Symposium on Hyperbaric Oxygen Therapy

HBO Therapy for Carbon Monoxide Poisoning ICU perspectives

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Contents

- Hyperbaric oxygen (HBO) therapy in Hong Kong
- It's application for patients with severe CO poisoning in Hong Kong

Hyperbaric Oxygen Therapy in Hong Kong

HBO facilities in Hong Kong

- Public
  - The Recompression Treatment Centre at Stonecutter's Island (multiplace chamber)
  - Burn Unit of the Prince of Wales Hospital (monoplace chamber)
- Private
  - Hong Kong Diving Medicine and Hyperbaric Medicine Center at Shum Wan Road, Wong Chuk Hang

Hong Kong Diving Medicine and Hyperbaric Medicine Centre
香港潛水醫學及高壓氧醫學中心

- Stable patients with chronic problems
  - Burn injury
  - Crush injury
  - Radiation injury
  - Chronic wound
  - Osteomyelitis
- http://www.hkhyperbaric.com/


Asia Hyperbaric Center

The Recompression Treatment Centre (RTC)

- Up to 1994, recompression therapy was provided by UK Royal Navy
- RTC opened in 1994
  - Operated by HK Fire Services Department
  - Maintenance by EMSD
  - Medical supervision offered by Occupational Health Division, Labour Department

Year of 1981


KOWLOON
九龍
HONG KONG ISLAND
香港島
VICTORIA HARBOUR
維多利亞港
KOWLOON TONG
MONG KOK
SHAM SHUI PO
CHEUNG SHA WAN
LAI CHI KOK
SHEK KIP MEI
SAN PO KONG
NGAU CHI WAN
RAZOR HILL
Tseng Lan Shue
NGAU TAU KOK
SAU MAU PING
TSEUNG KWAN O
HO MAN TIN
TO KWA WAN
KOWLOON BAY
KWUN TONG
LAM TIN
BLACK HILL
YAU TONG
RENNIE'S MILL
HUNG HOM
TSIM SHA TSUI
Ngong Shuen Chau
(Stonecutters Island)
NORTH POINT
北角
QUARRY BAY
鰂魚涌
Lei Yue Mun
TSEUNG KWAN O
SAI YING PUN
CENTRAL DISTRICT
中環
MT. DAVIS
WAN CHAI
灣仔
CAUSEWAY BAY
大坑
TAI HANG
SHAU KEI WAN
VICTORIA PEAK
太平山
Peak tram
MAGAZINE GAP
HAPPY VALLEY
跑馬地
MT. BUTLER
POK FU LAM
MT. KELLETT
MT. PARKER
CHAI WAN
SIU SAI WAN
Aberdeen Res
ABERDEEN
香港仔
WONG CHUK HANG
Tai Tam Reservoirs
MT. COLLINSON
VIOLET HILL
BIG WAVE BAY
DEEP WATER BAY
Ap Lei Chau
MA KONG SHAN
Middle Island
REPULSE BAY
George Island
TUNG POK LIU HOI HAP
(EAST LAMMA CHANNEL)
SHEK O
TAI TAM WAN
D'AGUILAR PEAK
CHUNG HOM WAN
STANLEY
CHEK CHUE WAN
Round Island
南丫島
PICNIC BAY
Sok Kwu Wan
LAMMA ISLAND
TUNG O WAN
STANLEY PENINSULA
SHEUNG SZ MUN


九龍半島
KOWLOON PENINSULA
Year of 2010
Kam Shan Country Park
Lion Rock Country Park
Ma On Shan Country Park
TATE'S CAIRN (TAI LO SHAN)
BEACON HILL
HA KWAI CHUNG
MEI FOO
LAI CHI KOK
CHEUNG SHA WAN
KOWLOON TONG
SHEK KIP MEI
SHAM SHUI PO
PRINCE EDWARD
STONECUTTERS ISLAND (NGONG SHUEN CHAU)
TAI KOK TSUI
MONG KOK
OLYMPIC
MA TAU WAI
HO MAN TIN
YAU MA TEI
KOWLOON
JORDAN
TSIM SHA TSUI
WONG TAI SIN
TSUEN SHEK SHAN
TSZ WAN SHAN
KOWLOON PEAK (FEI NGO SHAN)
LOK FU
SAN PO KONG
CHOK HUNG
KOWLOON CITY
KOWLOON BAY
MA TAU KOK
SAU MAU PING
NGAU TAU KOK
TO KWA WAN
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LAM TIN
YAU TONG
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SAI YING PUN
SAI WAN
SHEUNG WAN
HONG KONG
KENNEDY TOWN
CENTRAL
ADMIRALTY
WAN CHAI
CAUSEWAY
VICTORIA HARBOUR
NORTH POINT
QUARRY BAY
FORTRESS HILL
TAIKOO SHING
TIN HAU
SAI WAN HO
SHAU KEI WAN
HENG FA CHUEN
Tai Tam Country Park (Quarry Bay Extension)


