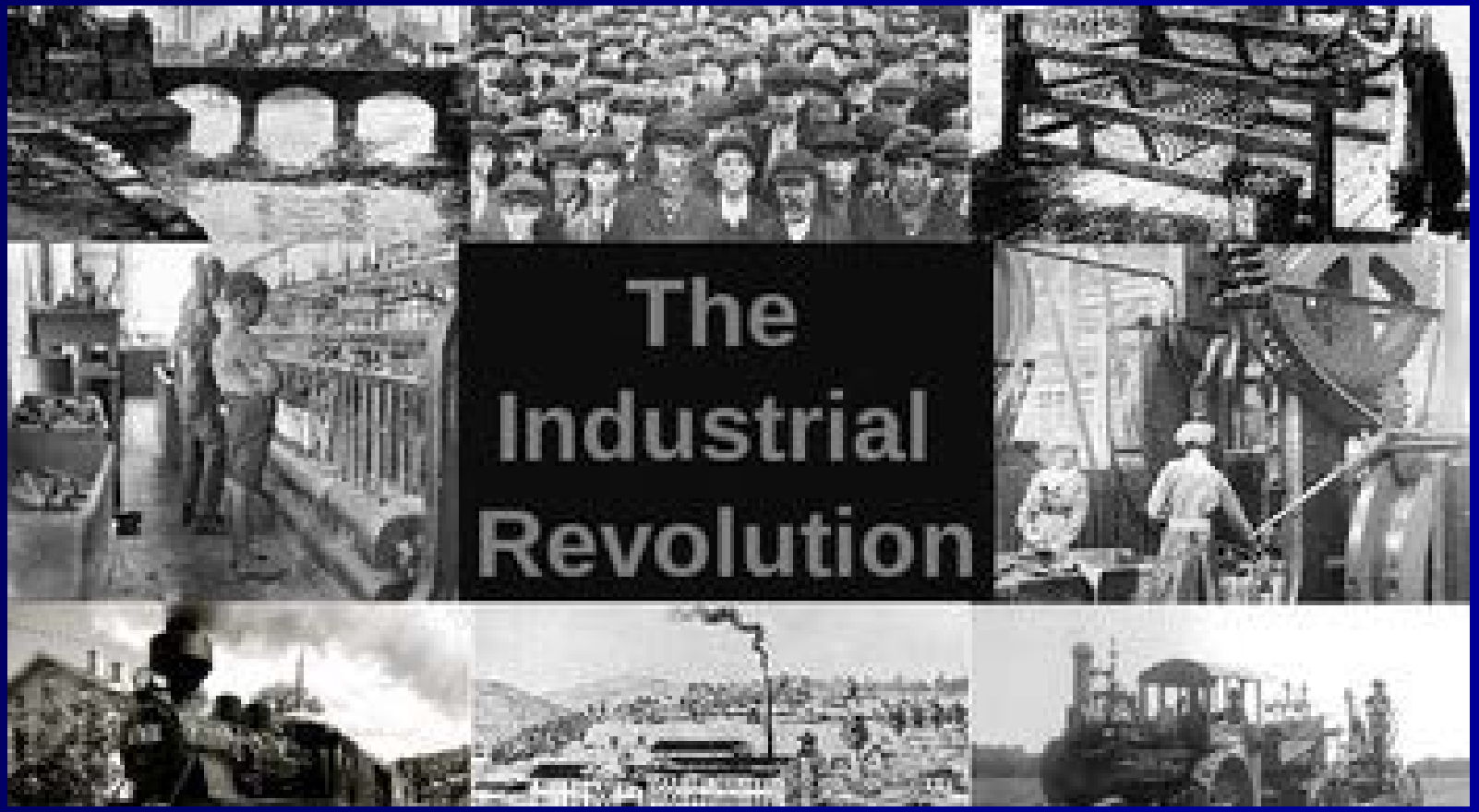


History of HBOT

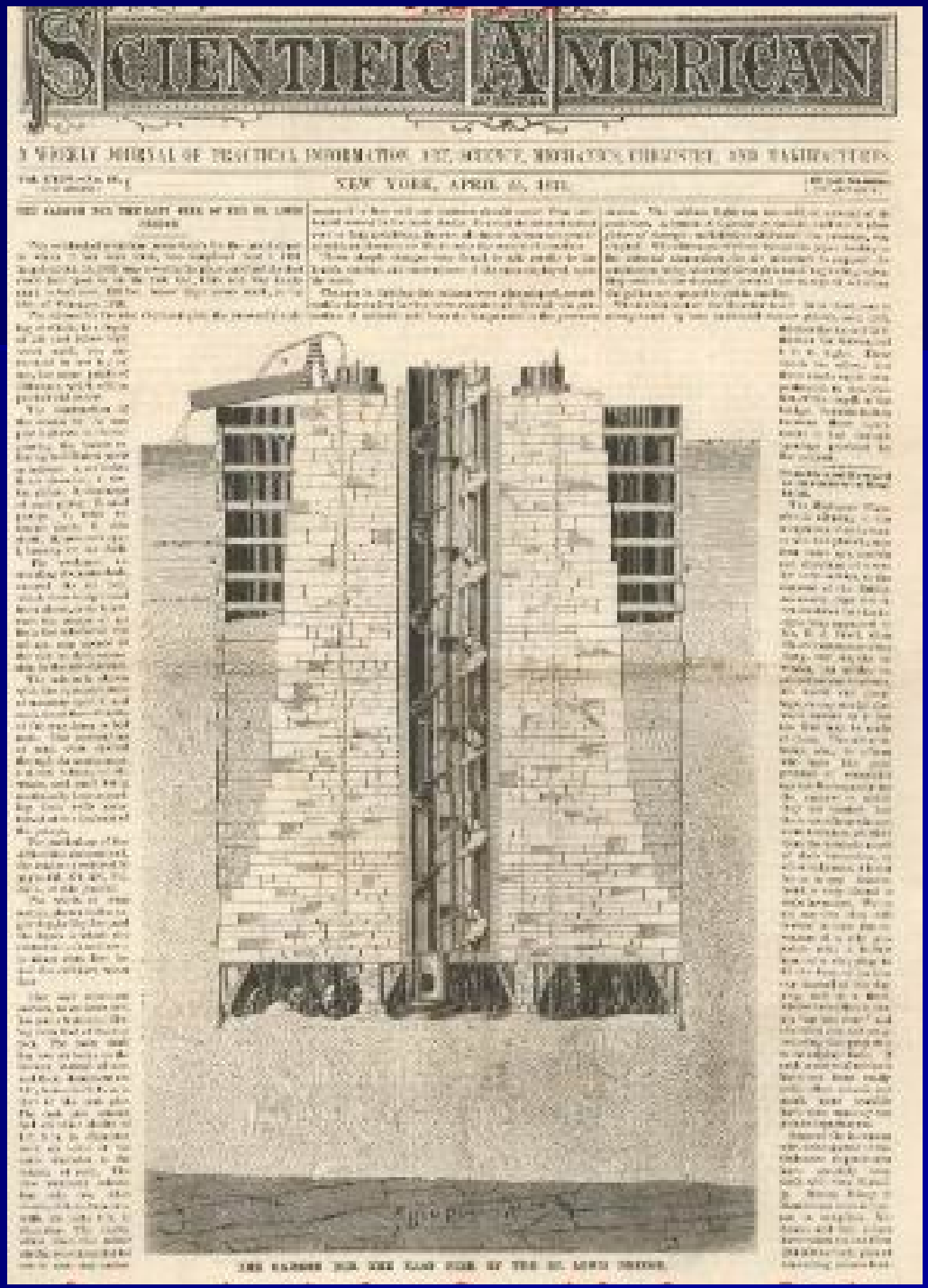
- 1670 Boyle
  - Produces bubbles in the vitreous humor of a snake
- "I once observed a viper furiously tortured in our exhausted receiver... that had manifestly a conspicuous bubble moving to and fro in the waterish humour of one of its eyes."



1800s

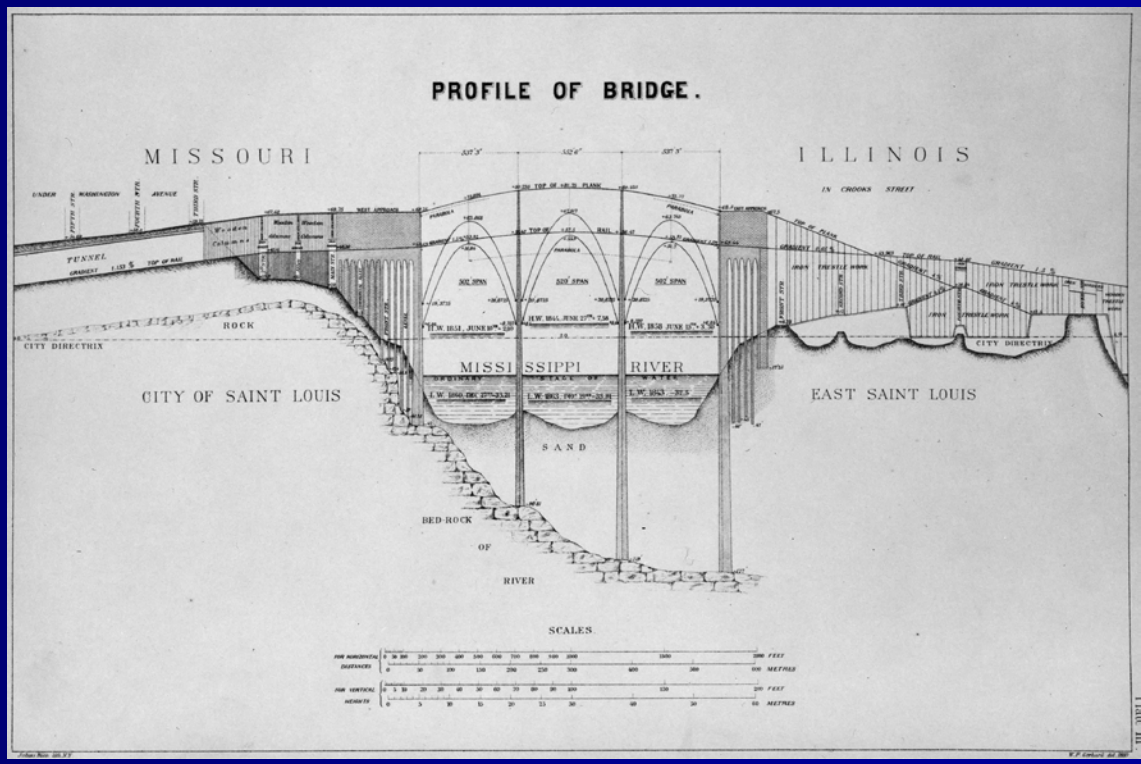


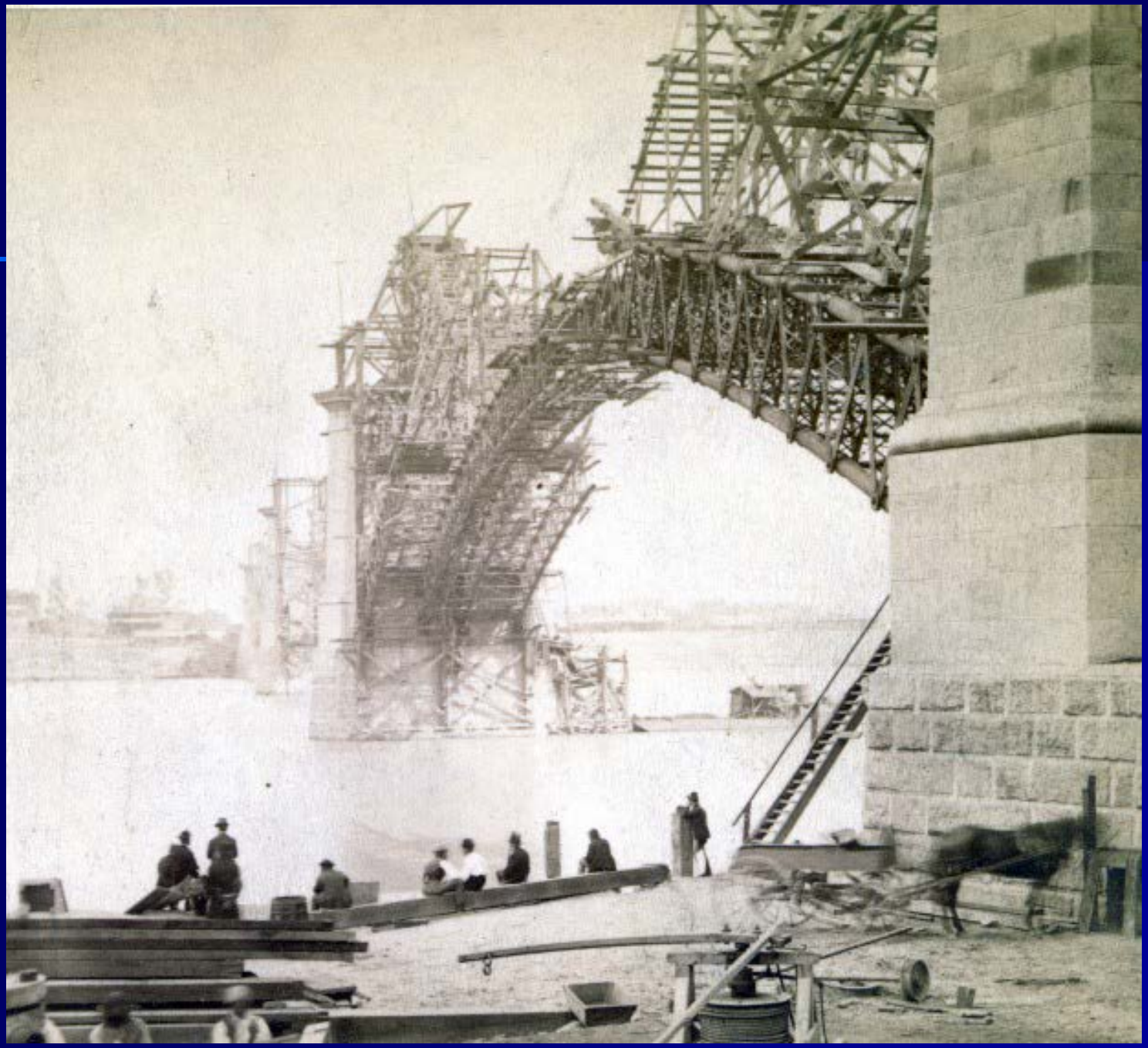
- Triger desinged the “Caison” – box in French
- Steel rings 5 ft in diameter
- Shaft sealed w an air lock
- compressed air to expel the water


