Certified Hyperbaric Registered Nurse

Study Guide

September 2009

National Board of Diving & Hyperbaric Medical Technology
NBDHMT.org

CHRN Study Guide

Contents

Introduction

The purpose of this Study Guide is to facilitate your preparation to take the Hyperbaric Nurse Certification Examination. The Study Guide has been divided into twelve sections. Each section is introduced with a brief narrative summary in order to rationalize its inclusion as an important component of each Hyperbaric Nurse's education and training base.

Terminal Objectives

Terminal objectives follow the summary and represent goals that the reader should attain after review of the referenced resources, in conjunction with prior training and experience.

Fundamental Knowledge

Fundamental knowledge is defined as a basic understanding of a given subject in the absence of a more detailed appreciation of specific underlying theory, mechanisms, biochemical or cellular aspects.

Example: A **fundamental** understanding of oxygen toxicity:

The reader will appreciate that elevated inspired oxygen values are capable of producing clinically manifested central nervous system and pulmonary toxicity and that the development of oxygen toxicity is based upon a combination of absolute pressure and exposure time. The reader will also appreciate the differential diagnosis of central nervous system vs. pulmonary oxygen toxicity and have a working knowledge of respective immediate management procedures.

The reader is not required to understand the biochemical process, nor cellular, tissue and metabolic effects of oxygen toxicity.

Working Knowledge

Working knowledge is defined as the ability to incorporate the subject matter or information into your daily activities in support of the safe and effective application of hyperbaric medicine.

Example: A **working knowledge** of the wound healing mechanisms and factors that are detrimental to wound healing.

The reader is expected to be familiar with the physiology of wound healing and wound care management by conducting a patient assessment and developing a plan of care for each patient's wound care needs.

Comprehensive Knowledge

Comprehensive knowledge is defined as a detailed in-depth understanding of a given subject.

Example: A **comprehensive knowledge** of the potentially harmful direct effects of alterations in atmospheric pressure:

> The reader is expected to be completely familiar with the concept of Boyle's Law, as it applies to gas filled and potentially gas-filled spaces, during both compression and decompression. The reader will also be completely familiar with the implications of Charles' Law in this setting. Identification of all patient personal and equipment risks is required, as are the methods of both reducing these risks and providing immediate management should resultant barotrauma occur.

Sample questions are provided with each section. They are not taken directly from the certification examination question pool but provide examples of questions, format, style and degree of difficulty.

Each section concludes with a list of references. Every effort has been made to provide the widest possible information base. This has been balanced with the need to consolidate referenced texts where possible, in order to limit the financial burden of procuring such material. Accordingly, the listing of reference works has been reduced significantly since the first printing of the Study Guide. Medical libraries will be able to provide copies of the articles referenced in scientific publications, at minimal cost. Many of the libraries of diving and hyperbaric physicians will contain the referenced texts. Technical references will often be found in hospital Engineering Departments, particularly the National Fire Prevention Association material.

History of Undersea and Hyperbaric Medicine

Narrative Summary

The early history of clinical hyperbaric medicine was characterized by a number of largely ill conceived attempts to use hyperbaric and oxygen enriched air for the treatment of a variety of acute and chronic conditions. Later studies reported the efficacy of hyperbaric oxygen to enhance decompression following exposure to elevated pressures and the subsequent insertion of oxygen into the early United States Navy decompression sickness treatment tables. Throughout the first half of the twentieth century hyperbaric treatment facilities were used almost exclusively for the definitive management of decompression illness. By the mid-1960's there was preliminary evidence of additional beneficial mechanisms associated with intermittent, short term, exposure to elevated oxygen pressure. Prior to the laboratory and clinical clarification of these findings there followed a period of over-zealous and often inappropriate application of hyperbaric oxygen therapy. In 1976 the Undersea and Hyperbaric Medical Society established a committee on Hyperbaric Oxygen Therapy. Under the Committee's guidance there has been a careful reevaluation of the appropriate utilization of hyperbaric medicine with increasing multi-center clinical experience and a growing number of randomized trials, hyperbaric medicine programs are no longer limited to military and research institutions. Today, they range across the continuum of health care institutions.

Terminal Objectives

Identify the pioneering contributions and observations of Behnke, Bert, Boerma, Bond, Boyle, Brummelkamp, Fontaine, Haldane, Henshaw and Yarborough.

Develop a **fundamental** understanding of the concurrent development of hyperbaric and diving medicine in historical perspective.

