Certified Hyperbaric Registered Nurse®

Resource Manual

National Board of Diving & Hyperbaric Medical Technology
NBDHMT.org

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Introduction

- The Baromedical Nurses Association (BNA) was created in 1985.
- The mission of the BNA is to provide nurses with a professional organization to define, develop, maintain, and promote status and standards of baromedical nursing.
- For nurses to be certified in their specialty is similar to physicians becoming Boarded. It signifies a degree of competence and education in the field, and a standard knowledge base.
- The hyperbaric nursing certification examination was developed over a period of several years for the National Board of Diving & Hyperbaric Medical Technology (NBDHMT) by the BNA board in conjunction with Dick Clarke, the American Nursing Association (ANA), and others.
- A test bank of several hundred questions was submitted by the 1994-1995 Baromedical Nurses Association Executive Board to the National Board of Diving & Hyperbaric Medical Technology.
- A contract was signed with the National Board of Diving & Hyperbaric Medical Technology to validate and administer the exam which would confer the designation of Certified Hyperbaric Registered Nurse® (CHRN®).
- CHRN® is an internationally recognized certification.
- Certification is valid for four years.
- The test bank is regularly monitored and updated.

Candidacy

Certification is an added qualification for the registered nurse. It is not an entry level pathway for hyperbaric nursing. The candidate must have met the following requirements when applying for certification:

1. Registered Nurse degree granted from an accredited school of nursing.
2. Current RN license in the state where you practice hyperbaric nursing.
3. A minimum of two years clinical experience in an in-hospital setting, or one year critical care experience.
4. Certification in Basic Life Support.
5. Completion of a NBDHMT approved 40-hour introductory hyperbaric medicine course.
6. Minimum of one-year active hyperbaric medicine experience within the last two years, which includes 480 hours performed after the applicant attends an NBDHMT approved 40-hour introductory course.
7. Letter of recommendation from your employer, including validation of hyperbaric experience.

Certification Levels

A passing grade on the certification exam entitles the registered nurse to display the applicable initials:

1. **CHRN®**, to signify Certified Hyperbaric Registered Nurse®. Advanced certification may be applied for at anytime after receiving the basic CHRN® certification.
2. **ACHRN®** to signify Advanced Certified Hyperbaric Registered Nurse®.
3. **CHRNC®** Certified Hyperbaric Registered Nurse Clinician®.

CHRN® - Certified Hyperbaric Registered Nurse®

Meets candidacy requirements outlined above.

ACHRN® - Advanced Certified Hyperbaric Registered Nurse®

An applicant may request an application for advanced certification after receiving the basic CHRN® certification.

Qualifications in addition to the basic standards of certification:

1. Minimum of three years experience in the field of hyperbaric oxygen therapy, currently working (10 hours/week or 40 hours/month) for a minimum of 480 hours/year in the clinical and/or administrative areas of hyperbaric nursing.
2. Written documentation of two of the following:
   a. Contributes to the administrative activities of the Hyperbaric Unit/Department.
   b. Taught BNACB approved entry level hyperbaric oxygen therapy courses and/or classes or lectures on hyperbaric oxygen therapy.
   c. Have primary responsibility for planning/coordinating nursing care for patients receiving hyperbaric oxygen therapy.

CHRNC® – Certified Hyperbaric Registered Nurse Clinician®

1. Master's Degree from an accredited academic program in Nursing or health related area.
2. Minimum of 5 years experience in the field of hyperbaric oxygen therapy, currently working (10 hours/week or 40 hours/month) for a minimum of 480 hours/year in the clinical and/or administrative areas of hyperbaric nursing.
3. Written documentation of three of the following:
   a. Responsible for administrative and nursing care activities of the Hyperbaric Unit/Department.
   b. Speaker at regional/national hyperbaric conferences and workshops.
   c. Contributes to hyperbaric materials for regional/national distribution, i.e. journal articles, manuals, videos, books, etc.
   d. Active participation in the Baromedical Nurses Association (BNA), Baromedical Nurses Association Certification Board (BNACB), Undersea and Hyperbaric Medical Society (UHMS), UHMS Chapters, and/or UHMS Associates as an officer or committee member.
   e. Principal investigator or co-investigator in a published hyperbaric or related study.