JU 9886


嚴禁吸煙
No Smoking


vcast


嚴禁吸煙
No Smoking

RTC at Stonecutter's island

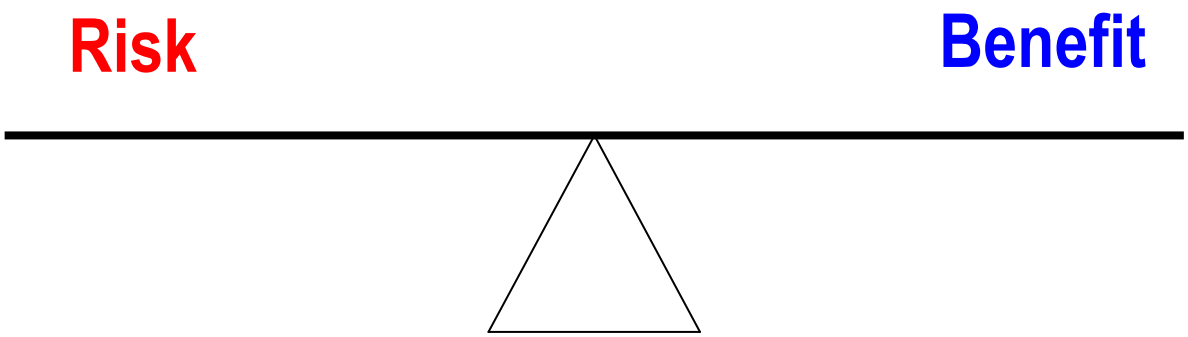
- Not only for medical uses
  - Also for disciplinary forces training

- Not attached to hospital
- Only basic monitoring and resuscitative equipments available
- Crowded environment

Emergency Trolley

Medical equipments and consumables

- Occupational Health Division of Labour department
  - Not used to deal with clinical emergencies or resuscitation
  - No nursing nor clerical support
- In case of unexpected event, no immediate support
  - From own department or
  - From other clinical specialties


Risk
Benefit

Indications for HBO –Undersea and Hyperbaric Medical Society (UHMS)

- Related to diving and compressed air work
  - decompression illness
  - Air or gas embolism
- Acute conditions
  - Carbon monoxide +/- cyanide poisoning
  - Clostridial myonecrosis
  - soft tissue necrotising infections
  - Crush injury, compartment syndrome and other traumatic ischaemias
  - Exceptional blood loss anaemia
  - Enhancement of problem wound healing
  - Intracranial abscess
  - Refractory osteomyelitis
  - Delayed radiation injury (soft tissue and bone necrosis)
  - Compromised skin flap or graft
  - Thermal burns

HBO treatment in RTC in 2008-2009

	2008		2009	
	No. of new cases	Total no. of treatment session	No. of new cases	Total no. of treatment sessions
DCI	6	14	7	7
CO poisoning	4	12	6	17
Gas gangrene	0	0	1	2
Osteoradionecrosis	9	198	13	286
Total	**19**	**224**	**27**	**312**

Use of HBO in CO poisoning in HK

HBO Indications	No. of cases (%)	HBO given (%)
Present *	59 (19.5)	4/59 (6.8)
Absent	244 (80.5)	0/244 (0)
Total	**303 (100)**	**4/303 (1.3)**

* *Hx of syncope / coma, cardiac ischemia/arrhythmia or CO-Hb>25%*

Hong Kong Poison Information Centre

Reasons for low HBO referral in HK

- Evidence of efficacy of HBO therapy
- Risk of Transport and lack of support in RTC
- Occupational health risk
- Manpower shortage

The New England Journal of Medicine

VOLUME 347 OCTOBER 3, 2002 NUMBER 14

HYPERBARIC OXYGEN FOR ACUTE CARBON MONOXIDE POISONING

LINDELL K. WEAVER, M.D., RAMONA O. HOPKINS, PH.D., KAREN J. CHAN, B.S., SUSAN CHURCHILL, N.P., C. GREGORY ELLIOTT, M.D., TERRY P. CLEMMER, M.D., JAMES F. ORME, JR., M.D., FRANK O. THOMAS, M.D., AND ALAN H. MORRIS, M.D.