Sample Questions

In 1878, a French physiologist named ______________________published his classic work concerning the effect of oxygen on the central nervous system.

a. Bert
b. Ernie
c. Pascal
d. Priestley
e. Fontaine

An Englishman named ___________________built the first known treatment chamber in ________________.

a. Charles, 1987
b. Priestley, 1774
c. Bakker, 1980
d. Henshaw, 1662

Source Material
Hyperbaric Medicine Practice 3rd edition. EP Kindwall and HT Whelan, Eds. Best Publishing Company: ISBN 9-780941332-78-1 2008 or
Hyperbaric Oxygen Therapy Indications, 12th edition. LB Gesell, Chair and Editor. The Undersea and Hyperbaric medical Society, www.uhms.org

The Physical Aspects of Undersea and Hyperbaric Medicine

Narrative Summary

A thorough understanding of the concept of pressure, the gaseous components of the multiplace and monoplace atmospheres and a sound **working** knowledge of the basic gas laws are essential to safely and effectively operate as a team member within the hyperbaric medicine program.

Terminal Objectives

The ability to differentiate the various terms used to describe pressure, namely: atmospheric, barometric, absolute, gauge and hydrostatic.

The ability to convert units of pressure, namely: atmospheres absolute (ATA); feet seawater (FSW); pounds per square inch (PSI); meters seawater (MSW) and millimeters of mercury (mmHg).

The ability to utilize Dalton's, Henry's, Boyle's and Charles' Laws to solve a variety of physical and physiological scenarios as they relate to undersea and hyperbaric environments.

The ability to convert temperature measurements to and from Fahrenheit, Celsius, Rankine and Kelvin.

Sample Questions

1. Which of the gas laws explains why a diver's tissues take up nitrogen during a dive?

a. Henry's
b. LaPlace's
c. Boyle's
d. Charles'

2. Gas molecules move in __________ motion within a closed space:

a. even
b. regulated
c. random
d. circular

Source Material
United States Navy Diving Manual, Volume 1 (air diving) 2006
National Oceanic Atmospheric Administrative Diving Manual: JE Miller, Ed. 1991

The Physiological Aspects of Undersea and Hyperbaric Medicine

Narrative Summary

It is important that all individuals who work within, and in support of, the hyperbaric environment has a comprehensive understanding of the profound physiological changes that occur during exposure to increased atmospheric pressure. The complex interactions of oxygen, nitrogen, helium and carbon dioxide in transfer from the lungs to the blood and into the tissues, and their return to the lungs, must be appreciated in order to fully comprehend the therapeutic benefits, risks and potential side effects associated with exposure to the hyperbaric environment.

Terminal Objectives

A fundamental understanding of normal respiration and circulation in man. A working knowledge of medical terminology as it applies to diving and hyperbaric medicine. A comprehensive knowledge of the beneficial and potentially harmful direct effects of pressure during compression and decompression. A fundamental understanding of the indirect effects of pressure, namely; oxygen toxicity and nitrogen narcosis.

A fundamental appreciation of the advantages and limitations of the various therapeutic gases, namely; air, oxygen, nitrogen-oxygen, and helium-oxygen.

Sample Questions

1. The double layer of tissue surrounding each lung, and lining the inside of the chest cavity is called the __________.

a. pleura
b. peritoneum
c. pericardium
d. meninges

2. Central nervous system oxygen toxicity may occur when the partial pressure of oxygen equals or exceeds ____________.

a. 0.21 ATA
b. 0.5 ATA
c. 1.0 ATA
d. 2.0 ATA

Source Material
United States Navy Diving Manual, Volume 1 (air diving) 2006, or
National Oceanic and Atmospheric Diving Manual: 4th edition, 2001. Joiner JT, Editor. Best Publishing Company: ISBN 0-941332-70-5

Mechanisms and Theory of Decompression

Narrative Summary

Fundamental to the practice of undersea and hyperbaric medicine is the concept of decompression. It is important that all those personnel who function within this field, regardless of chamber type, understand the basic principles of tissue inert gas exchange and principles that range from the early Haldanian Theory to those which involve current miniaturized individual dive computers. The ability to calculate decompression requirements is essential for multi-place and air-filled duo/mono-place chamber personnel. It is also an important requirement in the monoplace, oxygen-filled, chamber diagnosis setting. Evaluation of a series of dive/decompression profiles can be a crucial component in the diagnosis of the diving accident victim.

Inadequate or omitted decompression in a patient's immediate diving history may represent the only "objective" finding. The concurrent growth of recreational diving with an increased geographical availability of monoplace programs has resulted in increasing numbers of decompression illness cases being primarily evaluated and treated in the monoplace chamber setting.

Terminal Objectives

A **working** knowledge of the United States Navy Standard Air Decompression Table.
A working knowledge of the United States Navy No-Decompression Limits and Repetitive Group Designation Table for No-Decompression Air Dives.

A **working** knowledge of the United States Navy Residual Nitrogen Timetable for Repetitive Air Dives.