Examination Process

1. Tests at each location are unique and identified with the RN's name. The RN must pre-register with the NBDHMT 60 days before the test date. The RN cannot register at the testing site.
2. The exam is 120 multiple choice and true/false questions. Each examination consists of 80 questions from the CHT® test question bank and 40 questions from the CHRN® test question bank. There are no essays or short answer questions.
3. The exam is limited to two hours. Plan to be at the test site slightly longer for an explanation of the testing process and distribution of testing material.
4. The tests are scored by the NBDHMT and sent to the BNACB for recording and notification of test results.
5. A certificate and a wallet sized card saying "Certified Hyperbaric Registered Nurse®" are sent to each applicant who passes the exam.

What to Bring:

1. Several # 2 pencils
2. Passport or other government issued photo ID
3. A pocket calculator is helpful, but not required

Test Locations:

1. Examinations are offered in conjunction with the Baromedical Nurses Association annual meeting and the annual meeting of the Undersea and Hyperbaric Medical Society.
2. An effort is made to schedule exams at regional chapter meetings of the Undersea and Hyperbaric Medical Society, and other meetings for hyperbaric nurses.
3. Special arrangements can be made to have the examination proctored at educational institutions approved by the Board. It is not appropriate for hyperbaric programs to provide "in house" examination proctorship.

Score Reports

1. Passing score is 70%
2. Scores of 90% or greater will be graded as "With Distinction."
3. On rare occasions, misconduct or circumstances may make scores invalid. If there are doubts about the score, the candidate must cooperate with any BNACB investigation. The BNACB reserves the right to cancel the exam score, if in their opinion there is reason to question validity. Before exercising this right, the BNACB will offer the candidate an opportunity to retake the exam at no additional fee.

Recertification Requirements

Certified Hyperbaric Registered Nurse® (CHRN®)

1. Complete an application for recertification.
2. Have a current Registered Nurse license in the state where practicing hyperbaric nursing.
3. Have a current certification in Basic Life Support.
4. Document a minimum of (10 hours/week or 40 hours/month) 480 hours per year in the clinical and/or administrative areas of hyperbaric nursing.
5. Complete forty hours (40) of continuing education credits (hours) per previous four years, with at least twenty (20) of those credits in the field of hyperbaric oxygen therapy.

Advanced Certified Hyperbaric Registered Nurse® (ACHRN®)

1. Complete an application for recertification.
2. Have a current Registered Nurse license in the state where practicing hyperbaric nursing.
3. Have a current certification in Basic Life Support.
4. Document a minimum of (10 hours/week or 40 hours/month) 480 hours per year in the clinical and/or administrative areas of hyperbaric nursing.
5. Document a minimum of three years experience in the field of hyperbaric oxygen therapy.
6. Complete sixty hours (60) of continuing education credits (hours) per previous four years, with at least thirty (30) of those credits in the field of hyperbaric oxygen therapy.
7. Provide written documentation of at least two of the following:
    a. Contributes to the administrative activities of the Hyperbaric Unit/Department.
    b. Taught BNACB approved entry level hyperbaric oxygen therapy courses and/or classes or lectures on hyperbaric oxygen therapy.
    c. Have primary responsibility for planning/coordinating nursing care for patients undergoing hyperbaric oxygen therapy.

Certified Hyperbaric Registered Nurse Clinician® (CHRNC®)

1. Complete an application for recertification.
2. Have a current Registered Nurse license in the state where practicing hyperbaric nursing.
3. Have a current certification in Basic Life Support.
4. Document a minimum of (10 hours/week or 40 hours/month) 480 hours per year in the clinical and/or administrative areas of hyperbaric nursing.
5. Minimum of 5 years experience in the field of hyperbaric oxygen therapy.
6. Complete a minimum of 60 continuing education credits (hours) per previous four years, with at least 30 of those continuing education credits (hours) in hyperbaric oxygen therapy.
7. Provide written documentation of at least three of the following:
   a. Responsible for administrative and nursing care activities of the Hyperbaric Unit/Department.
   b. Speaker at regional/national hyperbaric conferences and workshops.
   c. Contributes to hyperbaric materials for regional/national distribution, i.e. journal articles, manuals, videos, books, etc.
   d. Active participation in the Baromedical Nurses Association (BNA), Baromedical Nurses Association Certification Board (BNACB),Undersea and Hyperbaric Medical Society (UHMS), UHMS Chapters, and/or UHMS Associates as an officer or committee member.
   e. Principal investigator or co-investigator in a published hyperbaric or related study.