SCIENTIFIC AMERICAN

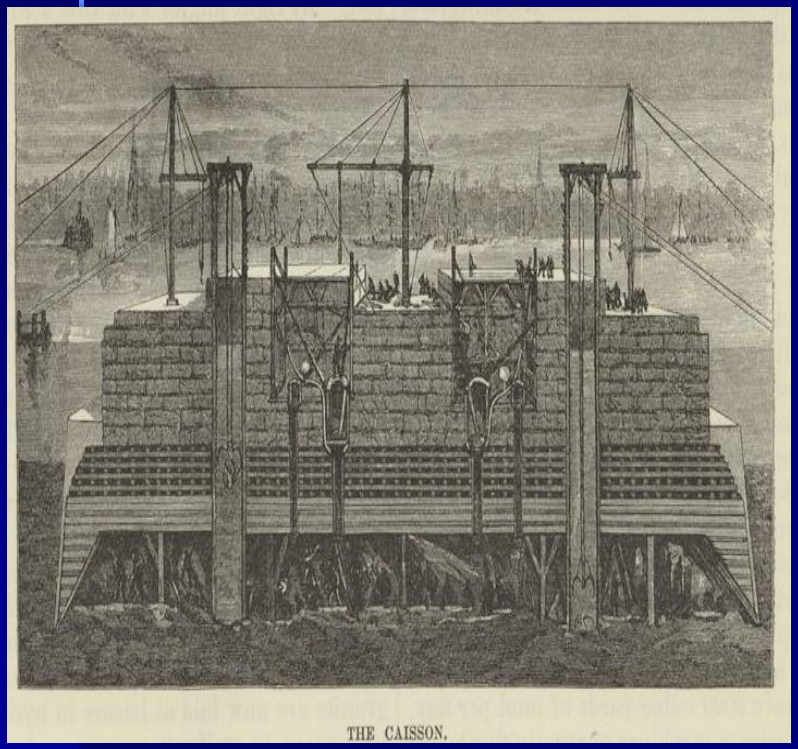
Eads Bridge

- 1870-89
  - 25% mortality among caisson workers on Hudson River Project
  - After installation of recompression chamber, mortality decreased to 1%



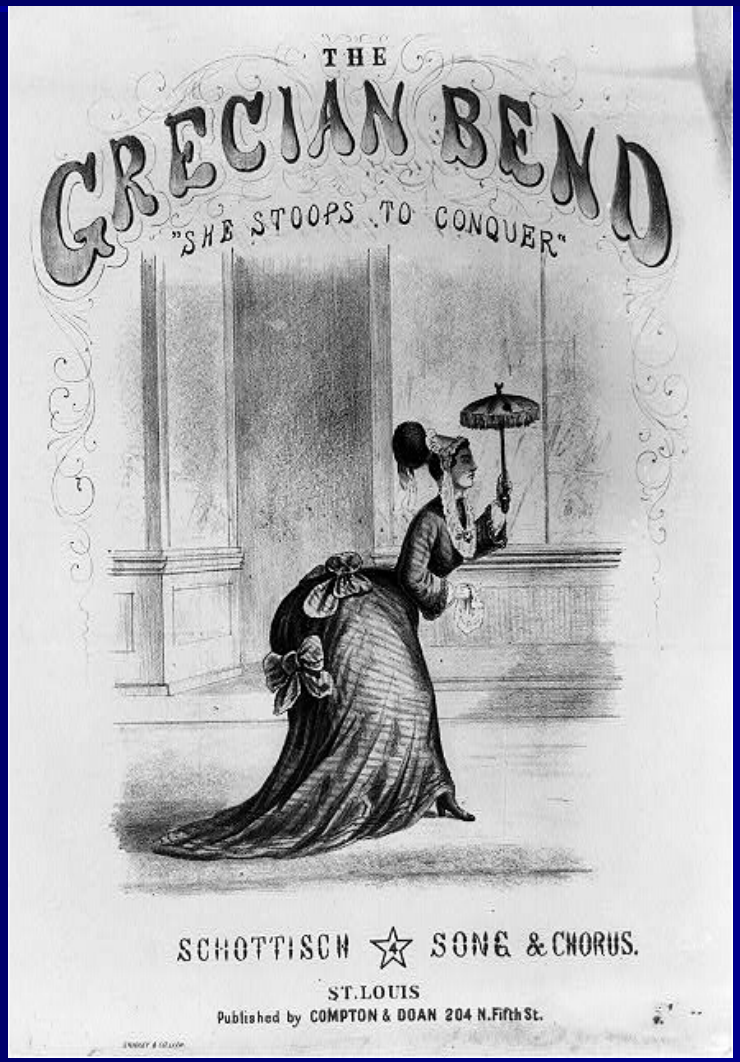


Caisson workers: “sandhogs”



THE CAISSON.

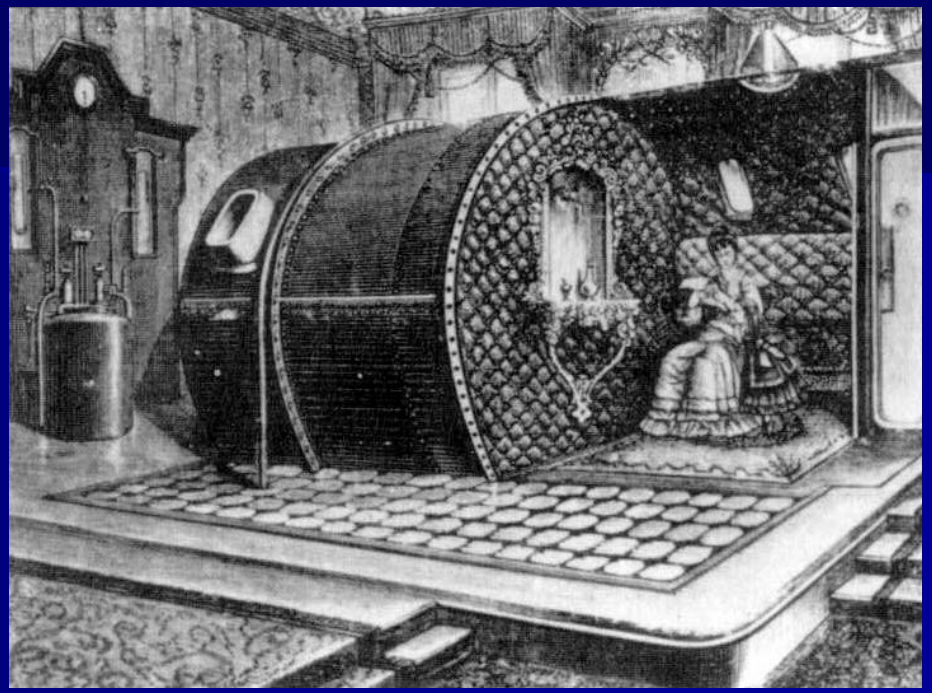
Decompression sickness becomes a problem



History of HBOT

- 1837-77:
  - European

  "pneumatic spas"



"Le Bain d' air comprime" – Compressed air bath

- *"Increase circulation to the internal organs, improve the cerebral blood flow, and produce a feeling of well being"*

HISTORY OF HBO

- 1879 – French surgeon (Fontaine) built a mobile operating room/hyperbaric chamber.
- Hypothesis: safer surgery because higher ppO_2.
- "Patients are not the usual cyanotic color when coming out of anesthesia."

Kindwall, 1999


CaviWipesXL
1
2
3
4
5
6
7
8
9
10
11

HISTORY OF HBO

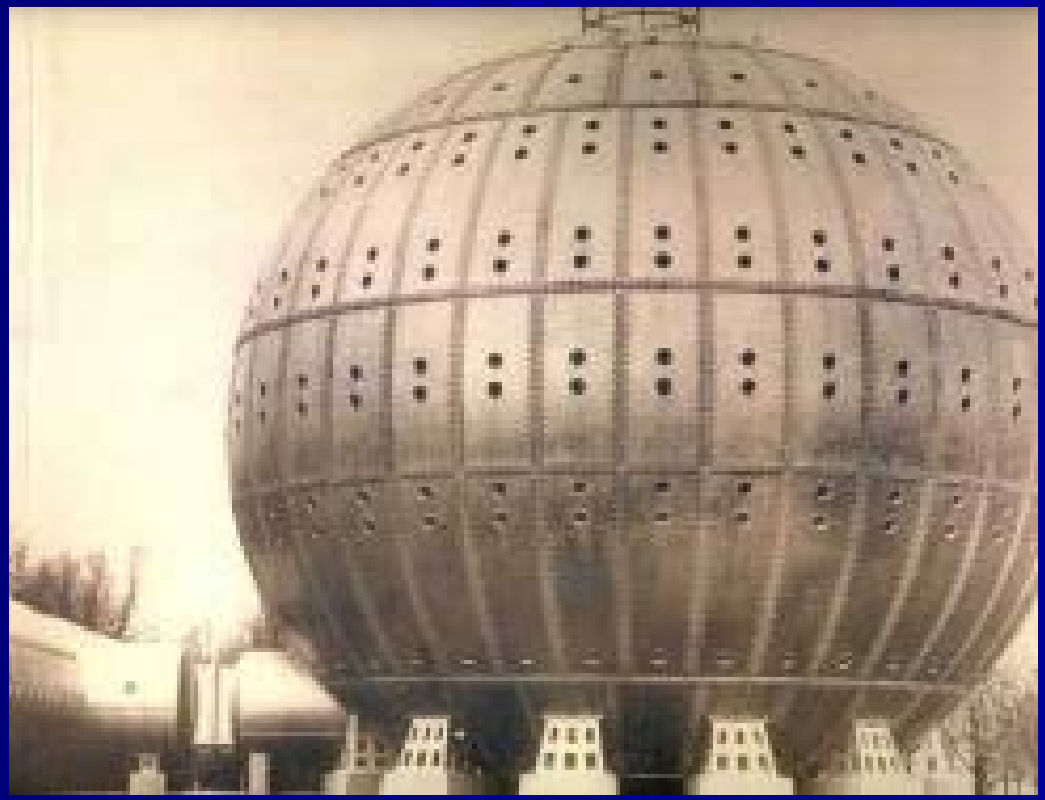
- 1915 - Dr. Cunningham (Kansas City) built 88 x 10 foot hyperbaric chamber.
- 1918 – successfully treats a resident physician with influenza.
  - "*patients whose lips bore the blue-black livid stamp of the kiss of death and were deeply unconscious, but if not too far beyond the brink, in a matter of minutes were brought back to normal color and to return of consciousness"*

History of HBOT

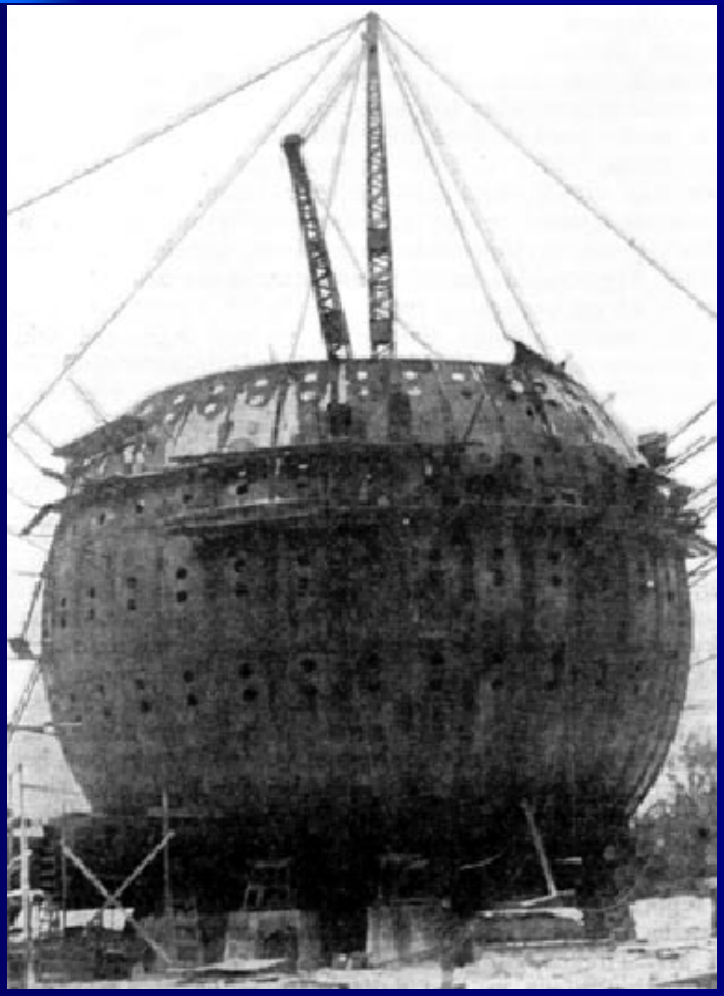
- Cunningham's Chamber
- "...used to treat diseases such as syphilis, hypertension, diabetes mellitus, and cancer. The reasoning was based on the assumption that anaerobic infections play a role in the etiology of all such diseases."