TABLE 2. OUTCOMES AT 6 WEEKS, 6 MONTHS, AND 12 MONTHS AFTER ENROLLMENT.*

OUTCOME	HYPERBARIC-OXYGEN GROUP (N=76)	NORMOBARIC-OXYGEN GROUP (N=76)	UNADJUSTED ODDS RATIO (95% CI)†	P VALUE
	no./total no. (%)			
Cognitive sequelae				
At 6 wk				
Intention-to-treat population	19/76 (25.0)	35/76 (46.1)	0.39 (0.20–0.78)	0.007
Patients with complete data	18/75 (24.0)	31/72 (43.1)	0.42 (0.21–0.85)	0.01
Results on cerebellar testing before treatment				
Normal	16/69 (23.2)	23/59 (39.0)	0.47 (0.22–1.02)	0.05
Abnormal	1/3 (33.3)	9/11 (81.8)	0.11 (0.01–1.92)	0.18
At 6 mo				
Intention-to-treat population	16/76 (21.1)	29/76 (38.2)	0.43 (0.21–0.89)	0.02
Patients with complete data	10/58 (17.2)	21/59 (35.6)	0.38 (0.16–0.90)	0.03
At 12 mo				
Intention-to-treat population	14/76 (18.4)	25/76 (32.9)	0.46 (0.22–0.98)	0.04
Patients with complete data	9/62 (14.5)	18/66 (27.3)	0.45 (0.19–1.10)	0.08
Symptoms				
Reported by patient at 6 wk				
Difficulties with memory	21/75 (28.0)	37/72 (51.4)	0.37 (0.19–0.73)	0.004
Difficulties with attention or concentration	24/75 (32.0)	31/72 (43.1)	0.62 (0.32–1.22)	0.17

*The five patients who did not have data on neuropsychological tests at six weeks were assumed to have cognitive sequelae at that time point. Cognitive sequelae present at 6 or 12 months were assumed not to be due to carbon monoxide poisoning if they had not been present at 6 weeks.[2,4-7,11] Patients with cognitive sequelae at 6 weeks who had missing data at 6 or 12 months were assumed to have cognitive sequelae at those time points.

†The normobaric-oxygen group was the reference group. CI denotes confidence interval.

Clinical Effectiveness Unit
Professional Services & Medical Development Division,
Hospital Authority

The Hospital Authority

Healthcare Technology Assessment

Report

Number: HTA TA/03/10

Hyperbaric Oxygen for Carbon Monoxide Poisoning

This report is based on literature search up to Jan 2003

Articles included for review

- Weaver LK, Hopkins RO, Chan KJ, Churchill S, Elliott CG, Clemmer TP, et al. Hyperbaric oxygen for acute carbon monoxide poisoning. NEJM 2002 Oct;347(14):1057-67.

- Scheinkestel CD, Bailey M, Myles PS, Jones K, Cooper JD, Millar IL, et al. Hyperbaric or normobaric oxygen for acute carbon monoxide posioning: a randomised controlled clinical trial. Med J Aust 1999 Mar;170:203-10.

- Thom SR, Taber RL, Mendiguren II, Clark JM, Hardy KR, Fisher AB. Delayed neurologic sequelae after carbon monoxide poisoning: prevention by treatment with hyperbaric oxygen. Ann Emerg Med 1995 Apr;25:474-80.

- Raphael JC, Elkharrat D, Jars-Guincestre M-C, Chastang C, Chasles V, Vercken J-B, et al. Trial of normobaric and hyperbaric oxygen for acute carbon monoxide intoxication. Lancet 1989 Aug;2:414-9.

- Juurlink DN, Stanbrook MB, McGuigan MA. Hyperbaric oxygen for carbon monoxide poisoning (Cochrane Review). In: *The Cochrane Library,* Issue 1, 2003. Oxford: Update Software. A substantive amendment made on 17 February 2000.

- Saunders P. Hyperbaric oxygen therapy in the management of carbon monoxide poisoning, osteoradionecrosis, burns, skin grafts and crush injury. Birmingham: West Midlands Health Technology Assessment Collaboration, University of Birmingham (Collaborative effort with Wessex Institute), ISBN No. 0704421747, Apr 2000:52.