Continuing Education Units (CEU's)

Hyperbaric related course development, course presentation, presentation of lectures, posters and/or papers, which are presented for CEU's, will qualify for continuing education units for recertification of 4 CEU's/per 1 CEU presented. This is to recognize the amount of time required to accomplish the above objectives. For example: if a person presents a two hour hyperbaric related course, representing 2 CEU's, that person will then have 8 CEU's toward the requirement for recertification.

This credit will be given only once for each presentation. If the same course is taught several times a year, the person will receive the extra CEU's only one time for that particular course presentation. If another course with CEU's is presented, that additional course qualifies for the additional CEU's.

Inactive Status

1. If the candidate does not recertify, he/she will be considered inactive.
2. If the candidate was denied recertification, the candidate will be notified in writing, listing the reasons. The candidate may reapply for recertification at no additional fee by applying in writing within 90 days of being notified that recertification was denied. If the candidate does not reapply within a 90 day period, he/she will be considered inactive.

Reinstatement to Active Status

1. To be reinstated to an active Certified Hyperbaric Registered Nurse® within 12 months of becoming inactive, you must complete all requirements listed above for recertification, plus pay a $50.00 reinstatement fee.
2. To become reinstated after a twelve-month period of inactive status requires a letter from the Manager/Medical Director validating the applicant's 480 hours of hyperbaric experience within the prior 12 months, retest of the CHRN® certification exam, and payment of recertification and reinstatement fees totaling $300.00 with no discounts.

Failing and Retaking the Exam

1. If on the first attempt the examination is failed, the CHRN® applicant must wait six (6) months before retaking the exam.
2. If on the second attempt the examination is failed, the CHRN® applicant is required to retake a NBDHMT Approved Hyperbaric Medicine training course in addition to waiting six (6) months before retaking the exam.
3. If on the third attempt the examination is failed, the CHRN® applicant is not allowed to sit again for the exam.

Fees

Certification

BNA Members $250.00

UHMS or ACHM Members $300.00

Non Member of organizations listed above $400.00

Recertification

BNA Members $150.00

UHMS or ACHM Members $200.00

Non Member of organizations listed above $250.00

Reinstatement to active status
in addition to recertification fee $50.00

Advanced certification in addition
to certification or recertification fees $20.00

Registration Forms

Applications can be downloaded from the NBDHMT website, www.NBDHMT.org.

Applications are also available from:

National Board of Diving & Hyperbaric Medical Technology
9 Medical Park, Suite 330
Columbia, SC 29203

Telephone: (803) 434-7802
Fax: (866) 451-7231
E-mail NBDHMT@aol.com

Disciplinary Procedures

In applying for certification, the applicant agrees to the following:

1. Compliance with all standards of the BNACB.
2. The Board's certificates, logos, emblems, the name Baromedical Nurses Association Certification Board, the titles and abbreviations of Certified Hyperbaric Registered Nurse® (CHRN®), Advanced Certified Hyperbaric Registered Nurse® (ACHRN®), Certified Hyperbaric Registered Nurse Clinician® (CHRNC®), are all the exclusive property of the Board and may not be used in any way without the Board's express written consent.
3. The certified Registered Nurse will immediately relinquish using the titles of Certified Hyperbaric Registered Nurse®, Advanced Certified Hyperbaric Registered Nurse®, or Certified Hyperbaric Registered Nurse Clinician® in case of suspension, limitation, or revocation from the BNACB, or as otherwise requested by the BNACB.
4. The certified Registered Nurse will immediately relinquish using the abbreviations of CHRN®, ACHRN®, or CHRNC® certificate, card, logo, emblem, and the BNACB's name

and related abbreviations in case of suspension, limitation, or revocation from the BNACB, or as otherwise requested by the BNACB.