Steel Ball Hospital

- 1928 Timken - Cunningham's Steel Ball Hospital
- Mr Timkin – Cured of uremia
- owner of Timkin Rollerbearing Co
- Gratitude = $$



“Steel Ball Hospital”: Cleveland, Ohio 1928.

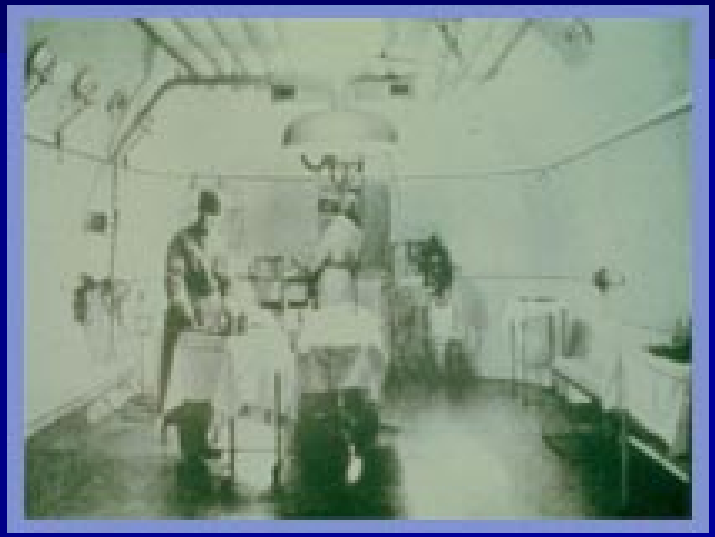


- AMA and Cleveland Med Society force closure in 1930.
- Used for scrap in WWII.

(AMA Bureau of Investigation. The Cunningham “Tank treatment.” The Alleged Value of Compressed Air in the Treatment of DM, pernicious anemia and Carcinoma. JAMA 1928;90: 1494)

HBO History

- 1956 Bohrema
  - Cardiothoracic surgeon
  - “Life without Blood”



What is the O_2 content needed to sustain life?

- About 6 mL/dL

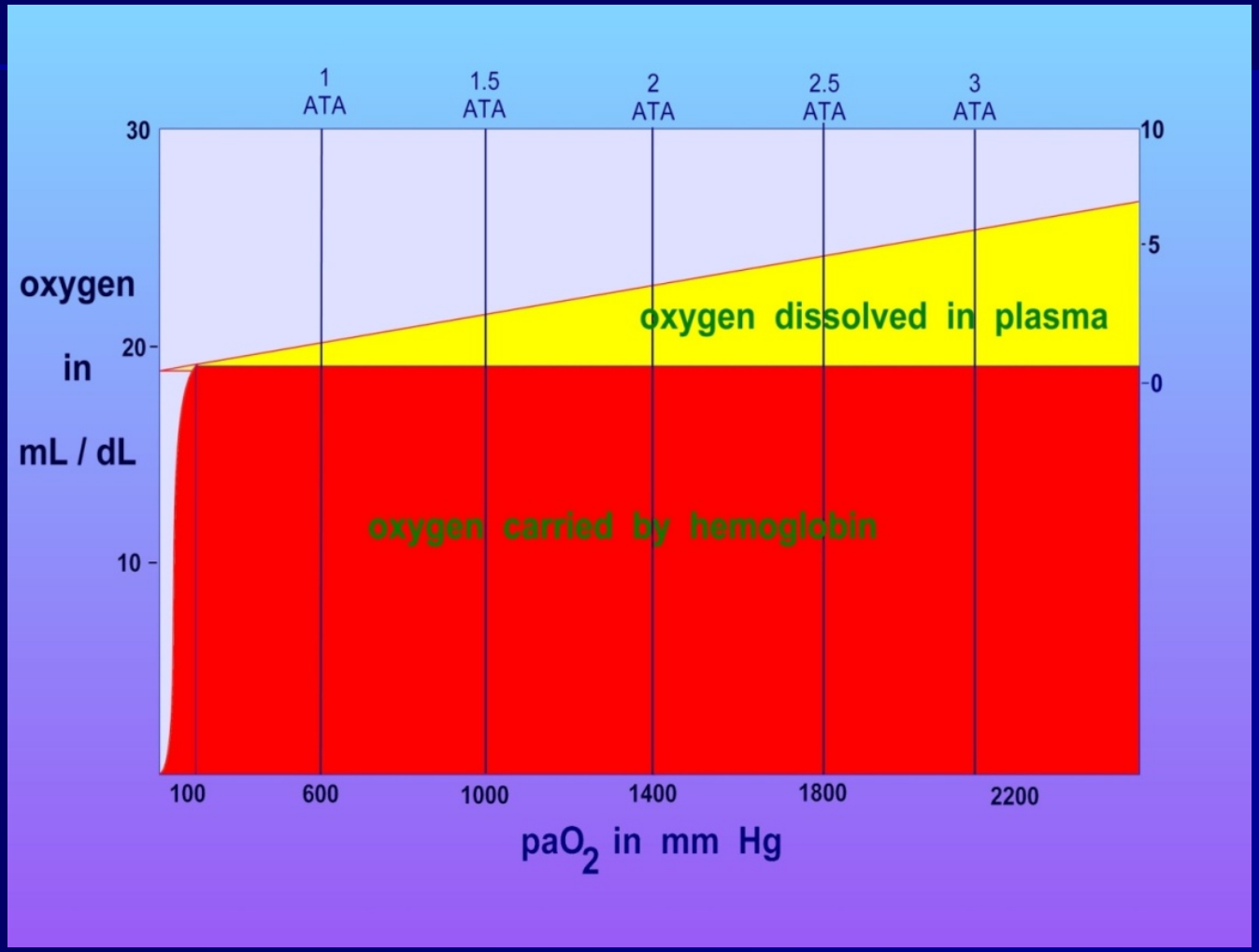
- Porcine study
- Removed all Hgb
- 100% O_2 at 3 ATA
- All survived

Boerema, 1960

Hyperbaric Oxygen
Dissolved Plasma Oxygen

- CaO2=(SaO2 x 1.39 X Hgb) + PaO2 x 0.0031

- PaO_2 x 0.0031 = vol% oxygen
- Sea level air (PaO_2 100 mmHg) = 0.3 vol%
- 3 atm abs 100% O_2 (PaO_2 2100 mmHg) = 6.6 vol%


1 ATA
1.5 ATA
2 ATA
2.5 ATA
3 ATA
30
20
10
10
5
0
oxygen in mL / dL
oxygen dissolved in plasma
oxygen carried by hemoglobin
100
600
1000
1400
1800
2200
paO2 in mm Hg

INDICATIONS FOR HBO

- Primary Therapeutic Modality:
  (Decompression Sickness and AGE)

- Adjunctive Therapeutic Modality:
  (Everything else)

14 INDICATIONS (UHMS)

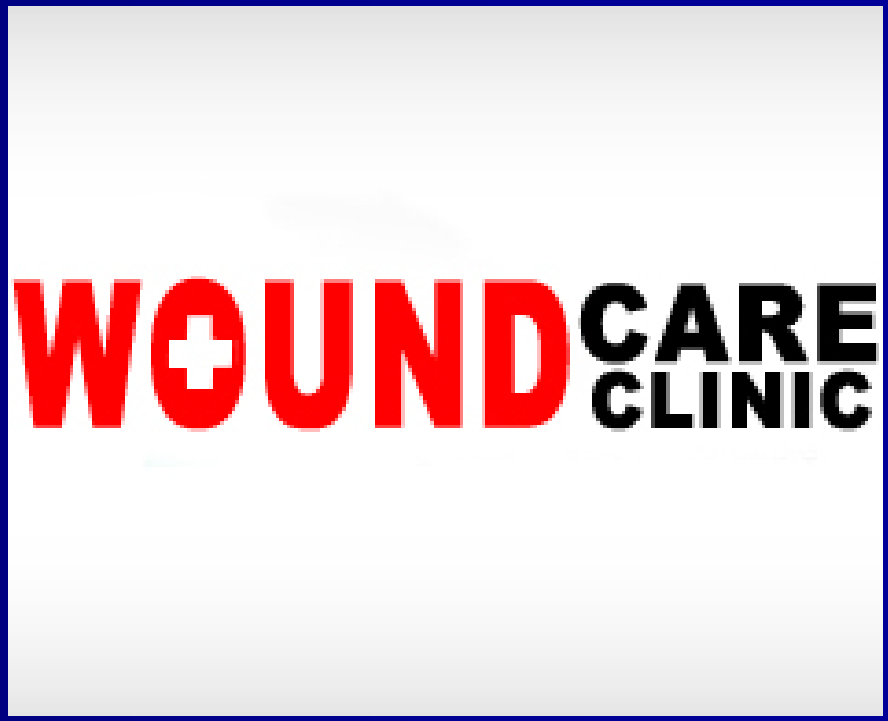
1. **Decompression Sickness (DCS)**
2. **Arterial Gas Embolism (AGE)**
3. Carbon Monoxide
4. Exceptional Anemia
5. Necrotizing Infections
6. Clostridial Myonecrosis
7. Intracranial Abscesses
8. Crush Injuries
9. Compromised Skin Grafts
10. Effects of Radiation
11. Refractory Osteomyelitis
12. Thermal Burns
13. Arterial Insufficiencies: CRAO and select problem wounds
14. Idiopathic sensorineural hearing loss

(UHMS Committee Report 2008)

Indications - Emergent

- CO / CN poisoning
- CRAO
- Gas Gangrene
- Necrotizing STI
- Acute thermal Burns
- ISSNHL
- Crush Injury
- Compartment syndrome
- Intracranial abscess
- Exceptional blood loss anemia
- Flaps / Grafts

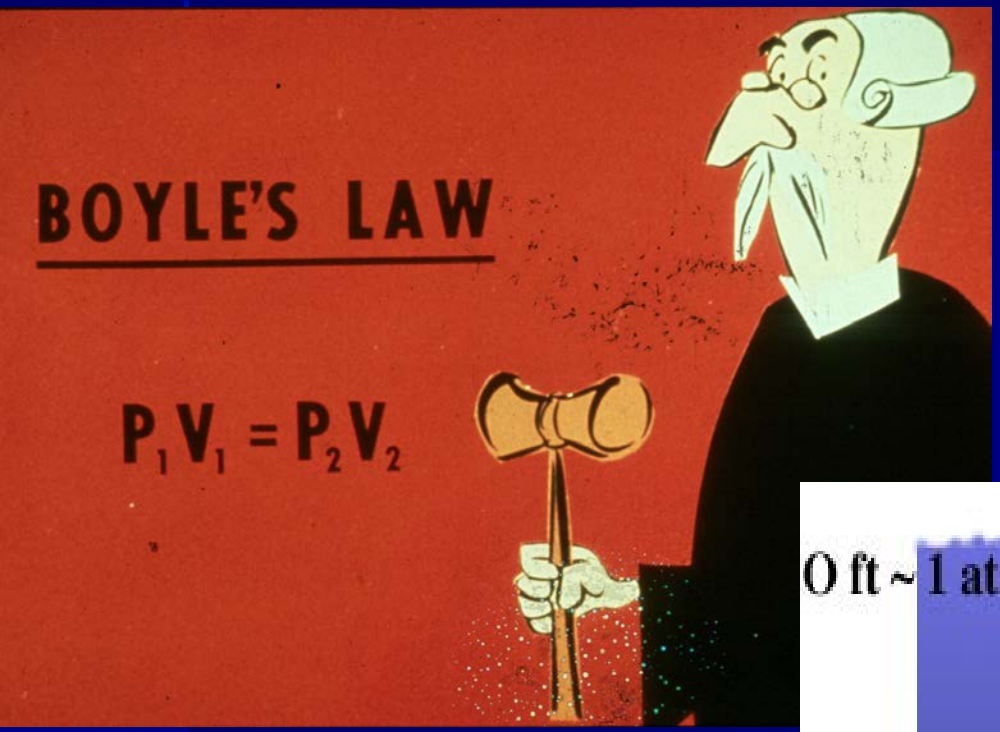
- Diabetic Foot Ulcers
- Radiation wounds
- Chronic Osteo
- Limb salvage

