EBM Conference on Emergency Medicine
Commissioned Training Programme of COC (A&E)

Critical Care During Hyperbaric Oxygen Therapy

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Scope

- Hyperbaric therapy in Hong Kong
- Indications / Contraindications of hyperbaric therapy (in Hong Kong setting)
- Care of critically ill patients for hyperbaric oxygen therapy

Hyperbaric Therapy in Hong Kong

HBO centres in Hong Kong

- Public
  - The Recompression Treatment Centre at Stonecutter's Island
- 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


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


JU 9886


消防處加壓室設施
FSD
COMPRESSION CHAMBER FACILITY

Year of 1981


KOWLOON
九龍
CHEUNG SHA WAN
SHEK KIP MEI
LAI CHI KOK
SHAM SHUI PO
KOWLOON TONG
SAN PO KONG
NGAU CHI WAN
KAI TAK
HK International Airport (Kai Tak)
RAZOR HILL
Tseng Lan Shue
MONG KOK
TO KWA WAN
HO MAN TIN
NGAU TAU KOK
SAU MAU PING
TSEUNG KWAN O
Ngong Shuen Chau
(Stonecutters Island)
YAU MA TEI
KOWLOON BAY
KWUN TONG
LAM TIN
BLACK HILL
HUNG HOM
TSIM SHA TSUI
YAU TONG
RENNIE'S MILL
VICTORIA HARBOUR
TSEUNG K
NORTH POINT
QUARRY BAY
Lei Yue Mun
LEI YUE MUN
SULPHUR CHANNEL
SAI YING PUN
CENTRAL DISTRICT
CAUSEWAY BAY
TAI HANG
MT. DAVIS
WAN CHAI
SHAU KEI WAN
Fat Tong Chau
VICTORIA PEAK
Peak tram
POK FU LAM
MAGAZINE GAP
HAPPY VALLEY
MT. BUTLER
MT. PARKER
CHAI WAN
SIU SAI WAN
MT. KELLETT
Cape Collinson
HONG KONG ISLAND
香港島
Aberdeen Res
Tai Tam Reservoirs
WONG CHUK HANG
ABERDEEN
VIOLET HILL
MT. COLLINSON
BIG WAVE BAY
DEEP WATER BAY
Ap Lei Chau
REPULSE BAY
MA KONG SHAN
Middle Island
SHEK O
George Island
TUNG POK LIU HOI HAP
(EAST LAMMA CHANNEL)
CHUNG HOM WAN
TAI TAM WAN
D'AGUILAR PEAK
STANLEY
CHEK CHUE WAN
Round Island
PICNIC BAY
HA MEI WAN
Sok Kwu Wan
STANLEY PENINSULA
LAMMA ISLAND
TUNG O WAN
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
KOWLOON PEAK
(FEI NGO SHAN)
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
MONG KOK
TAI KOK TSUI
OLYMPIC
STONECUTTERS ISLAND
(NGONG SHUEN CHAU)
MA TAU KOK
MA TAU WAI
HO MAN TIN
YAU MA TEI
KOWLOON CITY
KOWLOON BAY
NGAU TAU KOK
KWUN TONG
SAU MAU PING
LAM TIN
TO KWA WAN
JORDAN
TSIM SHA TSUI
KOWLOON
HUNG HOM
YAU TONG
NORTH POINT
QUARRY BAY
FORTRESS HILL
TAIKOO SHING
TIN HAU
SAI WAN HO
SHAU KEI WAN
HENG FA CHUEN
SAI YING PUN
SAI WAN
SHEUNG WAN
HONG KONG
KENNEDY TOWN
CENTRAL
ADMIRALTY
WAN CHAI
CAUSEWAY BAY
VICTORIA HARBOUR
VICTORIA PEAK
WONG TAI SIN
SAN PO KONG
CHOK HUNG
TSZ WAN SHAN
TSUEN SHEK SHAN
LOK FU
SCALE 1 : 34 965


嚴禁吸煙
No Smoking

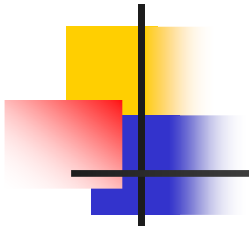

vcast

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 skillful in dealing 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

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

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

Contraindications (revised)