5. If the certified Registered Nurse refuses to immediately relinquish, refrain from using, or correct at their expense any misuse or misleading use of any of the above items when requested, they must also agree that the BNACB may obtain injunction relief for damages, costs and attorney's fees incurred.

BNACB Guidelines for Certification Review

1. The BNACB does not guarantee job performance of applicants.
2. The BNACB may revoke or otherwise take action with regard to the application or certification in the case of:
   a. Failure to comply with any rule of the BNACB.
   b. Any misrepresentation, misleading statement or fraud, by commission or omission, to the BNACB.
   c. Dishonesty in connection with any certification exam.

Violation of BNACB Standards

When the BNACB has reason to believe that a standard has been violated by any applicant or Certified Hyperbaric Registered Nurse® (CHRN®, ACHRN®, CHRNC®), the BNACB will send a statement of alleged violation(s) to the applicant or CHRN® by certified mail, return receipt requested. The statement will describe:

1. The applicable standard.
2. Facts constituting the alleged violation of the standard.
3. That the nurse may request an oral hearing against the allegations, bearing their own expenses.
4. That the nurse will have 30 days after receipt of the statement to respond to the allegations in writing, and request that the BNACB conduct a hearing.
5. That the nurse may appear in person, with counsel if he/she chooses, may examine and cross-exam any witness under oath, and produce evidence on his/her own behalf.
6. That if the nurse does not request a hearing, he/she consents that the BNACB may render a decision and apply available sanctions.

Hearing

If the nurse disputes the allegations or sanctions, or requests a hearing, the BNACB will:

1. Schedule a hearing, consisting of three members of the BNACB.
2. Send a Notice of Hearing to the nurse by certified mail, return receipt requested stating the time and place of the hearing.
3. Gather and review relevant evidence and resolve disputed questions by the BNACB Hearing members.
4. Resolve all matters relating to the hearing, on the record, by a majority vote.

Sanctions

Sanctions for violation of Board standard may include but are not limited to one or more of the following:

1. Revocation,
2. Non-Renewal,
3. Suspension,
4. Censure,
5. Reprimand,
6. Retest,
7. Educational Requirement,
8. Report to the Board,

Appeal

1. If the BNACB Hearing members find the allegations unsubstantiated, no further action will be taken.
2. If the decision rendered by the Hearing members is not favorable to the RN, the RN can appeal the decision to the Executive Board of the Baromedical Nurses Association.
3. The BNA Appeals Panel consists of three members of the BNA Executive Board who were not involved in the original Hearing.
4. The Appeals Panel shall determine the appeal by majority vote.
5. Decisions of the Hearing Panel or the Appeals Panel will be given in writing, following the hearing or briefing. The decision will contain factual findings, conclusions of law and any sanctions applied. It will be sent to the RN by certified mail, return receipt requested.

Submission of Information Concerning Possible Violation of BNACB Standards

1. Anyone concerned with possible violation of BNACB standards should submit the information in writing to the BNACB.
2. The letter must identify the person(s) alleged to be involved, and the facts concerning the alleged conduct in detail and with documentation. Include the name, address, telephone number, and that of others who may have knowledge of the facts and circumstances concerning the alleged conduct.

Approved Hyperbaric Medicine Training Course

California

Long Beach Memorial Medical Center
Stuart Miller, MD
2801 Atlantic Avenue
Long Beach, CA 90806
562-933-6960

National Polytechnic College of Engineering and Oceaneering
James A. Spelich, CHT, DMT
5245 Pacific Concourse Drive, Suite 134
Los Angeles, CA 90045
(310) 816-5766
docspelich@sbcglobal.net

Sharp Grossmont Hospital
Chris Stirk, CHT
5555 Grossmont Center Drive
La Mesa, CA 91941
(619 740-6000

Canada

Hyperbaric Consultants
Jim Wilson, CHT
23 Abbotsford Road
North York Ontario N2N 2P9
Canada
(419) 225-1753
wilsonj1@sympatico.ca

Florida

Commercial Diving Academy
David H. Weisman
8137 North Main Street
Jacksonville, FL 32208
(904) 766-7736
dweisman@cda.edu