A **fundamental** understanding of the limitations of the above referenced tables regarding their ability to prevent decompression sickness.

A **working** knowledge of the physiological and operational factors that increase one's susceptibility to decompression sickness.

Sample Questions

1. What is the maximum no-stop limit, in minutes, for a 66 fsw air dive, using the USN Standard Air Decompression Table?
    a. 60
    b. 66
    c. 40
    d. 50

2. An on-call physician attends a carbon monoxide intoxicated patient in a multiplace chamber at 66 fsw for 56 minutes. After a two-hour surface interval, the physician has to repeat the above exposure with a second patient. What is the physician's decompression requirement following the second dive?
    a. 18 mins @ 10 ft.
    b. 26 mins @ 10 ft.
    c. 14 mins @ 10 ft.
    d. 33 mins @ 10 ft.

Source Material
United States Navy Diving Manual, Volume 1 (air diving), 2006, or
National Oceanic and Atmospheric Diving Manual: 4th edition, 2001. Joiner JT, Editor. Best Publishing Company: ISBN 0-941332-70-5

Therapeutic Mechanisms Associated with Hyperbaric Oxygen Exposure

Narrative Summary

Elevated atmospheric pressure in conjunction with intermittent 100% oxygen breathing combines to produce a number of beneficial effects; effects that cannot be or are poorly duplicated by breathing oxygen at one atmosphere absolute.

1. **Decompression illness** responds to the effects of Boyle's Law and accelerated inert gas elimination during oxygen breathing
2. **Carbon Monoxide Poisoning** responds to both the increased oxygen-carrying capacity of the blood, and newly recognized mechanisms involving mitochondrial function and leukocyte adherence.
3. **Clostridial Gas Gangrene** and selected **Mixed Soft Tissue Infections** respond to the bacteriostatic and possibly bacteriocidal effects of hyperbaric oxygen and HBO's support of partially ischemic tissue.
4. Acute Traumatic Ischemia, Crush Injuries and Acute Exceptional Blood Loss Anemia benefit from oxygen-mediated vasoconstriction (without component hypoxia) and hyperoxygenation.
5. **Non-healing Ischemic Wounds** derive benefit from the angiogenic response of intermittent hyperbaric hypoxia.
6. **Compromised Skin Flaps** may respond to the improved oxygen carrying capacity of blood under conditions of hyperbaric hyperoxia. HBO may also limit leukocyte mediated ischemia-reperfusion injury.

A **fundamental** knowledge of these beneficial mechanisms is necessary in order to fully appreciate the underlying basis of the "Accepted Indications" for hyperbaric medicine referral and related investigational indications.

Terminal Objectives

Upon review of the indexed reference sources the reader will appreciate how exposure to partial pressures of oxygen, greater than one atmosphere absolute, produce the following mechanism:

1. antimicrobial effects
2. vasoconstriction
3. hyperoxygenation
4. neovascularization
5. attenuation of reperfusion injury
6. gas bubble reduction

Further, the reader will be able to classify each of the currently "Accepted Indications" for hyperbaric oxygen by proposed therapeutic mechanism.

Sample Questions

1. Hyperbaric oxygen is an important therapeutic modality in the treatment of decompression sickness due to which of the following mechanisms?
    a. Increased counter-diffusion gradient at the blood-bubble interface.
    b. Oxygenation of hypoxic tissues.
    c. Gas bubble reduction.
    d. All of the above.
    e. None of the above.

2. The hyperoxygenation effects of hyperbaric oxygen therapy cease immediately upon completion of hyperbaric chamber decompression.

a. True
b. False

Source Material

Hyperbaric Medicine Practice 3rd edition. EP Kindwall and HT Whelan, Eds. Best Publishing Company: ISBN 9-780941332-78-1 2008 or

Hyperbaric Oxygen Therapy Indications, 12th edition. LB Gesell, Chair and Editor. The Undersea and Hyperbaric medical Society, www.uhms.org

Currently Accepted Indications for Hyperbaric Oxygen Exposure

Narrative Summary

Recognizing the need for careful scrutiny of the clinical application of hyperbaric oxygen, the Undersea and Hyperbaric Medical Society established the Hyperbaric Oxygen Committee in 1976. This committee was charged with the responsibility for continuously reviewing research and clinical data and providing recommendations and guidance regarding clinical efficacy. The most recent edition of the Committee Report, 1992, lists 13 indications for which hyperbaric oxygen therapy represents a standard or important adjunct to other measures.

Prior to the 1992 publication, the Hyperbaric Oxygen Committee had also included a listing of investigational indications. The Committee considered these latter indications to represent fruitful areas for research. Within this category may be individual life or limb threatening situations for which evidence of hyperbaric oxygen's value exists. In general, patients with disorders in this category should be treated only according to a formal research protocol.