- Clinically very unstable patients (in Hong Kong setting)
- 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
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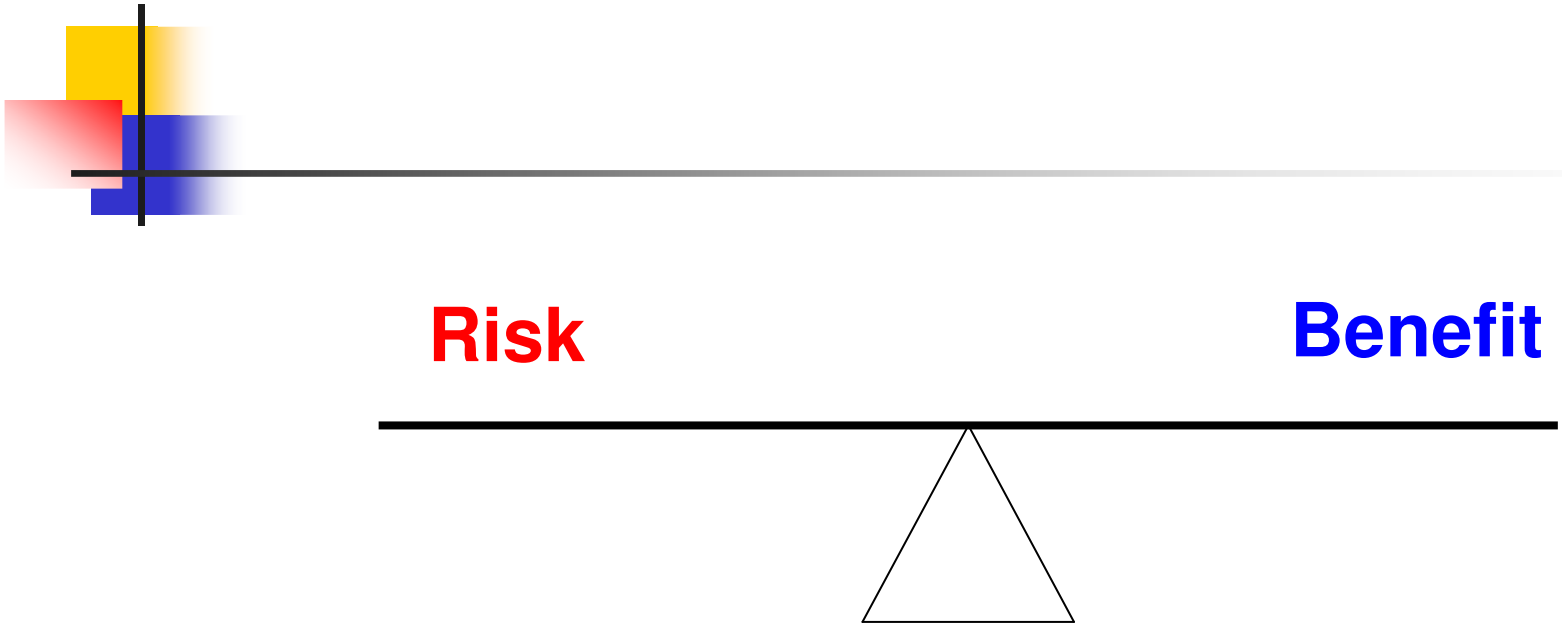

Risk
Benefit

Clinical Protocol for Hyperbaric Oxygen Therapy

Protocol for ICU Patients Undergoing HBO Treatment (1)

- Examine indication
- Observe all contraindications
- Medical conditions that required special attention
  - *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

Protocol for ICU Patients Undergoing HBO Treatment (2)

- 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

Protocol for ICU Patients Undergoing HBO Treatment (3)

- Discuss with chamber doctor
- Inform consent from patient
- Explain to relatives
- Prepare for the out-of-hospital transfer
- Simplify but not compromise monitoring & treatment before HBO
- Anticipate probable and possible complications
- May need bilateral myringotomy before HBO
- 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

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

For Monitoring Equipment


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 pneumonthorax
- For pulmonary artery catheter (Swan Ganz catheter)
  - Balloon port should be left open if not measuring wedge pressure
  - Measure wedge pressure during descent/ascent is not advisable

Monitoring (4)

- Arterial blood gases analysis
  - Specimen taken inside chamber and analyzed at surface
  - pH and PCO_2 are reasonably accurate
  - PO_2 must either use specially adjusted equipment within chamber, or expect spurious results (due to “off-gassing”)