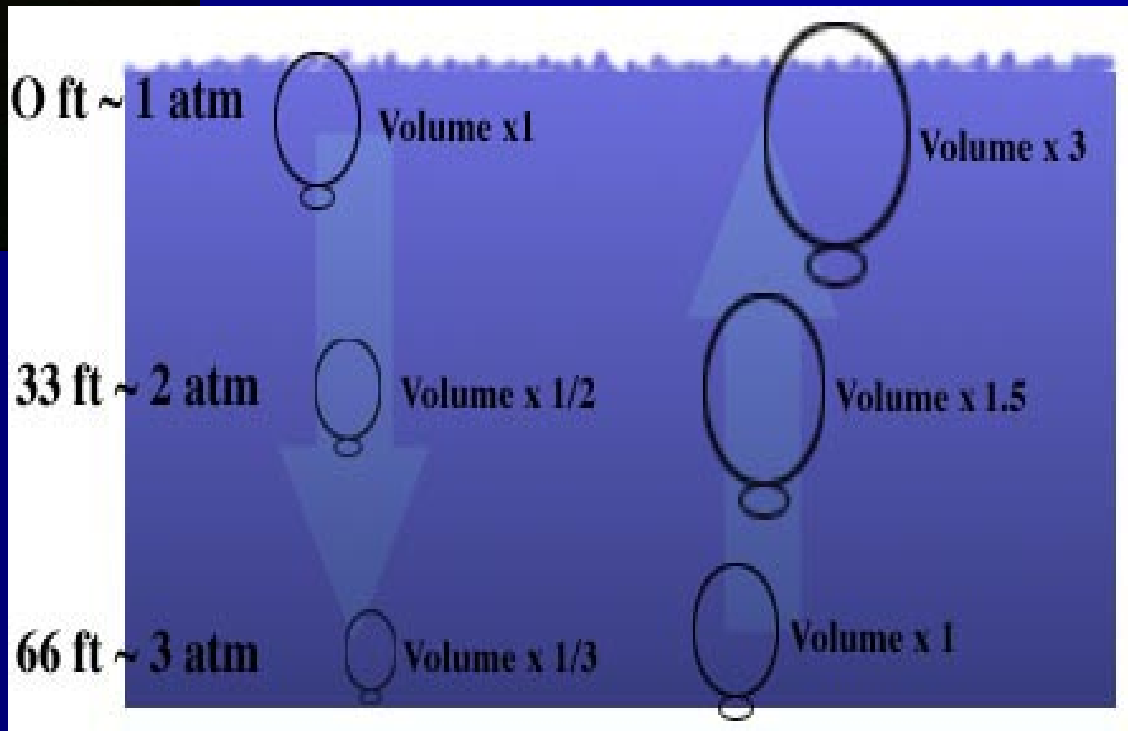


HOW HBO WORKS (PHYSIOLOGY)

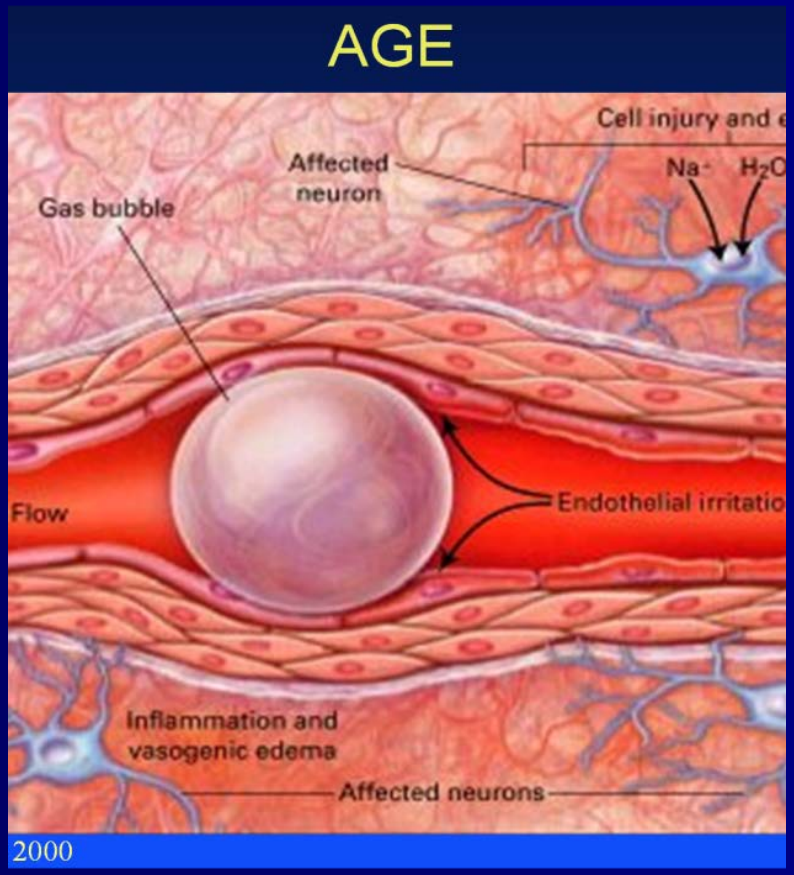
1. Mechanical effects of pressure ("crush the bubble")
2. Diffusion gradient ("shrink the bubble")
3. Increased O_2 delivery to tissue
4. Biochemical effects

Mechanical Effects

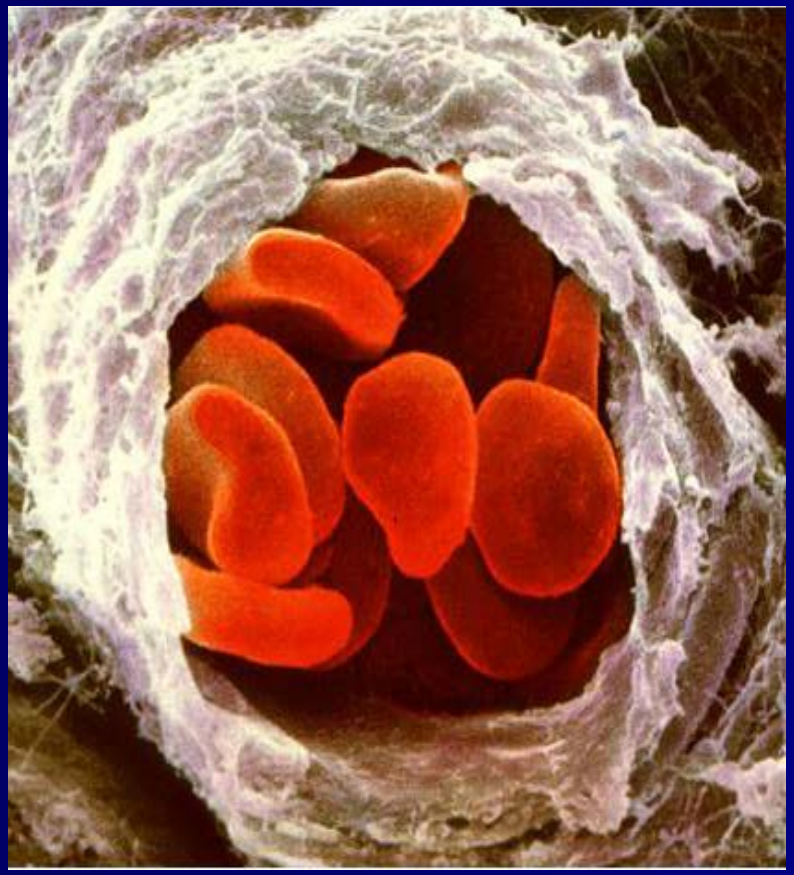




Applicable to AGE (diving and iatrogenic)



Increase O_2 delivery to tissue (Hyperoxygenation):



- More oxygen in the blood / plasma to be delivered

- Oxygen content =

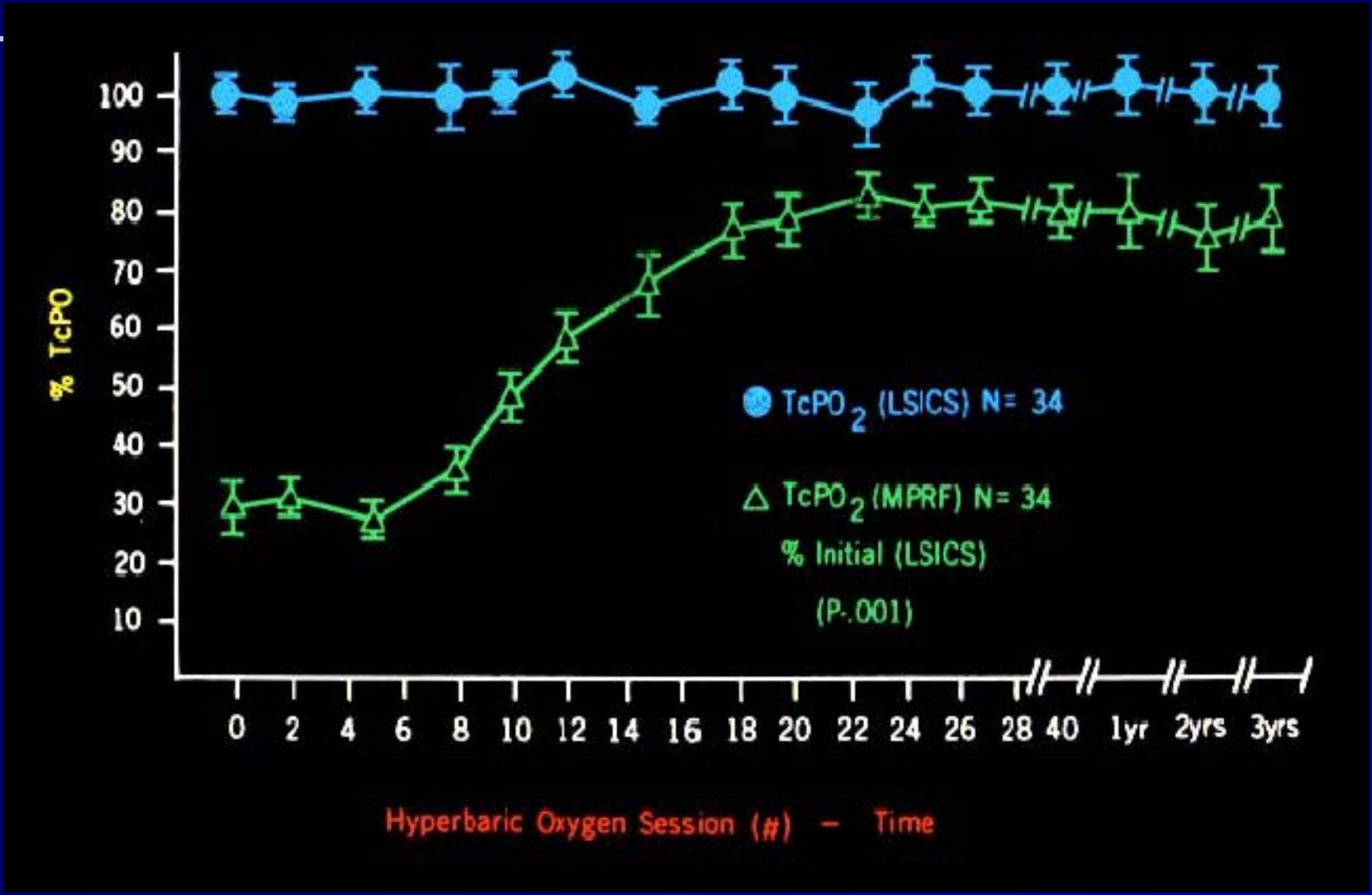
(Hgb)(O_2 sat)(1.34) + 0.31 * Po2

Hyperoxyia: Applicable to:

- Compromised tissue flaps and skin grafts
- Poorly perfused tissue
- Stimulates fibroblast activity in hypoxemic tissue
- Promotes wound healing in hypoxemic tissue
- Prevents growth of anaerobic bacteria
- Promotes Angiogenesis

(UHMS Committee Report 2008)

HBOT – Angiogenesis



BIOCHEMICAL EFFECTS OF HBO:

*Halts production of alpha toxin in clostridial infections (gas gangrene). Van Unnik, 1965

*Reduces the inhibition of mitochondrial resp. chain enzymes by CO. Brown, 1991

*Edema reduction through vasoconstriction while maintaining perfusion. Strauss, 1986

*Limits reperfusion injury. Thom, 1993; Zamboni, 1993

HBOT –Problem Wounds

Problem Wounds

- These patients frequently undergo
  - Prolonged hospitalization
  - Multiple surgical procedures
  - Significant disability
  - High morbidity
  - Exorbitant cost

Hypoxia and Wound Healing

- The relationship between hypoxia and impaired healing has been well documented

Niinikoski J. Acta Physiol Scand 1969

Hunt TK, et al. Am J Surg 1967

Sheffield PJ. HBO Rev 1985

Chronic Wound Hypoxia
Interstitial and Transcutaneous PO_2

	PtO_2	$TcPO_2$
Healthy control tissue	30-50 mmHg	50-80 mmHg
Chronic nonhealing wound	5-20 mmHg	20 mmHg

Hypoxia and Nonhealing
Effect of PO_2 < 30 mm Hg

- Decreased neutrophil killing
- Decreased fibroblast growth
- Decreased collagen production
- Impaired capillary growth

Rationale for Hyperbaric Oxygen Therapy

Hyperbaric Oxygen Mechanisms in Chronic Wounds

- HBO_2 stimulates wound macrophages to produce growth factors
- Fibroblasts produce and express more surface growth factor receptors
- Fibroblast proliferation rate is increased for 24-72 hours after a single HBO_2 exposure
- Improve PMN oxidative killing of microorganisms
- Stimulate angiogenesis