Edison Community College & Columbia SW FL Regional Medical Center
John Berte, MD
Fort Meyers, Florida
(941) 945-6617
bgabbard@edison.edu

Hyperbarics International, Inc.
Dick Rutowski
Key Largo, FL
(305) 451-2551
dick@hyperbaricsinternational.com
www.hyperbaricsinternational.com
(also a DMT Course provider)

Hyperbarics Medicine Education & Consulting Services, LLC
Edwin Santiago, CHT
Pembroke Pines, FL
(954) 391-9151
edwindeepsea@hotmail.com

National Healing Corporation
Robert Bartlett, MD
4850 T-Rex Avenue, Suite 300
Boca Raton, FL 33431
(561) 994-1174

U.S. Army Hyperbaric Training Course
Jason Smith, MD
Key West, FL
(305) 797-2712

Wound Care Education Partners, LLC
John Peters, MBA, FACHE
12900 Calais Circle
Palm Beach, FL 33410
(561) 271-3276
jpeters@woundeducationpartners.com

Approved Hyperbaric Medicine Training Courses (continued)

Georgia
Hyperbaric Physicians of Georgia
William F. Ryan, CHT, EMT/P
Marietta, GA 70447
(985) 651-9521
ryan60grit@aol.com

Louisiana
MATRIX Health Services, LLC
Mary Hirsch, ACHRN (504) 913-9195
Rebecca Evenson (504) 906-1024
Madisonville, LA 70447

New York
Westchester Medical Center
Glenn Butler, CHT
Valhalla, NY 10595
(914) 493-1500
butler@lifesupport-usa.com

Pennsylvania
Oxygen-8 Hyperbaric medicine Centers
Craig Broussard, Ph.D.
Warren, PA 16365
(409) 960-7747

Puerto Rico
Hyperbarics Medicine Education &
Consulting Services, LLC
Edwin Santiago, CHT
Yauco, Puerto Rico
(619) 621-0564
edwindeepsea@hotmail.com

South Carolina
Palmetto Health Richland Hospital
Dick Clarke, CHT
5 Richland Medical Park
Columbia, SC 29203
(803) 434-7101
dick.clarke@palmettohealth.org

Texas
Kevan Corson, CHT, DMT
108 Silver Lace Lane
Round Rock, TX 78664
(512) 924-4266
kcorson@oxyheal.com

International ATMO, Inc.
Robert Sheffield, CHT
San Antonio, Texas
(210) 614-3688
rsheffield@hyperbaricmedicine.com

U.S. Air Force School of Aerospace
Medicine
Clinical Hyperbaric Nursing Course
Brooks AFB., San Antonio, TX
(210) 536-3281

United Kingdom
Diving Diseases Research Center (DDRC)
Paul Dart, CHT
Plymouth, England
+44 1752 209999
pdart@ddrc.org

Steve McKenna, CHT
London, England
+44 20 8329 1222
steve@smckenna@freeserve.co.uk

Washington
Virginia Mason Medical Center
Claude Wreford-Brown, CHRN
Seattle, Washington
(206) 583-6543

Wisconsin
St. Luke's Medical Center
Stephen Fabus, CHT
Milwaukee, Wisconsin
(414) 649-6577
sufabus@aol.com

CHRN® Examination Registration Form

CHRN® Recertification Form

Transcutaneous Oxygen Monitoring (TCOM) Module

Background

CHRN®'s are occasionally called upon to conduct transcutaneous oximetry testing. Commonly, this involves patients with lower extremity wound healing deficiencies. Tissue oximetry testing is a non-invasive and quantitative assessment of oxygen availability in tissues directly beneath the sensor electrode. Used in an algorithmic manner, transcutaneous oxygen testing:

- Identifies whether or not local hypoxia is a factor in healing compromise
- Determines the physiologic capacity to respond locally (the wound) to centrally (the lungs) delivered increases in oxygen delivery
- Provides an early indication of therapeutic response
- Helps to identify a therapeutic end point

Purpose

The TCOM Module is designed to ensure that CHRN®'s are provided with sufficient knowledge and skill to effectively conduct transcutaneous oxygen data collection. This module contains both learning objectives and methods to demonstrate competency.