Conclusion in Efficacy

- Inadequate
- Inconclusive
- Conflicting outcomes

Hospital Authority Healthcare Technology Assessment Brief

Clinical Effectiveness Unit PS&MD

HA HTA Brief *offers prompt assessment to new or undecided technologies that may be of value or concern to the HA. It serves as a quick reference to inform care providers and practitioners of the safety, efficacy, opinion and/or state of technology diffusion in other parts of the world. We caution readers to interpret our report in light of the literature search and evidence presented, and on the role of HTA to provide information to aid decision-making on a system level rather than for individual patients. Besides technical efficiency, the suitability of a technology in public health services also depends on its cost-effectiveness, health and economic impacts on the society, resources available to the service provider and competing needs of other patients. By making technical efficiency explicit, one is in a better position to evaluate the other considerations.*

HTA RR/06/03 June 2006

Current Status on Medical Application of Hyperbaric Oxygen Therapy (HBOT)

Prepared by CHUNG, Kai-kwong; TSANG, Kwai-fan Ice and LIU, Hing-wing.

- 9 HTA Agency websites
- Cochrane Collaboration Database

- Publish in recent years
- Good quality studies or reviews

Table 1 Positions of HTA Agencies and Cochrane Database's Systematic Reviews on HBOT
(For details, please see direct quotes in Table.)

HTA Agencies / Conditions	OHTAC	ARIF	AHRQ	AHFMR	WIHRD	CETS	MSAC	WMHTAC	CRD	Cochrane Database
Citation	1	2	3	5	6-10	11	4&12	13	14	15-28
Year published	2005	2004	2003	2003	2002-2003	2001	2000, 2003	2000	1999	2004-2005
Decompression sickness				Support for use		Recommended	Supported. Widely accepted as standard care[1,2]	Widely accepted		
Embolisms (air or gas bubbles in the bloodstream, which may travel to the brain or lungs)				Support for use		Recommended	Supported. Widely accepted as standard care[1,2]			
Gas gangrene				Support for use		Recommended	Supported. Widely accepted as standard care[1,2]	Widely accepted		
Delayed radiation injury: (A) osteoradionecrosis (B) soft tissue radio-necrosis		Effective for (A) but evidence is highly susceptible to confounding & bias		Conditional support for (A). No consensus for (B)		Recommended	Inadequate to claim cost-effective in (A)[4] Supported interim funding for (A) - may be beneficial though evidence is inconclusive[1,2] Did not support (B)[1,2]	Not proven for (A)		May be justified in selected cases[21]
Healing for problem wounds (A) DM wound (B) Others	Low level evidence & inconsistent results			Conditional support for DM wound		Recommended in chronic tissue lesions associated with chronic critical ischaemia	Supported use in DM gangrene & ulcers but not non-DM wounds or pressure sore.[1,2] Inadequate claim on cost- effectiveness[4]		2 small RCTs with conflicting results: 1 showed no effect, another showed a similar rate of amputation but fewer major ones	May be justified in DM foot ulcer. More evidence is needed. Not justified for other chronic wounds[19]
Carbon monoxide poisoning				Conditional support for use	No evidence that it is effective & limited evidence that it may be harmful[7]	Recommended	Did not support[1,2]	Did not support		No evidence to support use[17]

HA Healthcare Technology Assessment
Clinical Effectiveness Unit

- Physicians interested in HBOT are encouraged to undertake trials
- In the meantime
- Based on clinical judgment, subject to individual doctors' understanding and belief
- Patients or relatives – informed about the evidence & uncertainties
- Balanced risks and benefits

The Hong Kong Society of Critical Care Medicine Position Statement

Protocol of Hyperbaric Oxygen Therapy for critically ill patients in Hong Kong

Dr YAN Wing Wa on behalf of the HKSCCM

This Position Statement was endorsed by the HKSCCM Council in the 14th Council Meeting on 18 May 2010

Introduction

Hyperbaric oxygen (HBO) therapy is the breathing of 100% oxygen inside a treatment chamber at a pressure higher than one atmosphere absolute (1 ATA). In Hong Kong, up to 1994, recompression therapy was provided by the United Kingdom Royal Navy. After the Recompression Treatment Centre (RTC) was open in 1994 in Ngong Shuen Chau, HBO was operated by the Hong Kong Fire Services Department, with maintenance provided by the Electrical and Mechanical Services Department (EMSD), and medical supervision offered by the Occupational Medicine Division (OMD) of the Labour Department. There are some limitations of treating critically ill