Terminal Objectives

The **ability** to list all of the "Currently Accepted Indications" considered appropriate for hyperbaric medicine referral by the Undersea and Hyperbaric Medical Society.

A **working** knowledge of the commonly utilized treatment protocols, in terms of the absolute pressure, exposure time and frequency of procedures, for each of the "Currently Accepted Indications".

Sample Questions

1. Hyperbaric oxygen is an approved therapy for all of the following except:

a. carbon dioxide poisoning
b. osteoradionecrosis
c. selected non-healing wounds
d. clostridial gas gangrene

2. A case of neurological decompression sickness responds well to recompression and oxygen at 60 fsw. However, upon completion of the third oxygen breathing cycle, at 60 fsw, resolution is incomplete. The most appropriate physician's order would be to:

a. Decompress to 165 fsw, on air.
b. Complete Treatment Table 6 and observe.
c. Complete Treatment Table 6 and retreat immediately.
d. Extend Treatment Table 6 at 60 fsw.

Source Material

Hyperbaric Medicine Practice 3rd edition. EP Kindwall and HT Whelan, Eds. Best Publishing Company: ISBN 9-780941332-78-1 2008 or

Hyperbaric Oxygen Therapy Indications, 12th edition. LB Gesell, Chair and Editor. The Undersea and Hyperbaric medical Society, www.uhms.org

Oxygen Toxicity

Narrative Summary

The safe and effective application of oxygen as a therapeutic modality within the hyperbaric environment requires strict adherence to established protocols. The basis for such protocols was the avoidance of toxicity rather than the delivery of a precise dose of oxygen to achieve a specific therapeutic effect. Complicating factors include varying degrees of tolerance from patient to patient, and what appears to be a varying degree of tolerance in the same patient from day to day. While oxygen toxicity will effect all organ systems, it is the central nervous system and the lungs that first become clinically manifest within the undersea and hyperbaric medicine setting. Modification of oxygen tolerance has been demonstrated with a number of pharmacological agents. Intermittent air breathing, however, is simple to administer and is particularly effective in delaying the onset of central nervous system oxygen toxicity. Appreciation of risk factors, early recognition of oxygen toxicity, and its subsequent management, will do much to lessen both the incidence and morbidity of this potential complication of hyperbaric oxygen exposure.

Terminal Objectives

The **ability** to differentiate the clinical presentation of central nervous system and pulmonary oxygen toxicity.

A **working** knowledge of commonly used methods to extend patient tolerances to hyperbaric exposure.

A **working** knowledge of the prevention and management principles for both central and pulmonary oxygen toxicity.

Sample Questions

1. A diver undergoing treatment for decompression sickness suffers what appears to be an oxygen-induced central nervous system reaction, in the absence of an overt seizure, at 0900. Oxygen breathing is immediately discontinued. By 0905 the patient appears able to continue the treatment table. According to U.S. Navy Table 6 protocols, what is the earliest time that oxygen breathing can be resumed?
   a. 0910
   b. 0915
   c. 0920
   d. 0935

2. During the latter stages of a hyperbaric oxygen procedure in a multiplace chamber, the inside attendant notices intermittent twitching around the corners of a patient's mouth. Appropriate immediate action is to:
   a. take the patient off oxygen and advise the hyperbaric medical staff.
   b. do a neurological examination.
   c. obtain a set of vital signs.
   d. insure the oxygen delivery hood/mask is secure on the patient's face.

Source Material
United States Navy Diving Manual, Volume 1 (air diving), 2006, or
National Oceanic and Atmospheric Diving Manual: 4th edition, 2001. Joiner JT, Editor. Best Publishing Company: ISBN 0-941332-70-5

Other Potential Complications

Narrative Summary

While an oxygen seizure might be one of the more dramatic side effects associated with exposure to elevated oxygen pressures, it is relatively uncommon. Far more frequent is a patient's inability to compensate pressure changes, usually occurring during the compression phase. The middle ear and sinus spaces are reported as common sites for this form of barotrauma. However, any gas filled space, both within the body, or equipment used to directly support the patient, is a potential barotrauma site. In addition, long-term hyperbaric therapy has been associated with a progressive myopia and isolated reports of cataractogenesis or enhanced cataract maturity. The patient is at risk for a more serious form of barotrauma during the decompression phase. The inability to adequately ventilate the pulmonary spaces during pressure reductions may result in local overpressure. If the resulting increase in pressure reaches a critical point, structural failure of the lung may result in cerebral arterial gas embolism, pneumothorax, mediastinal or subcutaneous emphysema or any combination of these results. Patients with significant degrees of left ventricular dysfunction may go into congestive heart failure during, or immediately following, hyperbaric oxygen exposure.