Knighton DR 1983; Hehenburger K 1997; Tompach PC 1997; Pipmeier EH 1999; Reenstra WR 1999

Diabetic Foot Ulcers

- Up to 6% of hospitalizations for diabetics incl Ulcer as DC Dx
- When present, DFU inc hosp LOS 59%
- Once an amputation occurs,
  - Up to 20% will req a repeat amupation by 1 yr, and up 52% in 5 yrs


cm 1 2 3 4 5 6
Virginia Mason Medical Center
Date: 2/6/04
MR# 1130908
HBO# Ø


cm 1 2 3 4 5 6
Virginia Mason Medical Center
Date: 2-23-04
MR# 1130208
HBO# 4


cm 1 2 3 4 5 6
Virginia Mason Medical Center
Date: 3-1-04
MR# 1130908 HBO# 11


cm 1 2 3 4 5 6
Virginia Mason Medical Center
Date: 3-16-04
MR# 1230908 HBO# 23


cm 1 2 3 4 5 6
Virginia Mason Medical Center
Date:
MR#
HBO#


cm 1 2 3 4 5 6
Virginia Mason Medical Center
Date: 4-7-04
MR# 1130908 HBO# Post


cm 1 2 3 4 5 6
Virginia Mason Medical Center
Date: 2/6/04
MR# 1130908
HBO# Ø

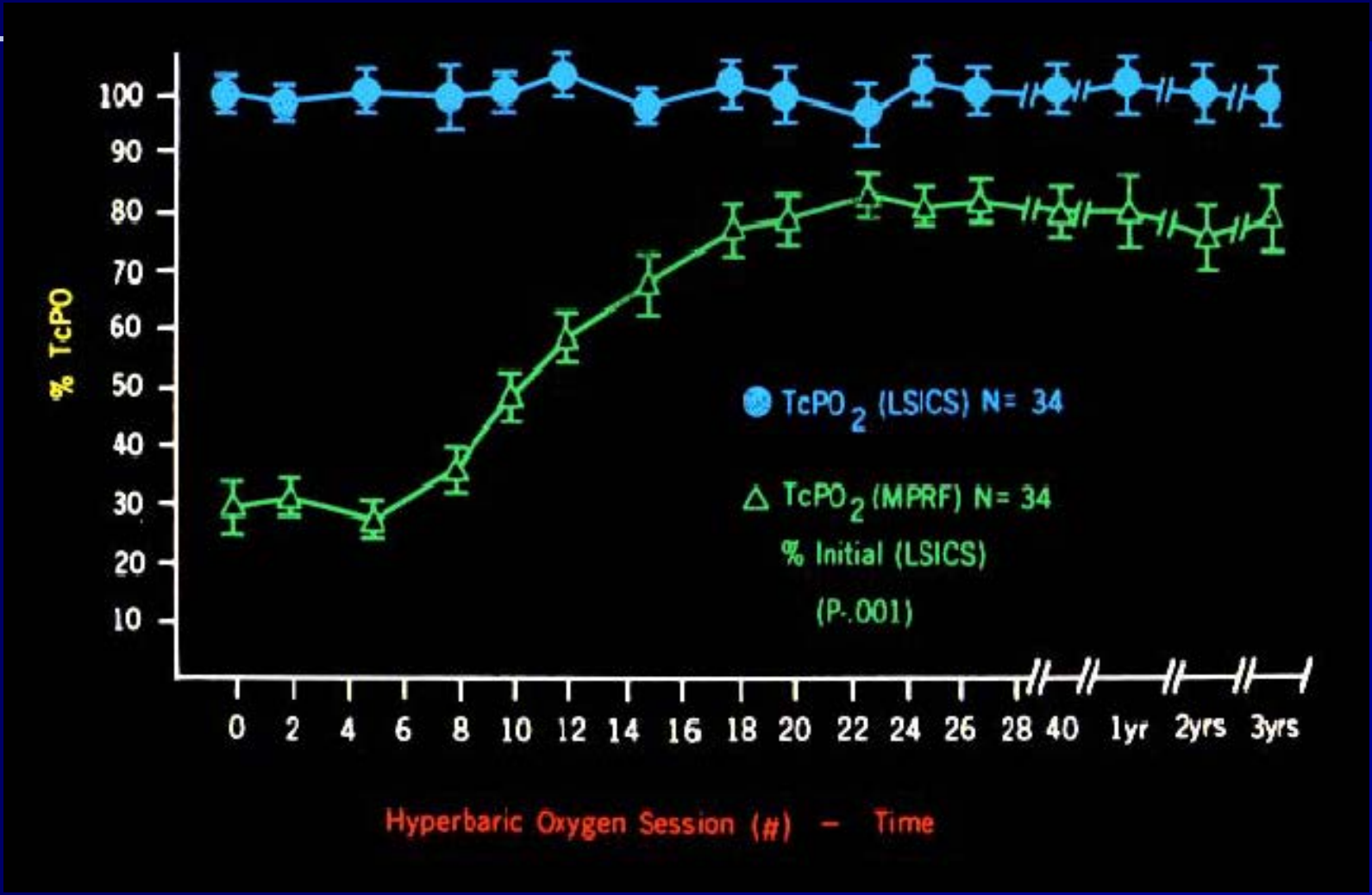

cm 1 2 3 4 5 6
Virginia Mason Medical Center
Date: 4-7-04
MR# 1130908
HBO# Post

40 HBOTs

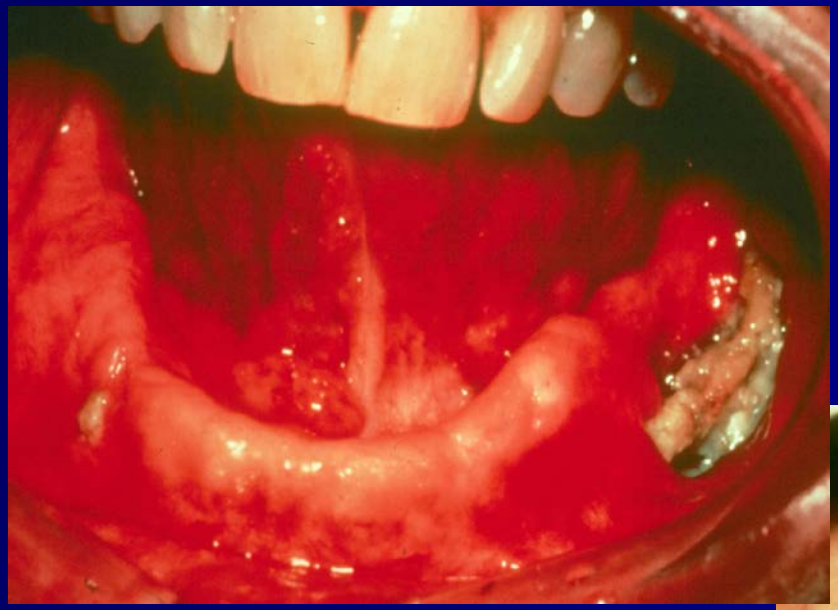
HBOT –Radiation Injury

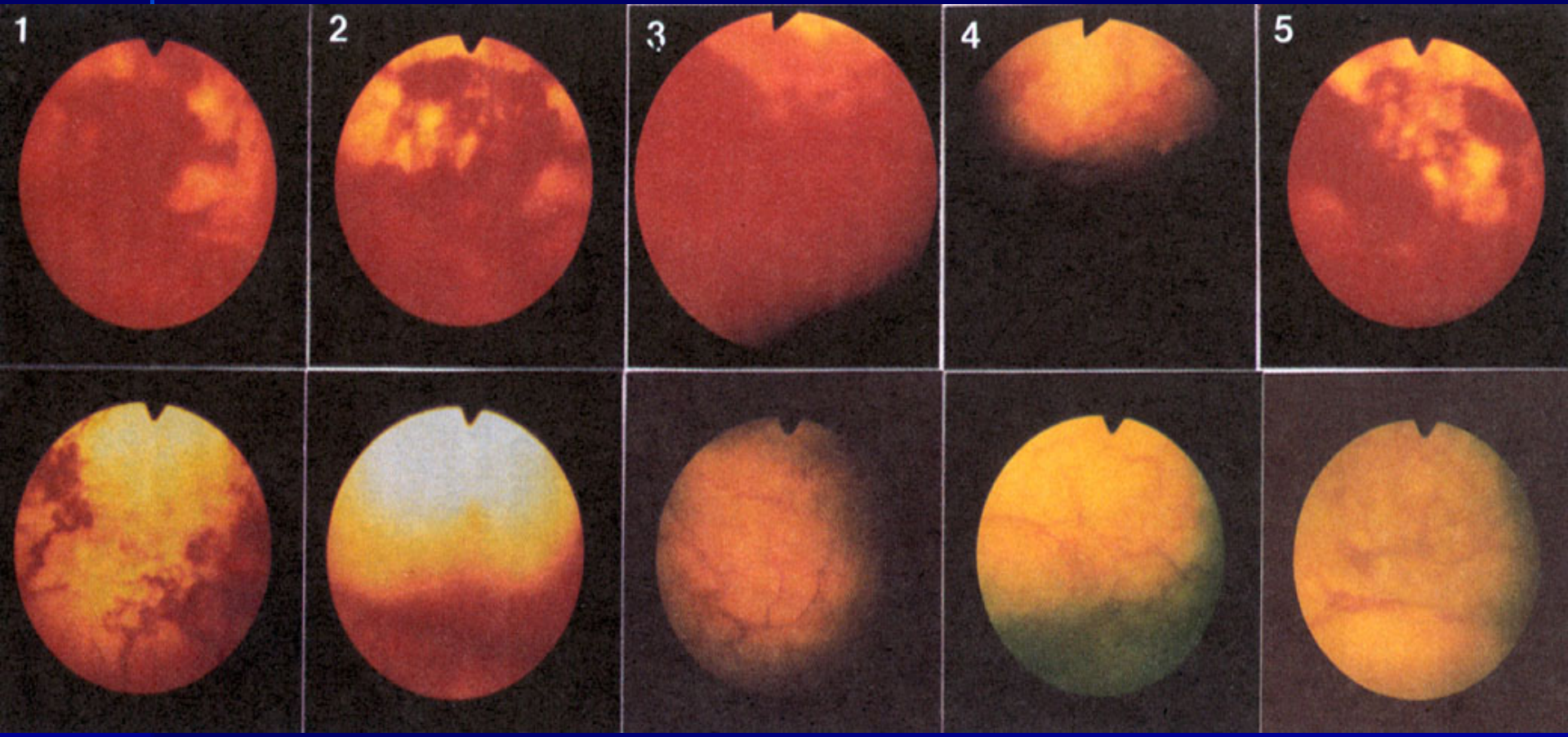
- Approx 600,000 patients recv XRT annually in the US
- Likelihood of Complication is 1-5% (30,000 pts)
- Result in surgery in an irradiated field →post op complication up to 50%

HBOT – Angiogenesis



HBOT – ORN

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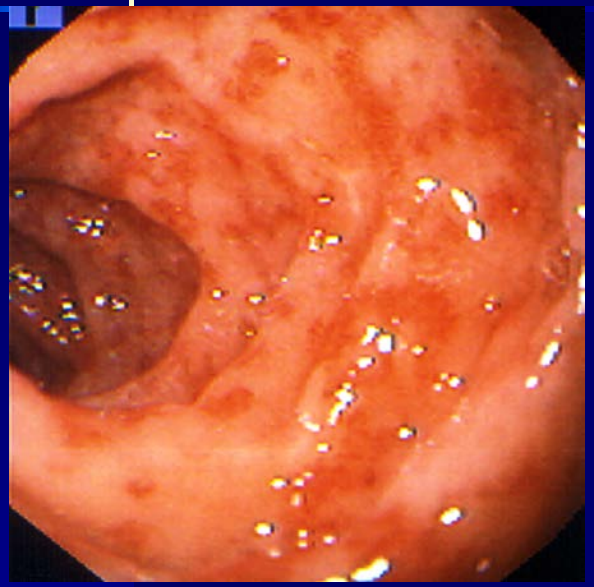
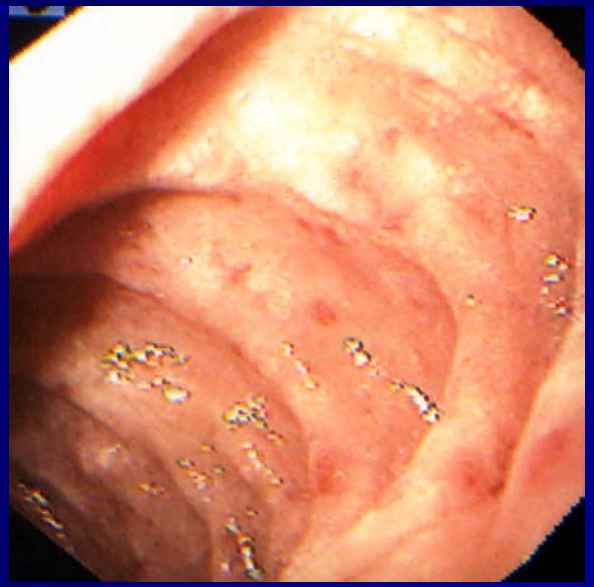
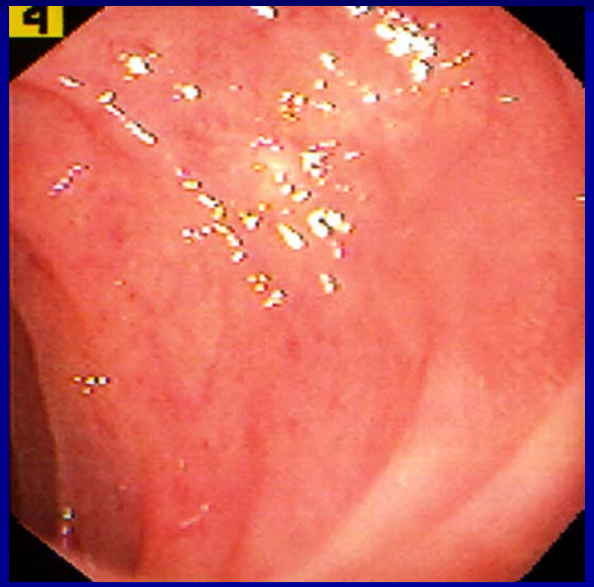
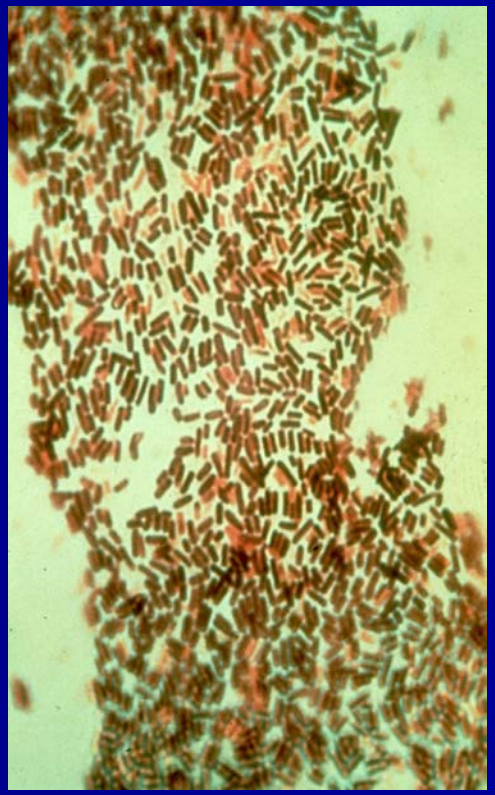