Disclaimer

It is not the intent of the TCOM Module to provide CHRN®'s with certification in transcutaneous oxygen testing.

LEARNING OBJECTIVES

The trainee is expected to be able to demonstrate a working knowledge of:

I. Transcutaneous oxygen (tcpO2) technology
   A. Principals of transcutaneous oximetry
   B. Applications of transcutaneous oximetry

II. A transcutaneous oxygen monitor and related equipment
   A. Operating functions of the monitor
   B. Calibration procedure
   C. Sensor electrode care and maintenance
   D. Membrane care and replacement
   E. Monitor care
   F. Operational trouble-shooting

III. The transcutaneous oxygen testing procedure
   A. Patient consent
   B. Site selection
   C. Site preparation
   D. Anticipated normal values
   E. Control/reference sites
   F. Normobaric air breathing
   G. Normobaric oxygen breathing
   H. Hyperbaric oxygen breathing
   I. Documentation and data recording
   J. Regional perfusion index (RPI) computation
   K. Common testing errors

RECOMMENDED READING

1. Fife CF, Smart DR, Sheffield PJ, et al. **Transcutaneous Oximetry in Clinical Practice. Consensus Statements Based on Evidence.** *UHM 2009; 36(1):43-53.*
2. Smart DR, Bennett MH, Mitchell SJ. **Transcutaneous Oximetry, Problem Wounds and Hyperbaric Oxygen Therapy.** *Diving and Hyperbaric Medicine 2006; 36(2):72-86.*
3. *Sheffield PJ**. Measuring Tissue Oxygen Tension: A Review.** Undersea and Hyperbaric Medicine 1998; 25(3):179-188.*
4. Jorneskog G , D javani K, B rismar 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.*

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

ELIGIBILITY REQUIREMENTS

Completion of the Transcutaneous Oxygen Monitoring Module is one of several prerequisites necessary for those who wish to certify as hyperbaric nurses (CHRN®'s). Other prerequisites include successful completion of a NBDHMT approved Hyperbaric Medicine Introductory Course and the prescribed clinical internship. As a component of the clinical internship, CHRN® applicant must complete this TCOM Module if it was not included in the approved introductory course. In order to complete the TCOM Module training process, applicants must:

- Review the learning objectives
- Study the Recommended Reading materials, referenced above
- Be formally trained by a competent source in each of the Learning Objectives
- Conduct at least three (3) preceptored lower extremity transcutaneous oxygen studies
- Complete the TCOM Module training post-test
- Include with the CHRN® application
    i. A letter from present employer or medical director that certifies completion of the TCOM Module
    ii. A copy of the TCOM Module training post-test

TCOM MODULE MINIMUM TRAINING OUTLINE

I. Trainee should be able to demonstrate a working knowledge of the transcutaneous monitor technology, specifically:
    A. Describe the principles of transcutaneous oximetry testing to include:
        i. Function of the sensor electrode
        ii. Physiological effect of the heating element
        iii. Potential patient risks
    B. Summarize the various applications of tcpO2 monitoring, as they relate to the wound healing deficient patient
        i. Small and large vessel abnormality screening
        ii. Wound hypoxia determination
        iii. Suitability to undergo HBO therapy
        iv. Evidence of therapeutic response
        v. Determination of potential therapeutic endpoint
        vi. Skin flap assessment

II. Trainee should be able to demonstrate a working knowledge of the transcutaneous oxygen monitor and its supportive equipment.
    A. Describe the operating functions of the monitor, including settings and adjustments
    B. Explain how the monitor is calibrated, and on what frequency
    C. Summarize the correct procedures for maintaining the sensor electrode and changing sensor membranes
    D. Describe how the sensor electrode is cleaned and disinfected
    E. Describe the necessary trouble-shooting procedures for alarms and error codes

III. Trainee should be able to demonstrate a working knowledge of the transcutaneous oxygen testing procedure.
    A. Describe the related anatomy of common testing sites
        i. Vascular supply
        ii. Bones and tendons
    B. Describe how the various testing sites are selected
        i. Anatomic characteristics
        ii. Skin characteristics
        iii. Peri-wound issues
    C. List the steps involved in site preparation

i. Removal of hair
ii. Removal of oils and dirt
iii. Removal of loose dry skin/stratum corneum