Terminal Objectives

The **ability to recognize** all anatomic and equipment gas-filled spaces or potential spaces prior to compression of the hyperbaric patient.

The **ability to minimize** the risk of barotrauma by patient education and instruction and appropriate venting of equipment prior to pressure changes.

The **ability to recognize** potential airway compromise, particularly during decompression, and a comprehensive knowledge of the immediate management necessary to reduce the risk of pulmonary barotrauma.

Understand the complicating role of central nervous system oxygen toxicity and reactive airway disease during decompression.

Sample Questions

1. Maintenance of effective mechanical ventilation through an endotracheal tube in the hyperbaric chamber is accomplished easily and effectively by:
    a. increasing the amount of air in the cuff
    b. overinflating the cuff with saline
    c. replacing the air in the cuff with an equal amount of sterile saline
2. When monitoring an intravenous fluid infusion in the hyperbaric chamber, one can expect the drip chamber to _____during decompression.
    a. empty
    b. stay the same
    c. fill with fluid
    d. implode

Source Material

Hyperbaric Medicine Practice 3rd edition. EP Kindwall and HT Whelan, Eds. Best Publishing Company: ISBN 9-780941332-78-1 2008 or

Hyperbaric Oxygen Therapy Indications, 12th edition. LB Gesell, Chair and Editor. The Undersea and Hyperbaric medical Society, www.uhms.org

The Hyperbaric Medicine Facility

Narrative Summary

Central to the therapeutic application of increased atmospheric pressure is the hyperbaric chamber. The chamber is constructed to withstand internal pressurization so that oxygen, and other therapeutic gases, can be administered at pressures greater than one atmosphere absolute (sea level). Early recompression chambers were constructed of steel, had two compartments and were designed for the management of decompression illness in divers and compressed air workers. The increased utilization of hyperbaric oxygen therapy in recent years, for a wide variety of disease states, has dictated that chamber construction take into account varying patient needs as well as economic considerations/constraints. Today, chambers are classified as either multi-place (with varying patient capacity), monoplace (single patient, not internally attended) and duo-place (patient and attendant). In order to adequately manage the broad cross-section of patients referred for hyperbaric therapy, a number of important ancillary services must be integrated into the chamber facility. They include, but are not limited to:

1. an air compression and air reserve capability
2. an oxygen supply, either directly into the chamber or to individual patient delivery systems
3. fire suppression equipment (internal in the case of multiple occupancy chambers and external regardless of chamber type)
4. gas sampling/monitoring equipment (internal atmosphere and supply gases)
5. diagnostic equipment (examples include ECG, transcutaneous oxygen monitors, EEG)
6. patient monitoring equipment (invasive and non-invasive arterial blood pressures, central venous pressures)

Terminal Objectives

A **fundamental** knowledge of each hyperbaric chamber type, to include a **working** knowledge of their respective advantages and disadvantages.

A **fundamental** knowledge of the operating characteristics of each chamber type.

Sample Questions

1. In a multiplace chamber, oxygen may be delivered to a patient via

  a. BIBS mask
  b. hood
  c. endotracheal tube
  d. any of the above

2. NFPA defines an oxygen-filled monoplace chamber as a class ____chamber.

  a. A
  b. B
  c. C
  d. D

Source Material

Health Care Facilities Handbook, Richard P. Bielen, 2005 edition, Chapter 20
Hyperbaric Facility Safety: A Practical Guide, Workman, W.T., Best Publishing Company, 1999

Hyperbaric Safety I. Protecting the Environment

Narrative Summary

The safe and effective operation of a hyperbaric medicine facility requires a thorough understanding of system design and operational characteristics. Various aspects of chamber safety include:

1. maintenance of pressure integrity
2. handling of high pressure gas cylinders
3. patient breathing systems
4. fire prevention and control
5. electrical safety, and
6. operating and emergency procedures

Pressure Integrity

Abrupt loss of pressure may cause pulmonary barotrauma, as well as decompression sickness in individuals who have been exposed to compressed air. Decompression sickness is not anticipated in patients undergoing hyperbaric oxygen therapy unless operational error or system failure results. Careful attention therefore, should be given to maintenance of the chamber's structural integrity. Damage to seals, doors, view ports, acrylic tubes or the chamber shell must be evaluated and addressed without delay.

Gas Cylinders

Non-flammable high pressure gas cylinders are commonly incorporated within the hyperbaric complex. They are used to provide oxygen or air to patient breathing systems in all types of chambers, and mixtures of certain other therapeutic gases are often found in the multiplace chamber setting. The contents of all gas cylinders must be clearly identified. Pressure reducing valves should be installed as close to the high pressure source as possible. Relocation, storage and operation must be in strict compliance with published recommendations.