HBOT – Gas Gangrene

- Clostridial Myonecrosis (Gas Gangrene)
  - Anaerobic, spore-forming G+ encapsulated bacillus
  - C. Perfringens (80-90%)
    - 20 toxins, most prevalent and lethal is alpha toxin



Clostridial Myonecrosis
Role of Hyperbaric Oxygen

- HBO_2 is adjunctive to antibiotics and surgery
- Oxygen is bactericidal for C. perfringens at PO_2 = 1400 mmHg
- At 3 ATA oxygen exotoxin production is stopped

Clostridial Myonecrosis Outcomes with HBO_2

- Mortality (classically 50%):
  - Bakker (2002) – 12% in 462 HBO_2 cases
  - Heimbach (1994) – 5% in 58 patients treated within 24 hours
  - Him (1993) – 28%
  - Korhonen (1999) 23% in 53 cases
- Amputation Rates:

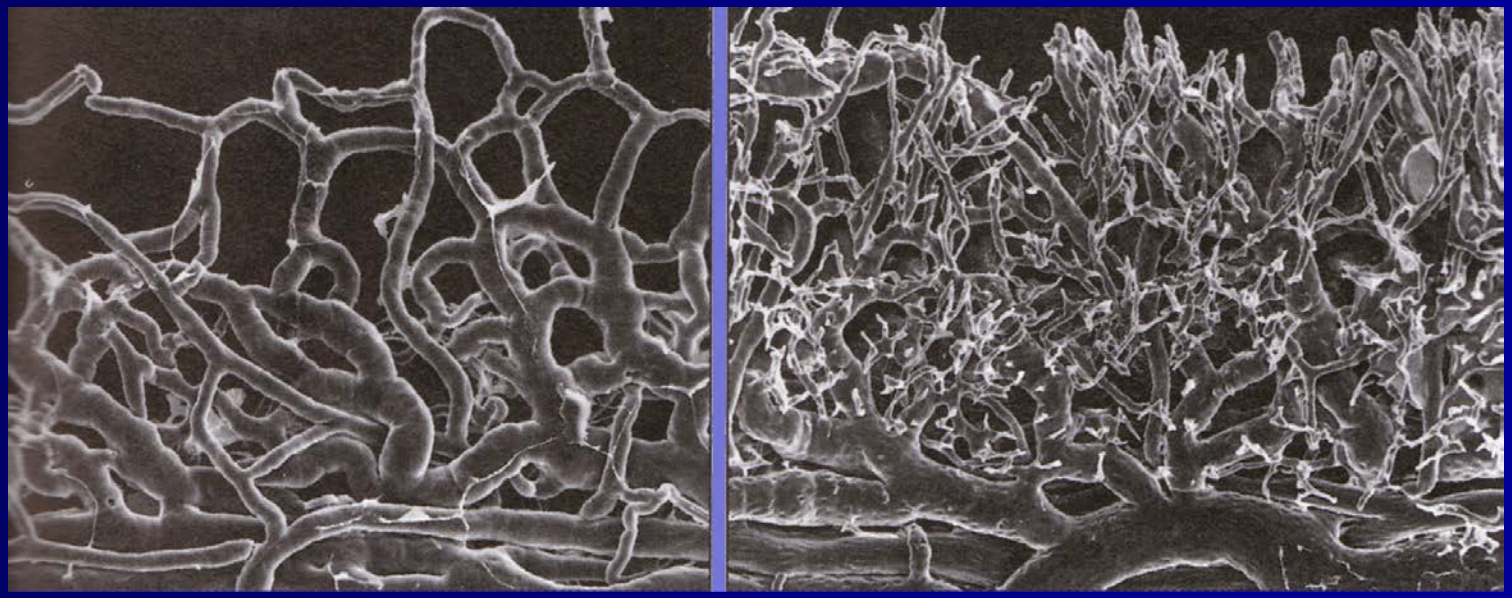
  17-18% vs. 50-55%

Myonecrosis from gas gangrene due to *C. perfringes*


4/28/84

HBOT – Skin Grafts and Flaps

- Rationale
  - Improves tissue oxygenation and increase flap capillary density

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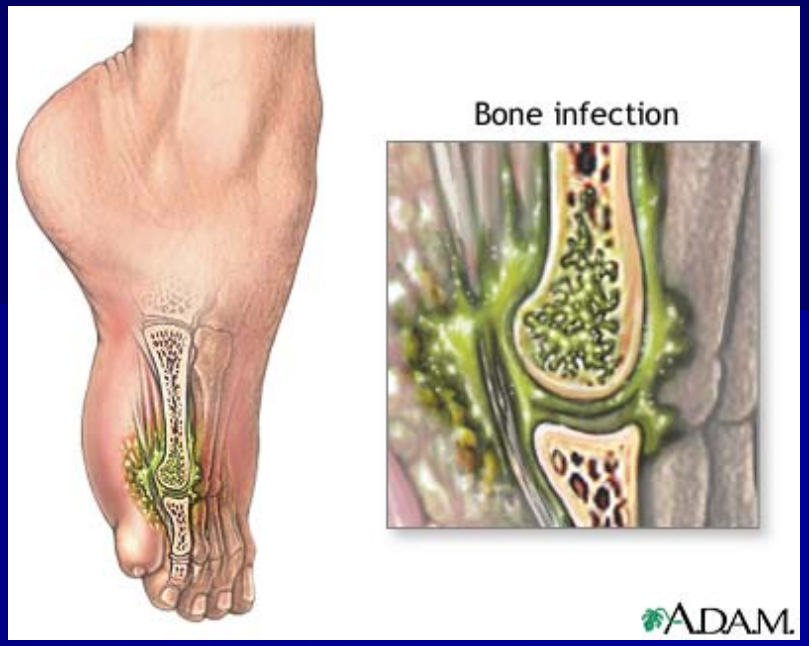
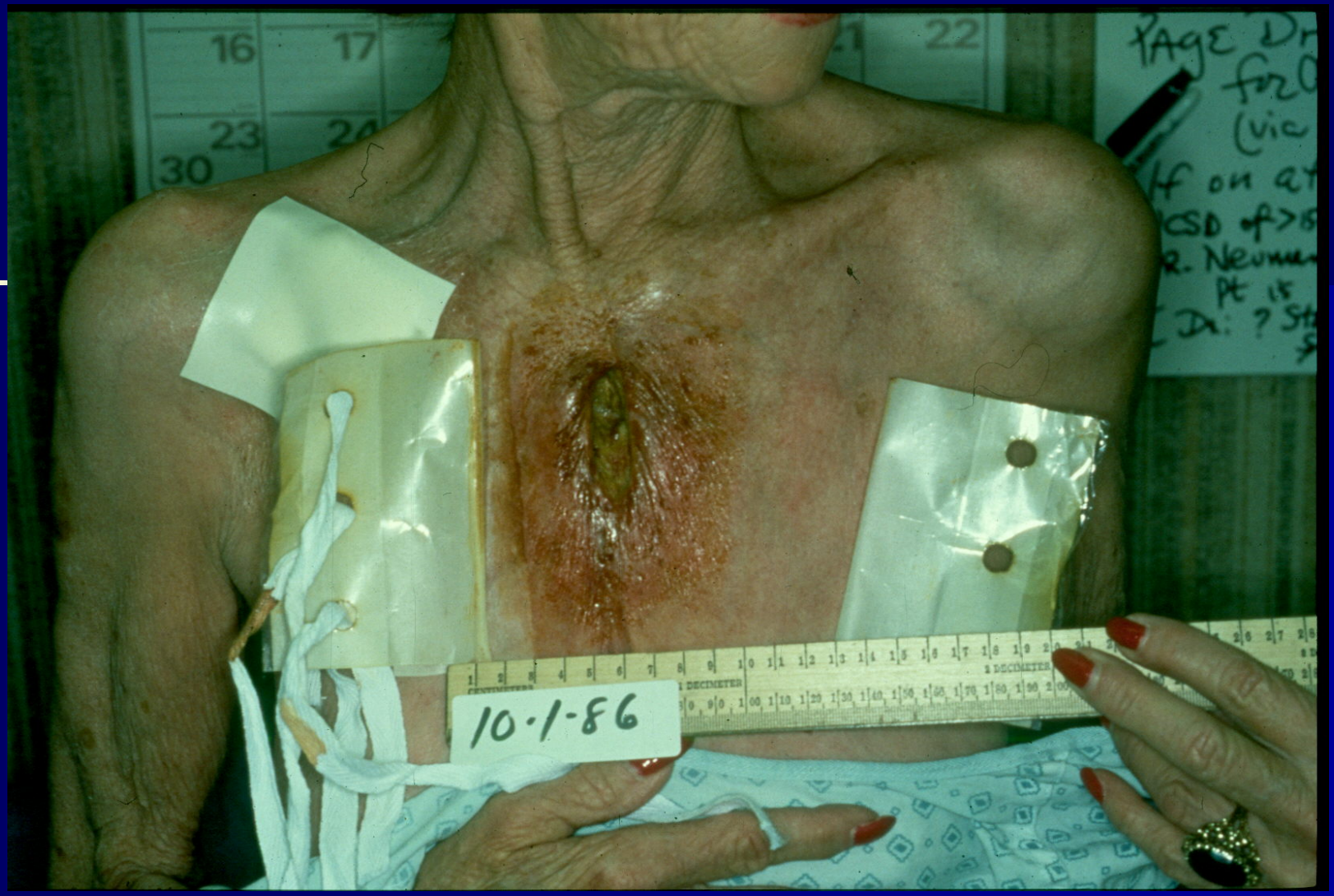
9/7/04 H00#1

HBOT - Osteomyelitis

- Rationale
  - Osteomyelitis refractory to standard therapy
  - HBO causes osteoclastic stimulation in animals
  - Enhance host defenses, PMN stimulation
- Indications
  - Adjunct with aggressive debridement and antibiotics for refractory cases





Sternal osteomyelitis following CABG who failed repeated debridements and two 6 weeks courses of IV antibiotics

Other Wounds

- HBO not Approved in
  - Venous
  - Decubitus / pressure ulcers
    - HBO may be beneficial to support skin grafting / or flaps

Complications and Side Effects of HBOT

- Middle Ear Barotrauma
- Sinus Barotrauma

- Claustrophobia

- Visual Refractive Changes
- Seizures

ABSOLUTE CONTRAINDICATIONS

- Untreated pneumothorax
  - once a chest tube is in place, OK to treat

- Doxorubicin (Adriamycin) cardiotoxicity
- Cis-Platinum increase cytotoxic effect
- Bleomycin pulmonary toxicity

