Critical Care in the Monoplace Chamber


Key points

• Staff must be certified and experienced in CCM
• Proximity to CCM services
• Must have study patient in chamber quickly
• CCM equipment
  • Without certain modifications, treating critically ill patients is compromised.

CCM Issues for HBO2 Therapy

• All will be intubated, sedated, so will require pressors
• IV capability (number, special pass-throughs)
• IV pumps
• Monitoring (ECG, invasive BP, EtCO2, ABG, ICP, brain PO2)
• Minimize perturbations (insulin, nutrition, sedation, analgesia, other ICU care)
• Transport

Critical Care - Monoplace

• 30 minutes, so only key points
• Highly suggest critical care medicine is involved
• Pitfalls
• Ventilator and IV issues
**Intervention & Medications**

- IV Therapy (9 Pumps)
  - Levophed
  - Dobutamine
  - Neosynephrine
  - Epi-Ca
  - Propofol
  - Fentanyl
  - Bicarb
  - FFP
  - KCl, Mg, Ca
  - LR

**IV Pass-throughs**

- Sechrist and Maxim
- Maxim — removable back-check valve so we can sample blood

**Materials & Methods**

- Occlusion pressure was adjusted for all three pumps
- Pump flow accuracy was tested for the monoplace hyperbaric chambers at different rates, pressures, and volumes

**Introduction**

- No FDA cleared infusion pumps for use with monoplace or multiplace chambers
- Two infusion pumps will work:
  - Zyno Medical Z-800F
  - Baxter Flo-Gard® 6201 infusion pumps


Results:

Monoplace 1 ml/hr CO profile

Monoplace 10 ml/hr CO profile

IV Performance – Tubing Compliance

Measured Fluid Volumes (ml) at 3.0 atm abs During Compression and Cumulative Compression/Decompression

IV Administration Issues

- IV tubing compliance
- Lack of drug administration for more than 10 minutes with HBO2 compression
- Bolus during decompression


A Solution to Tubing Compression

- Hard tubing plumbed from the door of the pump to the chamber
- Use Baxter pump for very low rates
- Pull IV set up as far as possible

IV, 5 or more lines

- Saline
- Levophed
- Insulin
- Fentanyl
- Propofol ("propofed")

Custom IV Penetrators

Ventilator Issues

- Marginal in performance, antiquated in function
  - No assist modes
  - No alarms
- Limited Options
  - Sechrist 500A
  - Omni-vent (Max O2, Magellan, Atlantis)
  - Atlantis (based on Omni-vent)

Sechrist 500A Ventilator

- Spirometer
- Airway Pressure
- Flow
- E-time
- T-time
- Nebulizer (we omit)
Sechrist 500A performance

\[ \Delta V_t (\%) \]

\( P = 55 \text{psig} \)

\( P = 85 \text{psig} \)

Weaver, et al. JHyperMed 1988

High Pressure Gases for Optimal Ventilator Operation

Manifold (85 psig)

Source (140 psig)

Ventilator Limitations

Sechrist 500A

< 15 l/m if PEEP > 10 cm H₂O at >2.4 atm abs

Omni-Vent (Max O₂ or Magellan)

22 l/m at 3 ATA
Monitor RR, Vt!!

Omni-Vent (Magellan); 3 ATA
Septic shock, PP = 22 cm H₂O

Mechanical Ventilation Concerns

- Air-trapping and hyper-expansion are risks, and seen often with VE > 15 l/m, PP > 5 cm H₂O
- Attempts to maintain VE prolong I-time, invert I/E, and stack breaths
- Result: decreased BP, pneumothorax, AGE
- If decrease RR to increase E-time, reduce air-trapping, but PaCO₂ increases (CNS risk for O₂ toxicity and increase in ICP)
PEEP and the Intubated Patient

- If patient needs >40% O₂, will need PEEP and higher chamber pressures to have PaO₂ values >1000 torr and brain PO₂ >150 torr.
- If PaO₂ is lower than desired, elevate by:
  - Increasing chamber pressure (per allocation)
  - Increasing PEEP
  - Improving lung function (bronchodilators, suctioning, diuresis)
  - Reducing CaO₂ – CvO₂ (dobutamine?)