Patient Breathing Systems

Face masks and hoods are used to deliver therapeutic gases to patients in multi and duoplace chambers. In the monoplace chamber, face masks or hoods are utilized for the intermittent delivery of compressed air.

Fire Prevention and Control

The hyperbaric chamber represents a unique environment with regard to fire safety. Physical isolation and an oxygen enriched atmosphere can combine to produce a potentially devastating setting should a fire occur. The need to protect chamber occupants and operational personnel, difficulties associated with escape, and the potential for significant increases in chamber pressure, secondary to the effects of Charles' Law, dictate that fire prevention remains a primary safety goal. Strict operational guidelines have been established for multi and single occupancy chambers, and should be incorporated into the operating policies of every hyperbaric medicine program.

Electrical Safety

As the majority of reported chamber fires have occurred as a result of faulty electrical apparatus, there has been a concerted effort to minimize the internal electrical requirements of the hyperbaric chamber. Where necessary, in communications for example, equipment and associated wiring must be certified as intrinsically safe for the maximum conditions anticipated.

Operating Procedures

Clearly established supervision and well-trained personnel are imperative for safe chamber operation. Each program should have available a set of operational and emergency procedures based upon the equipment, manufacturers recommendations and nationally published guidelines. Emergency drills should be discussed and practiced. Regularly scheduled maintenance and testing by competent personnel represent important components of a comprehensive program of chamber safety.

Terminal Objectives

A **fundamental** understanding of hyperbaric chamber design and configuration to include both acrylic and steel hulled vessels.

A **working** knowledge of the recommendations for the safe handling of compressed gas cylinders.

A **working** knowledge of the color codes for oxygen, compressed air, nitrogen-oxygen mixtures, helium-oxygen mixtures, nitrogen and helium.

A **comprehensive** understanding of the measures necessary to reduce the risk of chamber fires; to include ancillary equipment, chamber material and personal perspectives.

Sample Questions

1. According to NFPA codes for hyperbaric facilities, the maximum direct current of communications systems should be _____volts.
   a. 5
   b. 12
   c. 28
   d. 10

2. Oxygen
   a. explodes easily
   b. is lighter than air
   c. will not burn
   d. is necessary for combustion

Source Material
National Fire Protection Association, NFPA 99, Health Care Facilities, Chapter 20, 2005
National Fire Protection Association, NFPA 53, M-Fire Hazards in Oxygen Enriched Atmospheres
Handbook of Compressed Gases: Third edition 1990
Hyperbaric Facility Safety: A Practical Guide, Workman, W.T., Best Publishing Company, 1999

Hyprebaric Safety II. Protecting the Patient

Narrative Summary

The safety and well-being of any patient is paramount. This is particularly the case in those patients undergoing hyperbaric oxygen therapy. Physical and physiological risk factors, initially evaluated by the consulting hyperbaric physician, must be continually monitored throughout the treatment course. It is the responsibility of the hyperbaric medicine team to develop and implement a coordinated patient care plan designed to insure the highest possible level of safety.

Terminal Objectives

A **working** knowledge of the physical effects of alterations in atmospheric pressure on gas-filled spaces and potential gas-filled spaces within the body.

A **working** knowledge of the physical effects of alterations of atmospheric pressure on gas-filled spaces within patient vascular access lines, direct patient support and patient monitoring equipment.

A **working** knowledge of the special physical hazards associated with alterations in atmospheric pressure in patients with known pulmonary pathology.

A **working** knowledge of the special physiological risks associated with hyperbaric oxygen exposure in patients who are insulin and non-insulin dependent diabetics, patients with a seizure history or recent head injury, patients who are febrile, patients with a history of chest surgery or thoracic procedures, penetrating chest injury and patients with a history of reconstructive ear surgery.

A **comprehensive** knowledge of patient assessment requirements prior to each hyperbaric oxygen exposure. Namely, patient education regarding pressure equalization methods, anticipated chamber temperature changes, patient preparation (removing restricted items), namely, static producing clothing, hair pieces, recently applied nail polish, make-up and body lotions, loose dentures, velcro attachments, battery operated equipment such as hearing aids and Holter monitors.

The ability to recognize the signs and symptoms of pulmonary barotrauma of ascent. The ability to recognize pre-monitory signs and symptoms of central nervous system oxygen toxicity.