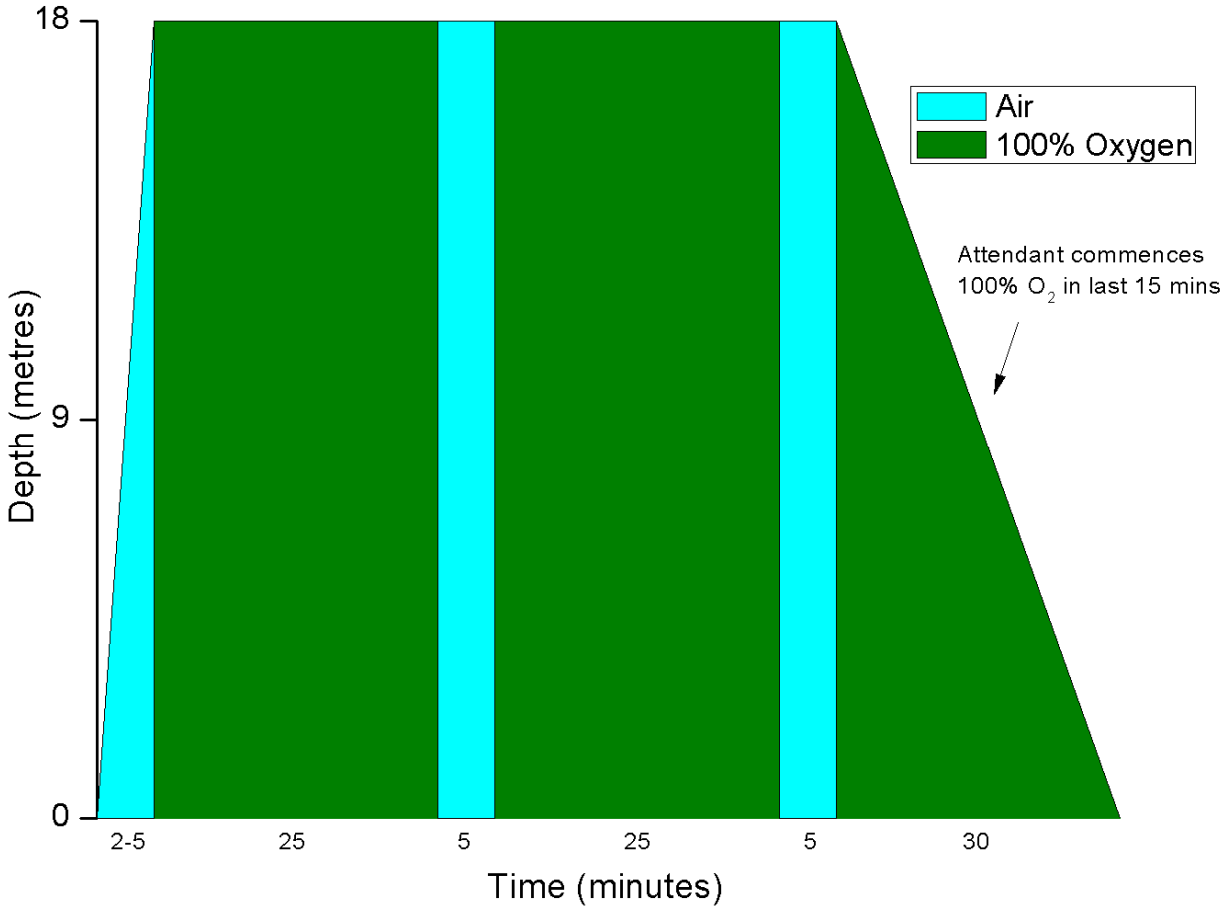
Indications for HBO –Undersea and Hyperbaric Medical Society (UHMS)

- Related to diving and compressed air work
  - decompression illness
  - Air or gas embolism
- Acute conditions
  - Carbon monoxide +/- cyanide poisoning
  - Clostridial myonecrosis
  - soft tissue necrotising infections
  - Crush injury, compartment syndrome and other traumatic ischaemias
  - Exceptional blood loss anaemia
  - Enhancement of problem wound healing
  - Intracranial abscess
  - Refractory osteomyelitis
  - Delayed radiation injury (soft tissue and bone necrosis)
  - Compromised skin flap or graft
  - Thermal burns