500 A does NOT give 100% O₂!

Air Breathing & Mechanical Ventilation
(We rarely provide air breathing unless specified by protocol)

Anesthesia bag filled externally

One-way pop-off to prevent over-inflation

Sedation for HBO

- Ventilator asynchrony is expected
- Deep sedation and analgesia
  - Fentanyl/Remifentanyl infusion
  - Propofol infusion
  - Levophed (“PropoFed”)
  - Alternative (e.g. Morphine +/- Ativan)
- Paralysis? Prefer none, but if ventilator asynchrony is pronounced, and gas exchange is affected, paralyze (Vecuronium, Cisatricurium if renal insufficiency).

HBO & CCM Monitoring

ECG
ART
RV
PA
SvO2
EtCO2
TcO2
TcCO2
Qt

S-G, Vent, PEEP, Suction

Spirometer  PEEP  Manometer

Suction  Canister

S-G

Multiple gas pass-through

Anesthesia Bag  Suction  Vent supply

Pan-America Hyperbarics

Oxygenation Monitoring During HBO

- Arterial blood gases:
  We perform measurements routinely to assess arterial CO2 and O2 tensions (ABL 525)
- Transcutaneous O2 and CO2?
  Often accurate, occasionally highly inaccurate.

Arterial Blood Gases
Blood gas sampling

ABG sample

Deadspace

Radiometer - ABL 800
Blood is 30% lower than predicted

Hypoxemia During HBO

PaO₂ = 346 torr
(expected 1500 torr)


Hypoxemia with air, Table 6

66 y/o female, AGE following IJ CVC removal.
Hypoxemia with air at 1.9 ata (30 fsw).


Can transcutaneous (PtcO₂) replace PaO₂?
Not always

PtcO₂ and PtcO₂ v. PaO₂ and PaCO₂

10 healthy subjects
Myringotomies: Intubated Patients Required in HOBIT

- Variable, some do them, others do not
- We did them routinely until 1992, then stopped because of CO RCT and survey results (of 20 centers half did them and half did not).
- No apparent damage to inner ear
- Patients need to be deeply sedated for compression
- Study warranted

Hypotension

- Compression – insufficient pressors
- Auto-PEEP
- Sepsis
- Decompression – Auto-PEEP, increasing tidal volume, pneumothorax
- Anytime – sedation level, esp. propofol

PEEP, sedation, paralysis

(Improve oxygenation)

- Auto-PEEP is common. If BP falls during HBO₂, often due to auto-PEEP
- We increase PEEP to improve lung function
- Recruitment (PEEP) before HBO₂
- Sedation (Fentanyl, Ativan, Propofol)
- Propofol: have levophed ready (“propofed”)
- Paralysis – rarely, but do this if PaO₂ marginal and HBO₂ continued

Cardiac Arrest and HBO²

- 66 y/o female, AGE following II CVC removal, severe hypoxemia. Arrest with dropping PaO₂ as chamber depressurized. Prolonged CPR. Brain injury, died days later (published).
- 60 y/o female, epidural spinal abscess, CRF, shock, levophed, epi; VT – synch cardioversion. MOF, withdrawal days later.
- 55 y/o female, DM, chest wall necrotizing fasciitis, shock, pressors, cardiac arrest: emergent decompression, Defib unsuccessful, pulled chest dressings off, Defib again in the wound, successful. MOF, withdrawal days later.
- Breast Ca, XRT, chronic chest wound, Aortic stenosis, stable heart failure; 3rd HBO₂, acute lung edema… OK, HBO₂ resumed, acute lung edema, then arrest, died (published)

Mortality and APACHE II

<table>
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<th>Diagnosis (n)</th>
<th>APACHE II</th>
<th>Mortality (%)</th>
<th>Predicted Mortality (%)</th>
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<td>AGE/AGE (5)</td>
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<td>40</td>
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<td>Failing Flaps (3)</td>
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