Sample Questions

1. A patient has recently undergone a subclavian IV placement. Before continuing hyperbaric therapy, the following is indicated:
    a. chest x-ray to rule out pneumothorax
    b. blood cultures
    c. discontinue hyperbaric therapy
    d. IV heparin to prevent clotting during hyperbaric therapy

2. Insulin dependent diabetic patients being treated with hyperbaric oxygen are:
    a. more likely to go into hypoglycemic shock.
    b. less likely to go into hypoglycemic shock.
    c. there is no effect on blood glucose levels.

Source Materials

National Fire Protection Association NFPA 99, Health Care Facilities, Chapter 20, 2005
Hyperbaric Medicine Practice 3rd edition. EP Kindwall and HT Whelan, Eds. Best Publishing Company: ISBN 9-780941332-78-1 2008
Hyperbaric Facility Safety: AQ Practical Guide, Workman, W.T., Best Publishing Company, 1999

Transcutaneous Oxygen Monitoring

Narrative Summary

Tissue oxygen tension is a direct, quantitative assessment of the oxygen available to tissue. Tissue oxygen studies are used in medical decision making by wound care and hyperbaric medicine specialists. Several types of oximeters have been used, but most common is the non-invasive transcutaneous oximeter. Transcutaneous oximetry (TcPO2) has gained importance as a non-invasive tool for predicting potential candidates for hyperbaric oxygen (HBO2) therapy. Clinicians use these data as an aid in vascular assessment to help predict non-responders to treatment and to choose successful amputation sites. The data are also used to select candidates for HBO2 by identifying the presence of tissue hypoxia and the responders to hyperoxia. In some instances tissue oxygen data are used to determine when HBO2 treatment is complete.

Terminal Objectives

A **working** knowledge of TcPO2 technology.

A **working** knowledge of a TcPO2 monitor and ancillary equipment.

Be able to **demonstrate** knowledge of a TcPO2 test that is consistent with current industry standards.

Be able to **demonstrate** knowledge of obtaining the subject’s consent for the TcPO2 procedure.

Be able to **demonstrate** knowledge of inspection procedures for equipment needed to conduct a TcPO2 study.

Sample Questions

1. Proper site preparation for transcutaneous oximetry requires the skin to be shaven, cleaned and degreased.
    a. True
    b. False

2. If the normobaric air TcPO2 value recorded at the chest is 10 mmHg after the electrode is equilibrated, it is most likely that;
    a. The value is correct.
    b. The monitor is defective.
    c. The electrode cable is defective.
    d. The membrane is dried out.
    e. The electrode fixation to the skin has a leak.

Recommended Reading

Fife CF, Smart DR, Sheffield PJ, et al. **Transcutaneous Oximetry in Clinical Practice. Consensus Statements Based on Evidence.** *UHM 2009; 36(1):43-53.*

Smart DR, Bennett MH, Mitchell SJ. **Transcutaneous Oximetry, Problem Wounds and Hyperbaric Oxygen Therapy.** *Diving and Hyperbaric Medicine 2006; 36(2):72-86.*

*Sheffield PJ**. Measuring Tissue Oxygen Tension: A Review.** Undersea and Hyperbaric Medicine 1998; 25(3):179-188.*

Jorneskog G, Djavani K, Brismar K. **Day-To-Day Variability of Transcutaneous Oxygen Tension in Patients with Diabetes Mellitus and Peripheral Arterial Occlusive Disease.** *J Vasc Surg 2001; 34(2):277-282.*

Niinikoski J. **Hyperbaric Oxygen Therapy of Diabetic Foot Ulcers, Transcutaneous Oximetry in Clinical Decision Making.** *Wound Rep Reg 2003; 11:458-461.*

Transcutaneous Oxygen Monitor Operations Manual.

Nursing Management of the Patient Undergoing Hyperbaric Oxygen Therapy

Narrative Summary

Patients undergoing hyperbaric oxygen therapy represent a range of acuity from chronically ill outpatients to the critically ill, and from pediatrics to geriatrics. The hyperbaric nurse must be knowledgeable and experienced in the care of a multi-faceted population of patients. Application of the nursing process is essential to the appropriate planning and delivery of nursing care in the hyperbaric hyperoxic environment.

Terminal Objectives

A **working** knowledge of human responses to actual or potential problems related to an altered health status (physiological, psychological, sociological and cognative)

A **fundamental** knowledge of the application of the nursing process in the development of a patient care plan

A **working** knowledge of pharmacology and the interaction or alteration of drug effects in the hyperbaric hyperoxic environment

A **comprehensive** knowledge of wound healing and adjunctive therapies that stimulate and/or enhance the healing process

A **fundamental** knowledge of the care of critically ill patients and pediatric patients Sample Questions

1. An infant is most at risk of losing body heat:
    a. during compression
    b. at pressure
    c. during decompression
    d. immediately after treatment