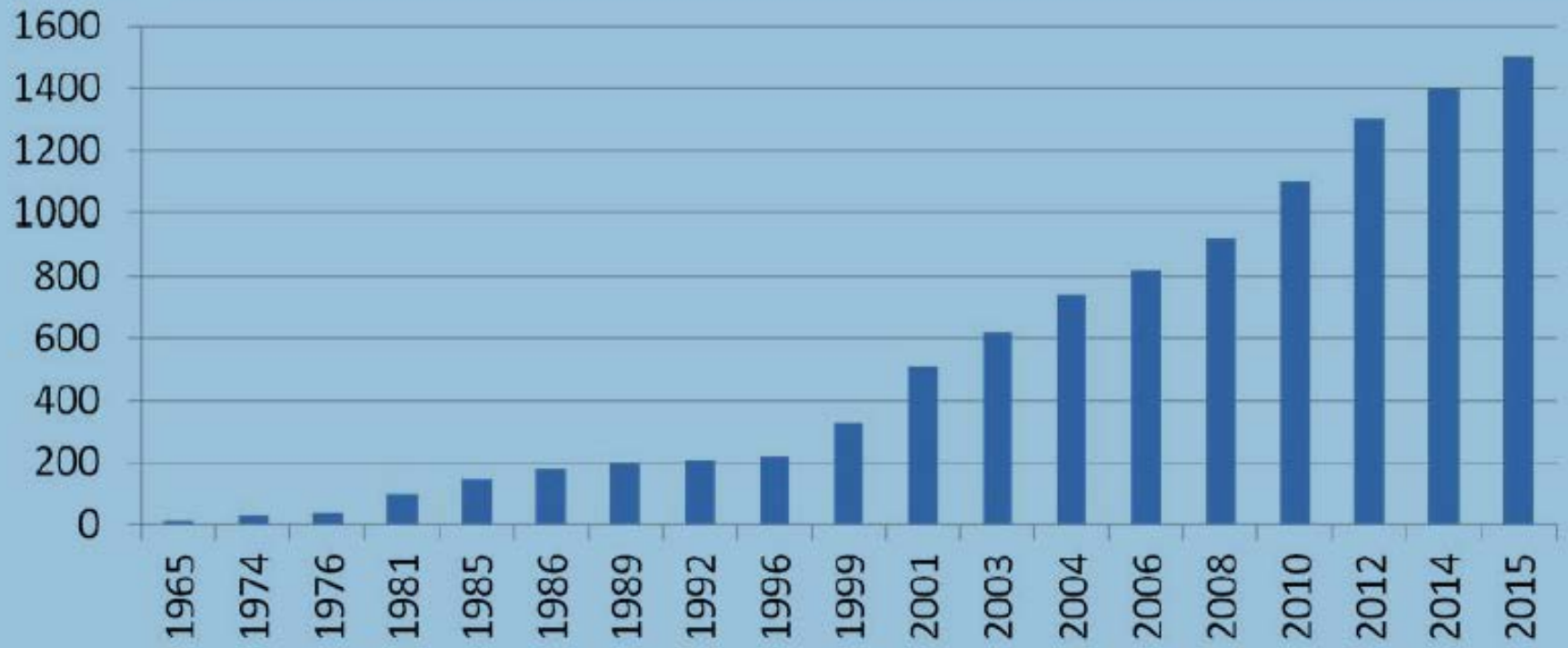
RELATIVE CONTRAINDICATIONS

- Inability to equalize ears or sinuses
  - URI, OM, acute/chronic sinusitis
- Emphysema with CO_2 Retention
- Seizure Disorder
- Pregnancy
  - not contraindicated in an emergency

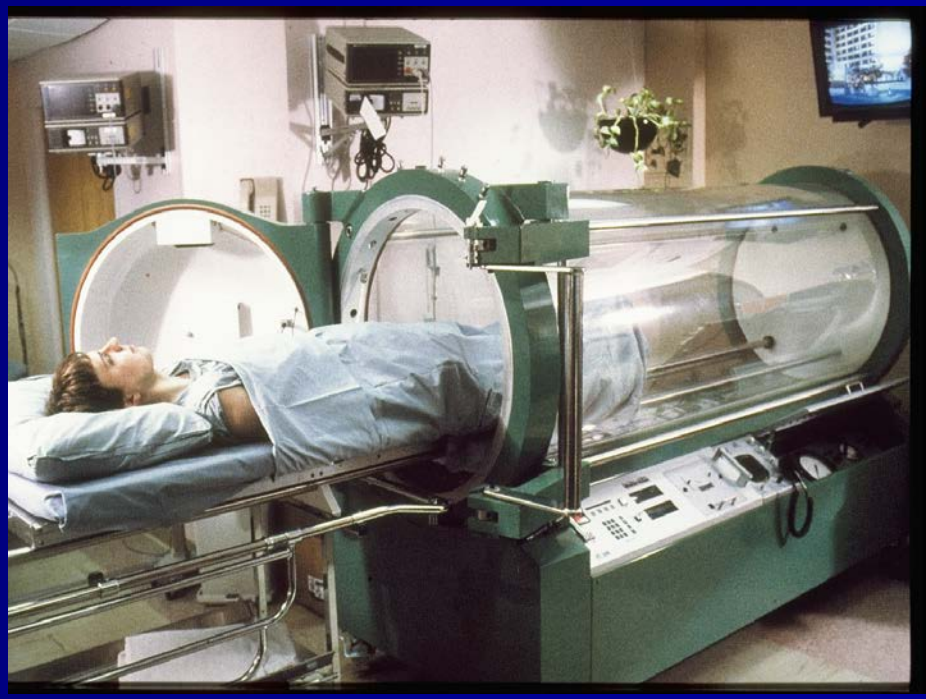
HBO Centers

- 505 centers registered in the US as of 2005
- 403 monoplace
- 81 multiplace
- 21 have both

Half Century Growth of Clinical Hyperbaric Facilities in USA (1965 – 2015)

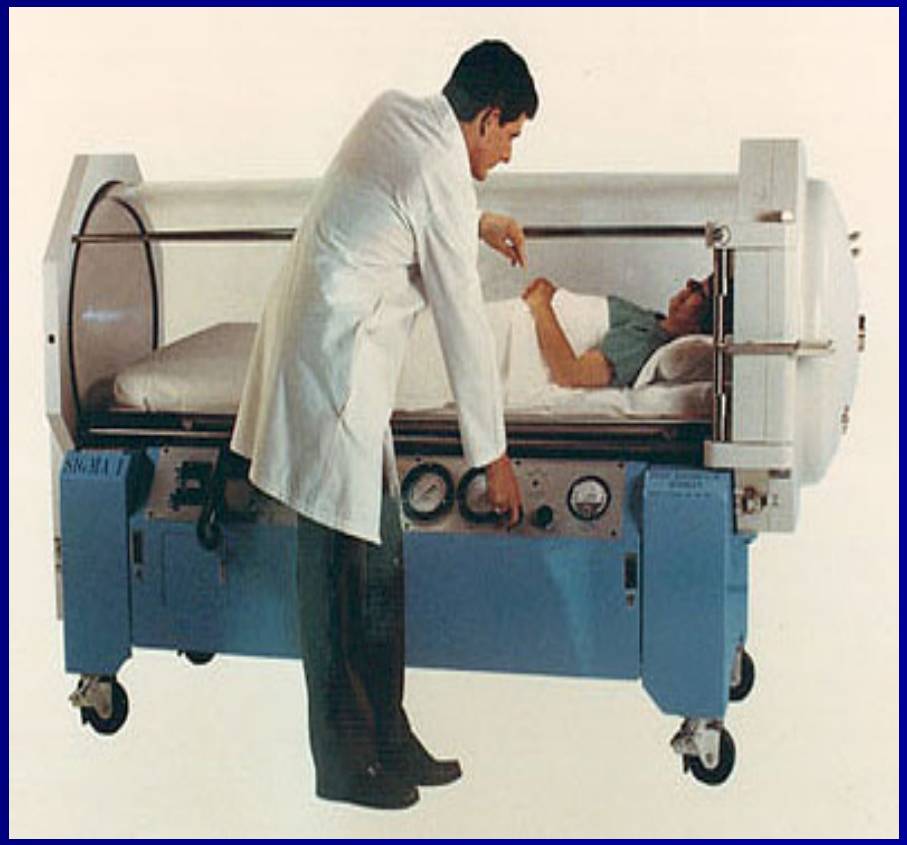


Monoplace Chambers



MONOPLACE CHAMBERS

- Majority of chambers
- Less space, less expensive
- Pressurized 100% O_2
- Can be configured for invasive monitoring
- Direct access limited
- Depth of treatment limited

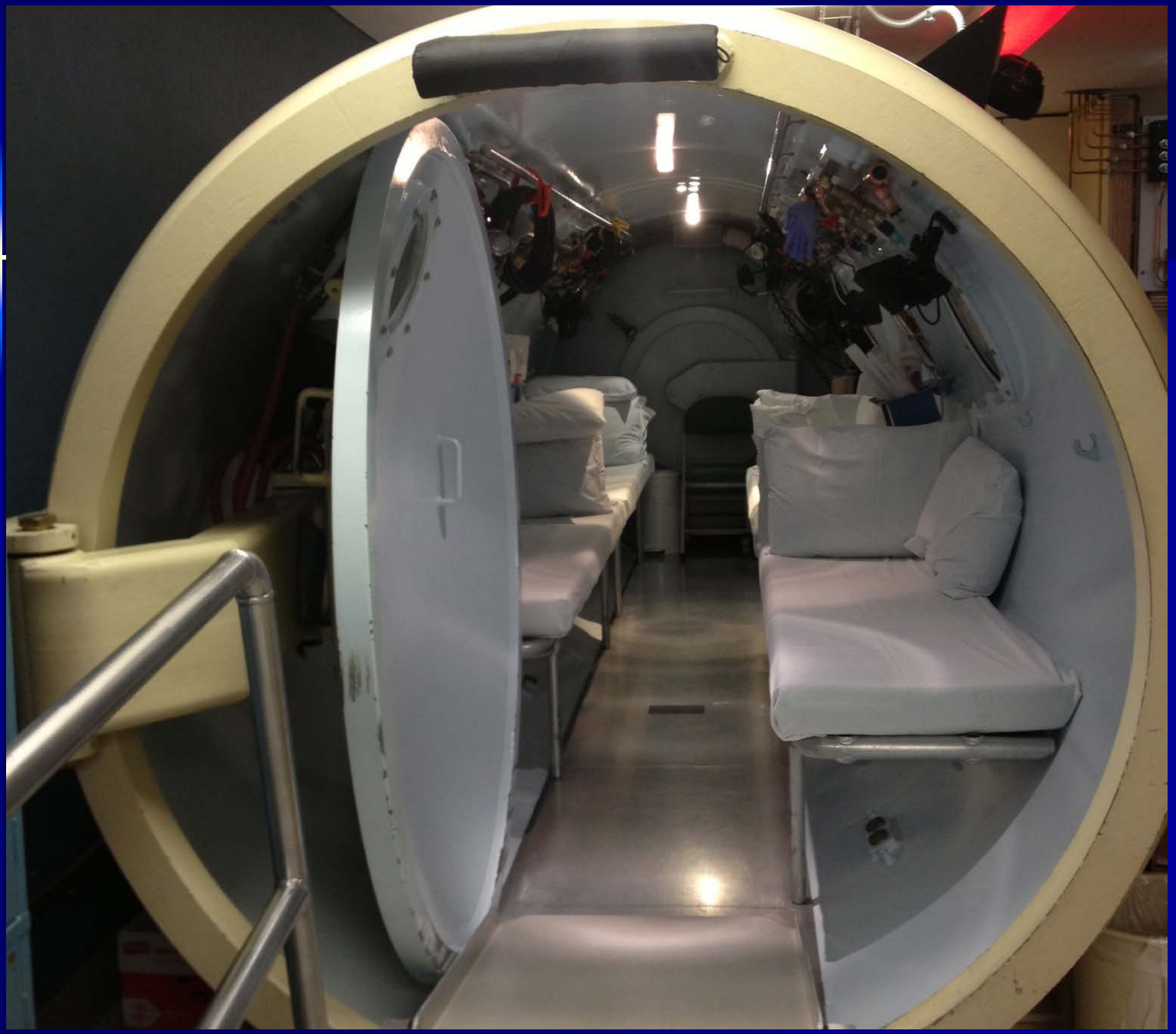


Multiplace Chambers

MULTIPLACE CHAMBER

- More than one patient
- Compressed with air, O_2 by mask or head tent
- Inside attendant, immediate access
- ICU level monitoring
- 6 ATA (165 fsw)
- Disadvantage
  - DCS risk to tender
  - more expensive

UCSD Chamber



Animal Chamber


ENTRANCE
9'-9" CLEARANCE
VIRGINIA MASON
↑ Emergency
Hospital Main Entrance
↑ 9th Ave Parking
Buck Pavilion
Inn at Virginia Mason
Lindeman Pavilion Parking
VIRGINIA MASON
Emergency
Hospital Main Entrance
9th Ave Parking
Buck Pavilion
Inn at Virginia Mason
Lindeman Pavilion Parking