	3 ATA		1 ATA	
	Blood	Bubble	Blood	Bubble
PO_2/mmHg	1800	477	1800	149
PCO_2/mmHg	40	0	40	0
PH_2O/mmHg	47	47	47	47
PN_2/mmHg	0	1756	0	564
Total	1887	2280	1887	760

Oxygen/Air with build-in-breathing system

Should be tightly fit

Build-in-breathing system

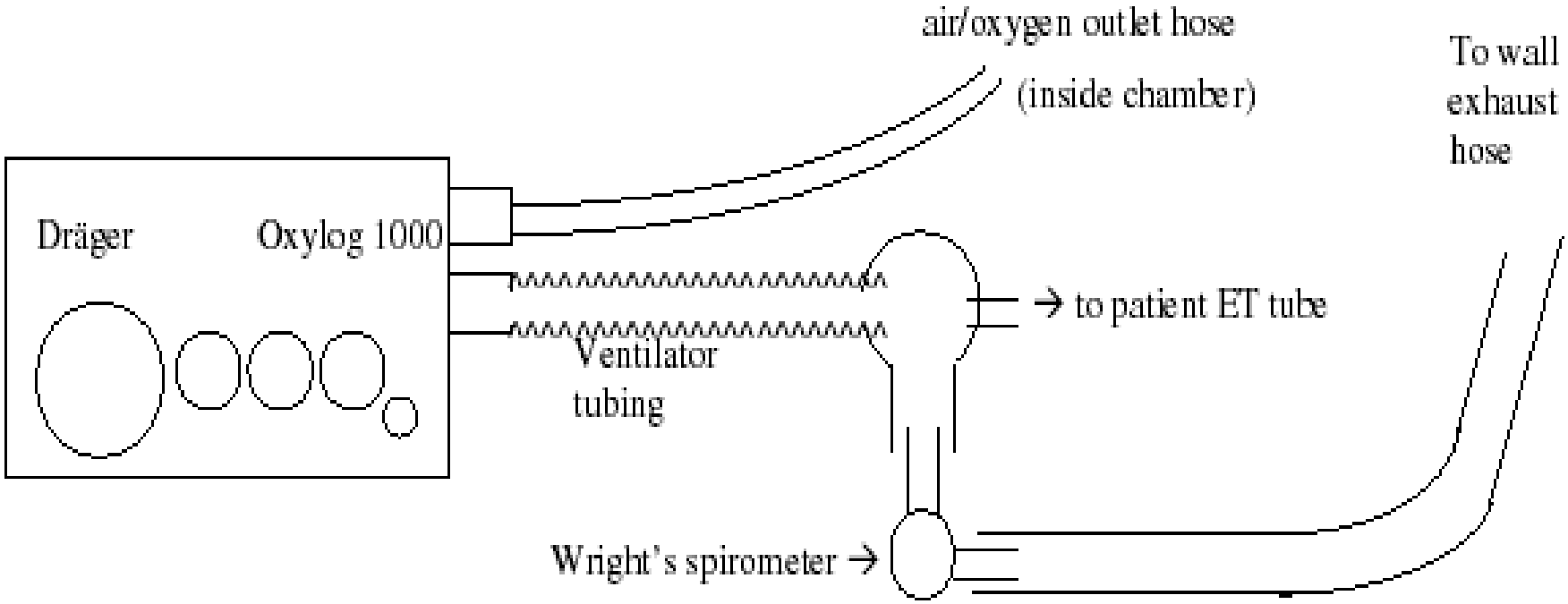
Hood
for uncooperative patient

Should have inlet and outlet limbs

Ventilation

- Endotrachael tube/Tracheostomy tube
  - Use **water** to inflate the cuff.
- Mechanical ventilator systems
  - Oxylog 1000 is to be used for ventilating patient in the hyperbaric chamber. When the chamber pressure is changed, the tidal volume delivered to the patient will change accordingly.
  - 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. (Wright spirometer should be calibrated first)
  - Expired gas from patient should be scavenged by attached tubing
    - Not dump into the chamber