2. Patients taking lanoxin/digoxin need to be monitored for possible digitalis toxicity:

a. True
b. False

Note: BNACB highly endorses the Hyperbaric Medical Review for Board Certification Exams: CHT/CHRN "In Plain English" by Jolie Bookspan, Ph.D., 2000

Resource Material

Hyperbaric Medicine Practice 3rd edition. EP Kindwall and HT Whelan, Eds. Best Publishing Company: ISBN 9-780941332-78-1 2008

Diving and Subaquatic Medicine, C. Edmonds, C. Lowry & J. Pennefather Editors. Third edition 1992, Butterworth-Heinemann, Ltd. Publishers -Available through Best Publishing Company, P.O. Box 30100, Flagstaff, AZ 86003-0100. Tel.602-5271055, 602-526-0376, or the Undersea and Hyperbaric Medical Medical Society, P.O. Box 1020, Dunkirk, MD 20754, Tel. 410-257-6606, Fax 410-257-6617, ISBN# 0-7506-0259-7

United States Navy Diving Manual – Volume 1 (Air Diving) 2006 Best Publishing Company, P.O. Box 30100, Flagstaff, AZ 86003-0100. Tel.602-527-1055, 602-526-0376

Handbook of Compressed Gases – Third edition 1990, Van Norstrand Reinhold Publishers - Available through the Compressed Gas Association, 1725 Jefferson Davis Hwy., Suite 1004, Arlington, VA 22202-4102, Tel. 703-413-4341, Fax 703-412-0128, ISBN#0-442-21881-8

National Fire Protection Association NFPA 99, Health Care Facilities Chapter 20, 2005 -Available through NFPA, 1 Batterymarch Park. P.O. Box 9101, Quincy, Massachusetts, 02269-9904, Tel. 1-800-344-3555

National Fire Prevention Association 53M – Fire Hazards in Oxygen-Enriched Atmospheres 1990 -Available through NFPA, 1 Batterymarch Park. P.O. Box 9101, Quincy, Massachusetts, 02269-9904, Tel. 1-800-344-3555

Hyperbaric Facility Safety: A Practical Guide, W.T. Workman, Best Publishing Company, 1999, -Available through Best Publishing Company, P.O. Box 30100, Flagstaff, AZ 86003-0100. Tel.602-5271055, 602-526-0376

Health Care Facilities Handbook, Richard P. Bielen, 2005 edition, Chapter 20 Available through Best Publishing Company, P.O. Box 30100, Flagstaff, AZ 86003-0100. Tel.602-5271055, 602-526-0376

Hyperbaric Oxygen Therapy Indications, 12th edition. LB Gesell, Chair and Editor. The Undersea and Hyperbaric medical Society, www.uhms.org

AACN Procedure Manual for Critical Care, 1993 (Third edition) Available through Philadelphia W. B. Saunders Company. ISBN 9-801. Tel, 206-488-2154

Diving Physiology in Plain English, 1999 by Jolie Bookspan - by Dr. Jolie Bookspan -Available through The Undersea and Hyperbaric Medical Society, P.O. Box 1020, Dunkirk, MD, 20754, Tel. 410-257-6606, Fax 410-257-6617, ISBN# 0-930406-13-3, website: www.uhms.org, email: uhms@uhms.org, and your on-line bookstores such as www.amazon.com, www.barnesandnoble.com and www.borders.com

Hyperbaric Medical Review for Board Certification Exams: CHT/CHRN "In Plain English" (with new updated test questions and contact information) by Dr. Jolie Bookspan, 2000 -Available through The Undersea and Hyperbaric Medical Society, P.O. Box 1020, Dunkirk, MD, 20754, Tel. 410-257-6606, Fax 410-257-6617, ISBN# 0-930406-18-4, website: www.uhms.org, email: uhms@uhms.org. $40.00 plus $7.50 S&H and your on-line bookstores such as www.amazon.com, www.barnesandnoble.com and www.borders.com

Hyperbaric Nursing, 2002, editors Valerie Larson-Lohr, Helen C. Norvell - Available through Best Publishing Company, P.O. Box 30100, Flagstaff, AZ 86003-0100. Tel.602-5271055, 602-526-0376, ISBN# 1-930536-00-3

Wound Care Practice, 2nd edition, 2007, editors Sheffield, PJ, Smith, AP, Fife, CE - Available through Best Publishing Company, P.O. Box 30100, Flagstaff, AZ 86003-0100. Tel.602-5271055, 602-526-0376, ISBN 1-930536-38-0

CHT and CHRN Certification Exam Practice Book, D.A. Sheffield, MSN, CHT, CHTN and R.B. Sheffield, BA, CHT, 2006, Available through: International ATMO, Inc. San Antonio, Texas, ISBN-13:978-1-4243-1119-4