PORT
DIVE
START
Critical Care Decision


CATALINA HYPERBARIC CHAMBER


USC Wrigley Institute
for Environmental Studies


EXIT


WARNING
AED
NO

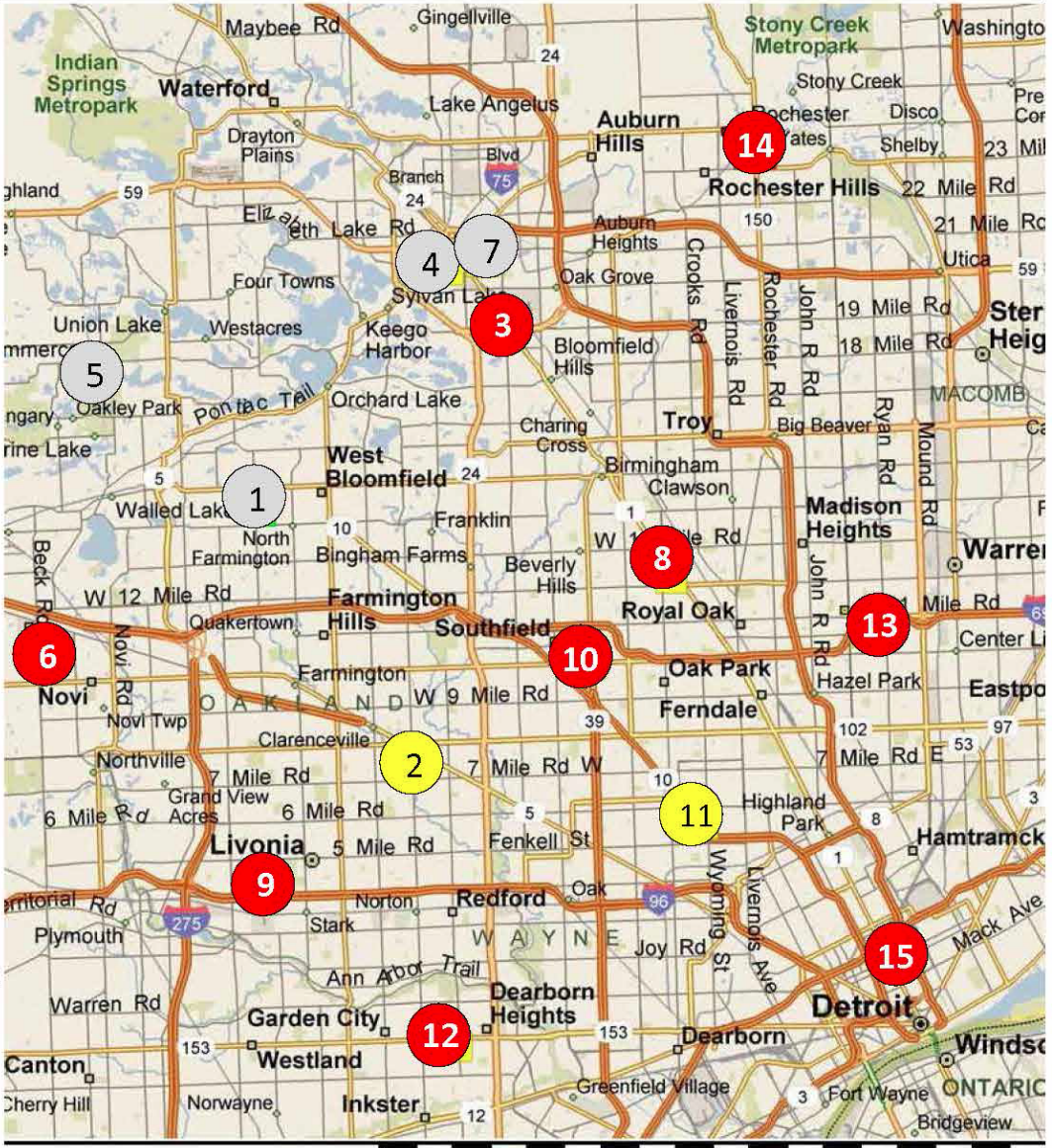
OxyHeal Health Group®

Availability of Hospital Based Wound Healing and Hyperbaric Oxygen Therapy (HBOT) Services

West Bloomfield, MI

Updated - May 2015

1. **Henry Ford West Bloomfield** – (191 Beds / 11,811 Discharges)
   (Henry Ford Health System)
2. **Botsford Hospital** – (321 / 14,823)
   (Beaumont Health)
3. **St. Joseph's Mercy Oakland** – (432 / 19,097)
   (St. Joseph's Mercy Health System)
4. **Doctor's Hospital of Michigan** – (77 / 1,103)
   (Physician Ownership)
5. **DMC Huron Valley – Sinai Hospital** – (198 / 9,328)
   (Detroit Medical Center)
6. **Providence Park Hospital – Novi** – (200 / 8,576)
   (St. John Health)
7. **McLaren Oakland** – (169 / 4,218)
   (McLaren Health Care Corp.)
8. **Beaumont Hospital – Royal Oak** – (1,070 / 52,945) - 12 Patient Multi.
   (Beaumont Health)
9. **St. Mary Mercy Hospital** – (304 / 15,363)
   (St. Joseph Mercy Health System)
10. **Providence Hospital – Southfield** – (628 / 32,878)
    (St. John Health)
11. **DMC Sinai Grace Hospital** – (382 / 18,775)
    (Detroit Medical Center)
12. **Garden City Hospital** – (159 / 8,493) – 8 Patient Multi.
    (Prime Healthcare)
13. **St. John Macomb-Oakland Hospital** – (529 / 23,297)
    (St. John Health)
14. **Crittenton Hospital** – (233 / 10,843)
    (Crittenton Corp.)
15. **DMC – Receiving Hospital** – OxyHeal Operated 18 Patient Multi.
    (Detroit Medical Center)



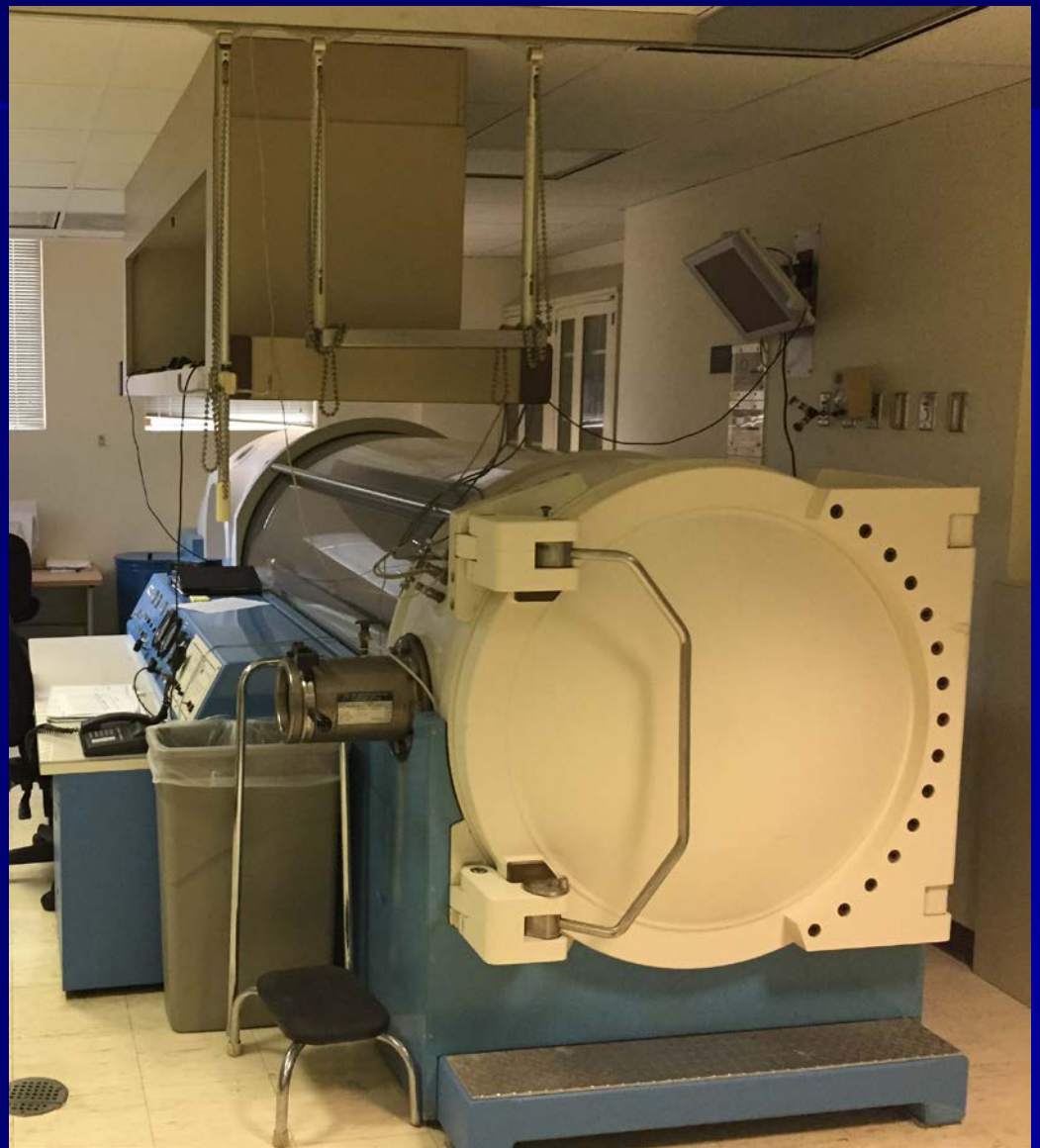
Map Key

- Wound Care Only Available (No Hyperbaric Medicine)
- Both Wound Care and Hyperbaric Medicine Available
- No Outpatient Wound Care or Hyperbaric Available

Henry Ford Health System

HFHS HBO - 1988

Michael
Eichenhron, MD



Typical HBO Treatment

Treatment Table 9

1. Descent rate - 20 ft/min.
2. Ascent rate - 20 ft/min. Rate may be slowed to 1 ft/min depending upon the patient's medical condition.
3. Time at 45 feet begins on arrival at 45 feet.
4. If oxygen breathing must be interrupted because of CNS Oxygen Toxicity, oxygen breathing may be restarted 15 minutes after all symptoms have subsided. Resume schedule at point of interruption (see paragraph 20-7.11.1.1).
5. Tender breathes 100 percent O_2 during last 15 minutes at 45 feet and during ascent to the surface regardless of ascent rate used.
6. If patient cannot tolerate oxygen at 45 feet, this table can be modified to allow a treatment depth of 30 feet. The oxygen breathing time can be extended to a maximum of 3 to 4 hours.

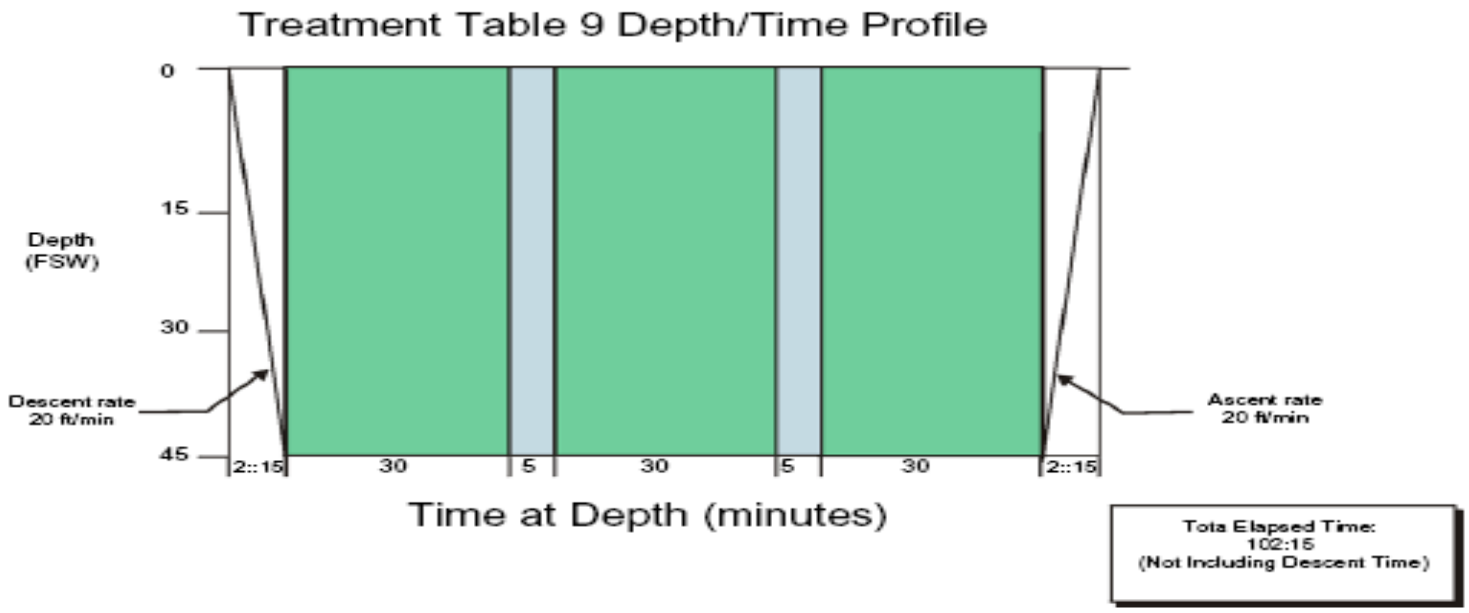


Figure 20-11. Treatment Table 9.

Future Directions

- Pre-Conditioning
  - Mitigates ischemia-reperfusion
- Modulation of the inflammatory cascade
  - IBD and other chronic inflammatory conditions

UNIVERSITY *of* CALIFORNIA, SAN DIEGO
MEDICAL CENTER, HYPERBARIC DEPARTMENT

THANKS!!!
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Henry Ford Hyperbarics

- Thanks!!
- Dr Eichenhorn

THANK YOU

- Hyperbaric Questions
- Fitness to Dive

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