Ventilator connection diagram




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

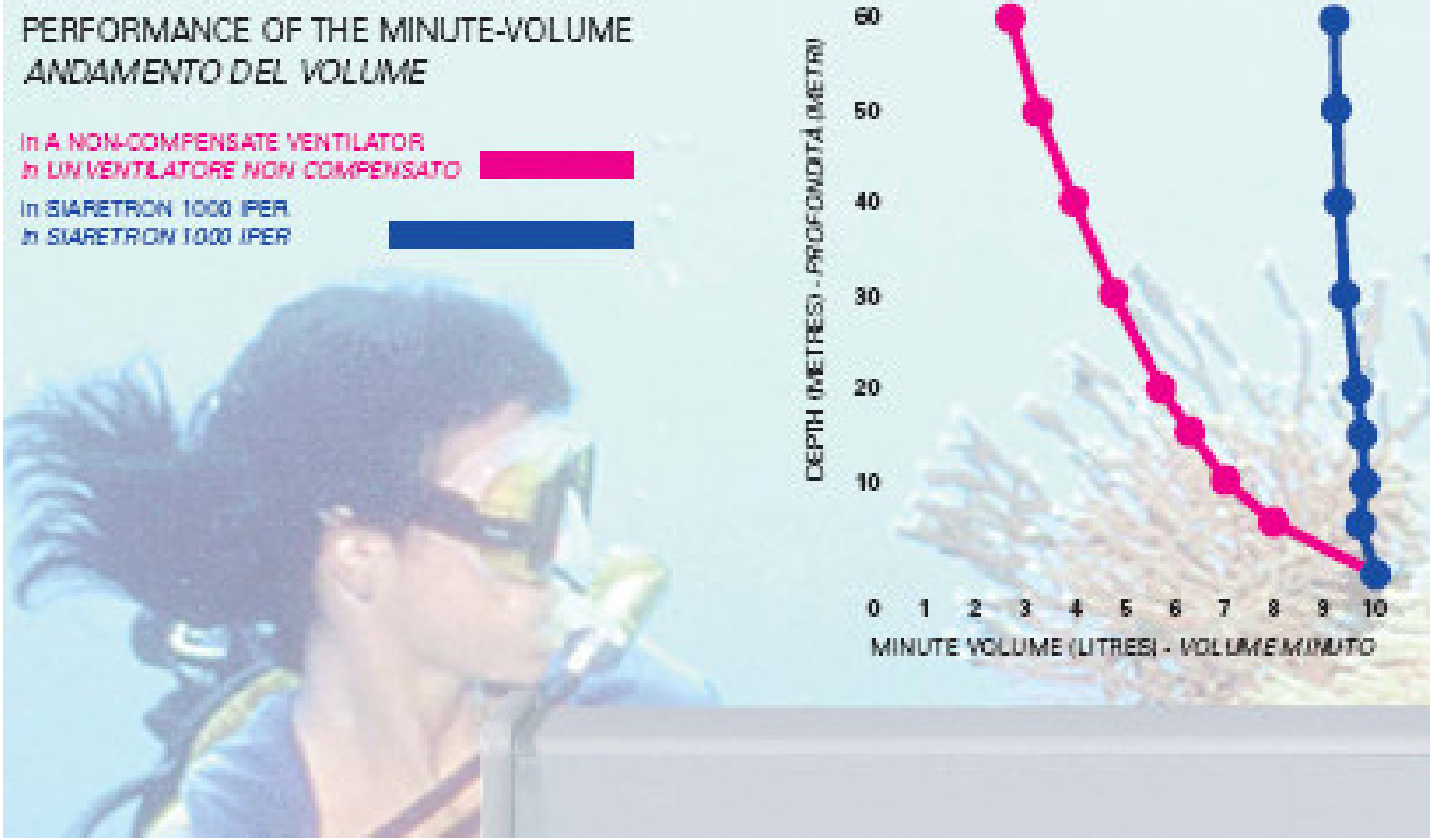
Lung ventilator for hyperbaric chamber

SIARETRON 1000 IPER

PERFORMANCE OF THE MINUTE-VOLUME
ANDAMENTO DEL VOLUME

In A NON-COMPENSATE VENTILATOR
In UN VENTILATORE NON COMPENSATO

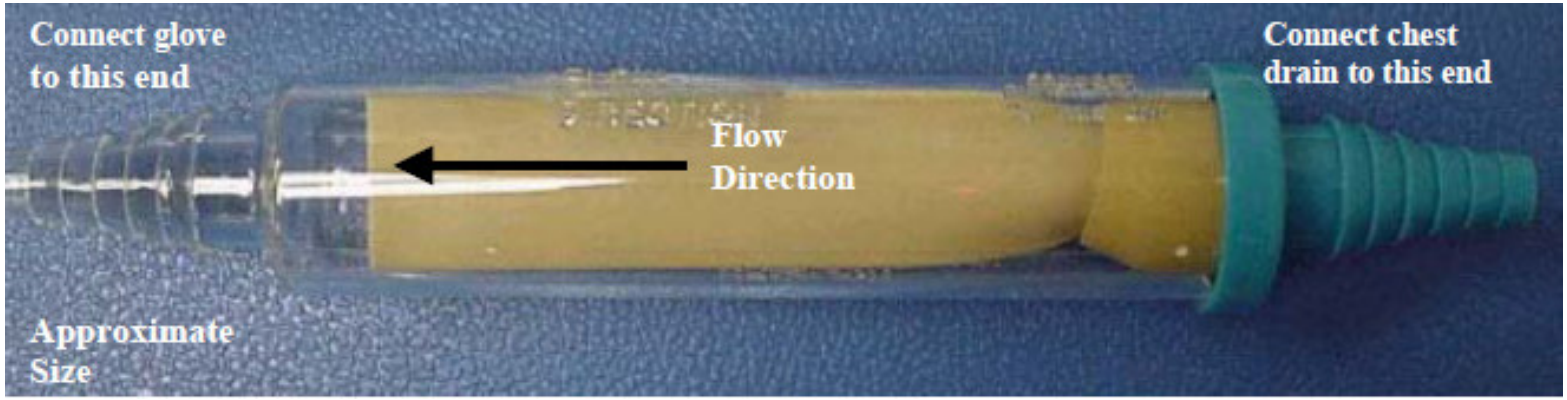
In SIARETRON 1000 IPER
In SIARETRON 1000 IPER



Respiratory

- Chest tube drainage system
  - Must have thoracostomy set ready within vicinity of chamber for emergency chest drain insertion
  - Monitor chest drain box air-fluid level during descent and ascent
  - May substitute with one-way Heimlich valve

Heimlich valve



Intravenous therapy

- Avoid glass bottle
  - Implosion, vacuum developed during infusion if air-vent blocked
  - Trapped air inside bottle during ascent may cause increased rate / risk of air embolism
- Rigid plastic bottle
  - Trapped air inside bottle during ascent may cause increased rate / risk of air embolism
- Collapsible bag preferred
- No bubbles in tubing allowed
- Safeguard against disconnection

Intravenous therapy (2)

- IV infusion pump / Syringe pump (with battery)
  - Avoid because of fire risk
  - Purged continuously with N_2
  - Seriously justify HBO therapy if patient's condition required inotrope / vasopressor support
- IV drugs
  - Bolus or infusion by drop count
  - Prepared outside chamber and transfer via air-lock