PYN ICU indications for HBO in CO poisoning

- Loss of consciousness at any time
- Neurological symptoms and signs
- Chest pain or evidence of myocardial ischemia
- Pregnancy
- CO-Hb >25%

Treatment table for CO poisoning (Royal Navy table 60)
Total treatment duration is 90 mins



Process of transfer to RTC

- An accurate assessment and preparation of patient before transport
- Effective liaison between referring and receiving staff
- Deployment of appropriately trained staff
- Availability of essential equipment and drugs
- Adequate monitoring for patient
- Appropriate infection control measures
- Proper documentation

Contraindications

- Abnormal Eustachian Tube function
  - e.g. Upper respiratory tract infections or sinusitis
  - ENT assessment to ensure normal Eustachian tube function
  - prophylactic myringotomy if necessary
- Drug therapy with
  - doxorubicin, disulfiram, bleomycin, cisplatin or mafenide acetate
- Untreated pneumothorax
- Claustrophobia or emotional unstable

Severe lung dysfunction

- May affect the effectiveness of HBO
  - e.g. compromised flaps need to be treated with 2ATA
    - PaO_2 133-187kPa (1,000-1400 torr)
    - If PaO_2 <107kPa (800 torr) → HBO not effective
- Desaturation during air break
  - If FiO_2 > 0.4 in order to maintain adequate PaO_2

Severe haemodynamic instability

- Not syringe / infusion pump allowed inside chamber
- Nitrogen purge is not available
- Limitations of equipment and expertise
- Crowded environment
- Long distance of between hospital and RTC

An accurate assessment and preparation of patient before transport

- Medical conditions that required special attention
- Anticipate probable and possible complications
  - *Respiratory*
    - Chronic obstructive lung disease (emphysema)
    - Asthma
    - Upper respiratory infection
    - History of thoracic surgery
    - History of spontaneous pneumothorax
    - Pneumothorax (all pneumothorax should be drained first)
    - Chest x-ray film with asymptomatic pulmonary lesions
  - *Otolaryngologic*
    - Chronic sinusitis
    - History of ear surgery

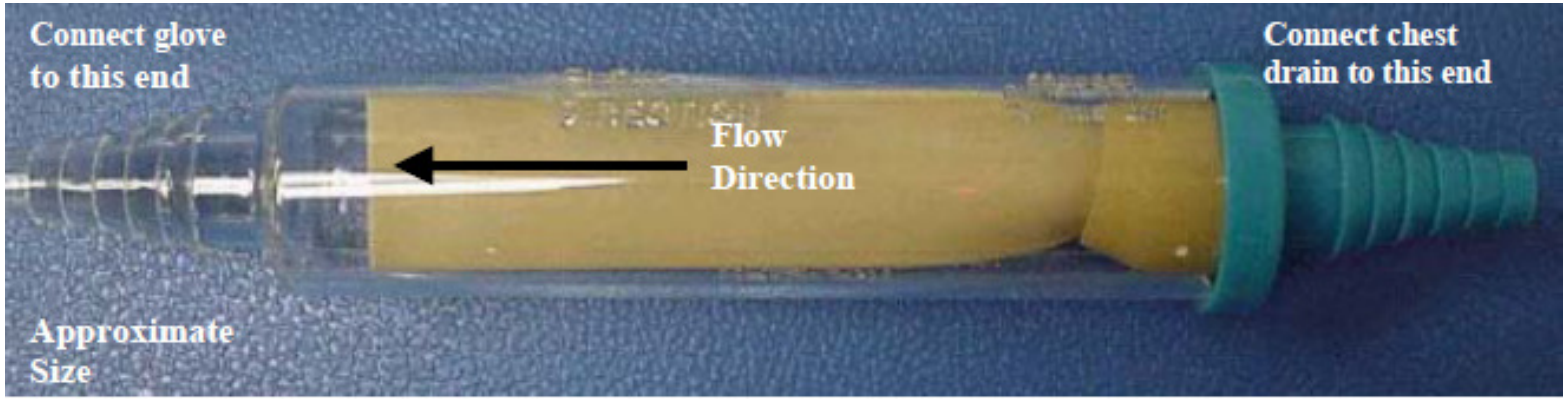
An accurate assessment and preparation of patient before transport