Air-lock

Outside

Inside

Others

- Nasogastric tube
  - Open to collapsible bed side bag
  - Intermittent suction
  - Especially during last minute of ascent
- Foley's catheter
  - Ensure balloon filled with water
- Injection
  - Avoid ***Intramuscular/subcutaneous***
    - delayed/erratic absorption (vasoconstriction)
- Defibrillation
  - Should only be done when the patient was surfaced because of fire hazard
- Suction
  - Hand held aspirator /in-line trap and vacuum regulator

Strictly forbidden (combustible material)

- All material/equipment inside chamber are HBO compatible; if in doubt, don't bring into chamber
  - Cigarettes, matches or lighters
  - Oil based cosmetic, face creams, body oils, hair spray, nail polish.
  - Nylon clothing
  - Ink filling pen
  - Electronic instrument
  - Pagers, mobile phone, watches (except diving and no battery)


報紙
打火機
吸煙引發
呼吸系統疾病

Occupational Safety for Tenders

- 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 Tenders (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

Hyperbaric Medicine Unit

- Inside a hospital
- Medical, nursing and technical staff
- Multiplace hyperbaric chambers
- Adequate space
- Provide hyperbaric therapy and consultation
- Quality Assurance, training and research programme

- Critical care hyperbaric medicine possible

Royal Adelaide Hospital
Australia

Thank you for your attention.