- Medical conditions that required special attention
  - *Ophthalmologic*
    - History of optic neuritis
  - *Neurologic*
    - Seizure disorder
  - *Haematologic*
    - Congenital spherocytosis
  - *Systemic*
    - Viral infections
    - Hyperthermia (uncontrolled high fever)
  - *Miscellaneous*
    - Pregnancy

An accurate assessment and preparation of patient before transport

- Inform consent from patient
- Explain to relatives
- Myringotomy for comatose patients
  - Not routine in some centres
- Tracheal cuff filled with water/saline
- Simplify treatment / monitoring if possible
- Connect all tubes/drains to BSB
  - Chest drain to chest drain box/Hemlich valve with BSB

Heimlich valve



Effective liaison between referring and receiving staff

- Staff of OMD of Labour Department and Fire Services Department should be notified before transport
- Exact treatment time and duration of HBO
- Police escort is very helpful especially during rush hours (intubated patient)

Deployment of appropriately trained staff

- Experienced (with HBO therapy) ICU doctor should accompany the patient throughout the whole procedure although he/she may not need to enter into the chamber
- Need to know how to operate the ventilator and monitor the tidal volume

Occupational Safety for Staff

- Occupational health safety programme for staff

- Normal Eustachian Tube function
- No history of pneumothorax
- No history of obstructive or restrictive airway diseases, no history of chest surgery
- Not pregnant
- No recent diving

Occupational Safety for Staff (2)

- No flying after dive – at least 24 hours
- Recognise symptoms of complications of HBO and seek treatment
  - Barotrauma especially ears
  - Decompression illness e.g. joint pain, numbness, weakness etc.
- Consult chamber doctors urgently if DCI is suspected


醫生
DOCTOR

Availability of essential equipment and drugs

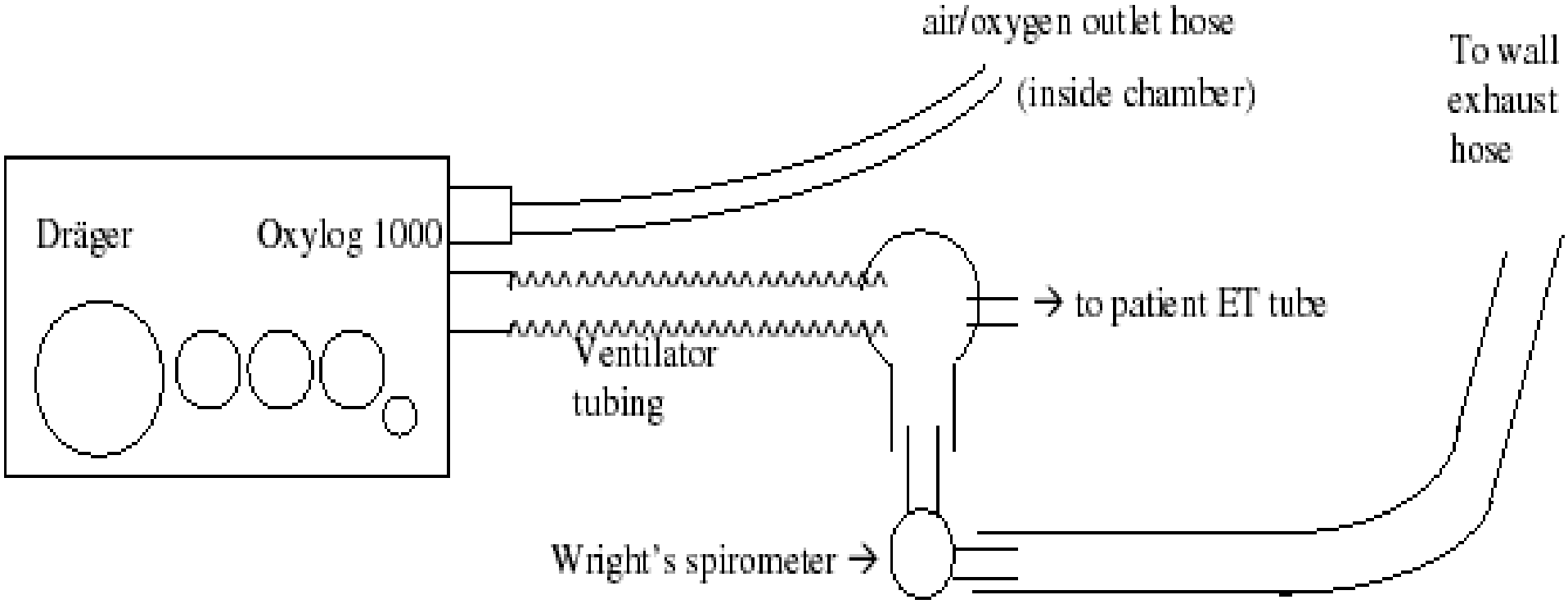
- Only essential and hyperbaric compatible equipment are allowed to be used inside a chamber
- Any item potentially inflammable are strictly prohibited
- Collapsible bag intravenous bags instead of rigid plastic bags be used to avoid inadvertent gas embolism
- Common drugs for resuscitation is available inside chamber / within RTC (air-lock)


報紙
打火機


Dräger
Oxylog 1000
Psupply
Paw
Air
Mix
Pmax
mbar
25
55
Freq
10
35
5
1/min.
MV
10
7
3
20
L/min.
O
-10 mbar 80
Abridged Instructions for use of the Oxylog 1000

Ventilator Circuit

Ventilator connection diagram



Ventilation

- Oxylog 1000 is to be used for ventilating patient in the hyperbaric chamber.
- One may refer to the calibration table provided by the chamber
- Wright's spirometer should be connected into the ventilator circuit for tidal volume monitor.
- Expired gas from patient should be scavenged by attached tubing
  - Not dump into the chamber

Monitoring during HBO

- Clinical monitoring
  - Conscious state
  - Cyanosis
  - Chest movement
  - Pulse rate
- Anticipate complications
  - Barotrauma (ear, sinuses, lung, tooth caries/fillings)
  - Oxygen toxicity (convulsion)
  - CO2 narcosis (decrease in conscious state)
  - Nitrogen narcosis (euphoria, hallucination, coma)
  - Decompression illness (DCI)
  - Claustrophobia
  - Reversible worsening of visual acuity
  - Transient GI pain

Monitoring (2)

- Build-in multi-parameter physiological monitoring system
  - ECG, heart rate
  - SpO2, plethysmography (may not be accurate)
  - Respiratory rate
  - Capnography (may not be accurate)
  - Blood pressure
    - Invasive arterial pressure monitoring (continuous)
    - Non-invasive blood pressure (intermittent)
    - Pulmonary artery catheter monitoring
- Module inside chamber, monitor outside chamber
  - No monitor with a hot wire stylus inside the pressure chamber


Rack 1
Rack 2

Monitoring (3)

- Invasive arterial pressure monitor
  - Pressure bag volume and pressure should be monitored during descent and ascent
  - No bubble allowed within tubings
  - Zero pressure transducer with reference to chamber pressure in the standard way
- No mercury sphygomanometer
  - Risk of spillage of Hg and contamination
- No battery-run monitoring system
  - Fire risk, unless it is purged continuously with nitrogen
- For central venous line
  - Try to avoid subclavian puncture, risk of undetected lung puncture resulting in pneumothorax

Appropriate infection control measures

Proper documentation

Case presentation

- M/39, unremarkable past health
- Diagnosis of Fournier's Gangrene, care in ICU
- Put on IV Tazocin + Flagyl + Clindamycin
- Laparotomy and debridement done
- Borderline hemodynamic
- Worsening RFT / metabolic acidosis requiring CVVH
- R scrotal abscess swab & peritoneal fluid grew *Bacteriodes sp.* & *Propionibacterium Granulosum*

ICU Progress

- Multiple sessions of follow-up debridement
- Started hyperbaric oxygen therapy (HBO) after 2nd debridement (2.5 ATM for 1.5 hours Daily)
- Unable to tolerate “air-break” during ascending phase after 2 sessions of HBO therapy with near-arrest requiring adrenaline injection
- Further HBO therapy stopped and patient eventually died

Their learning points

- HBO is just an adjunct therapy for Fournier's gangrene
- May increase patient survival
- Not suitable for unstable patients i.e. on high ventilation demand, inotrope dependent and not fit for transfer.

We hope in near future

Hospital-based Hyperbaric Medicine Unit

- Inside a hospital
- Medical, nursing and technical staff
- Multiplace / monoplace hyperbaric chambers
- Adequate space
- Provide hyperbaric therapy and consultation
- Quality Assurance, training and research programme
- A safe HBO therapy is possible for patients and staff

Thank you.