D. Describe the testing process, and at least two types of provocative challenges
i. Baseline air breathing test procedure
ii. Provocative challenges
a. Normobaric 100% oxygen at ambient pressure
b. Extremity elevation; air breathing
c. Extremity dependency; air breathing
d. Limb occlusion
e. Hyperbaric oxygen challenge

E. Explain why patient-specific control/reference sites are employed and provide examples
i. To allow each patient to serve as their own control
ii. To determine differences in degree of 'central' (chest) vs. 'local' (extremity or wound) tissue oxygenation
iii. Example sites include the chest (left second intracostal space, mid-clavicular), the tricep, where the chest is not suitable (large amount of fatty tissue; previous history of therapeutic radiation; CABG surgery and mammary artery diversion; contralateral extremity).

F. List anticipated tcpO2 values or range of normal values for both 1.0 ATA air testing and at elevated altitudes
i. Chest reference site 60-95mmHg
ii. Lower extremity; normal > 50mmHg adequate for oxygen-dependent wound healing; > 40mmHg
iii. Foot; as per ii above.

G. Describe trouble shooting procedure for
i. Alarms
ii. Error Codes

IV. Trainee should be able to demonstrate knowledge of a tcpO2 test that is consistent with current industry standards.

A. Describe the anatomy of the most common tcpO2 sites
i. Vascular supply
ii. Bones and Tendons

B. Describe how to determine site selection
i. Anatomical characteristics
iii. Skin characteristics
iv. Peri-wound characteristics

B. List 3 steps of site preparation
i. Remove hair
ii. Remove loose dry skin
iii. Cleanse skin to remove oils and dirt

C. Explain how to perform a comprehensive tcpO2 study that will identify basic tcpO2 values and tcpO2 responses to 3 physiologic challenges
i. Baseline with normobaric air
ii. Physiologic challenges
a. Elevated extremity challenge with normobaric air
b. Normobaric oxygen challenge with 100% 02
c. Hyperbaric 02 challenge with 100% 02

D. Explain why reference information is obtained during tcpO2 tests
i. Control sites
ii. Contra-lateral sites

E. List the anticipated normal tcpO2 values
i. Chest
ii. Leg

iii. Foot

F. Explain how one calculates Regional Perfusion Index (RPI)
   i. Completed for air breathing only
   ii. Divide wound site value by chest control site value

G. Explain the effects of common testing errors on tcpO2 value obtained
   i. Positioning of patient
   ii. Patient animated
   iii. Ambient room temperature variances
   iv. Inconsistent electrode temperature with serial readings
   v. Inconsistent electrode placement with serial readings
   vi. Inadequate time for electrode equilibration
   vii. Inadequate oxygen flow during oxygen challenge
   viii. Improper adhesion of electrode to skin surface

H. Trainee should be able to describe how to obtain the subject's consent for tcpO2 procedure
   i. Explain the planned procedure
   ii. Explain the risks involved
   iii. Explain the potential value of the test

I. Trainee s hould b e ab le t o i nspect t he eq uipment neede d t o c onduct a tcpO2 study
   i. Monitor
   ii. Electrode
   iii. Ancillary Equipment
      a. Oxygen source
      b. Oxygen delivery device
      c. Calibration gas (if applicable)

J. Trainee s hould b e a ble t o c ontact a t cpO2 test t hat i s c onsistent with current industry standards
   i. Set up the oxygen monitor
      a. Sensor temperature setting
      b. pO2 setting
      c. pCO2 setting (if available)
      d. Re-membrane electrode
      e. Calibrate electrode
   ii. Prepare the patient
      a. Brief the patient
      b. Obtain patient's consent
      c. Position patient for test
   iii. Prepare the site
      a. Prepare the selected site for accepting the electrode
      b. Attach the electrode to the skin surface
   iv. Collect the data
      a. Baseline tcpO2 on normobaric air
      b. Physiologic challenge (any 1 of 2 below)
      c. Normobaric oxygen challenge on 100% oxygen
      d. Hyperbaric oxygen challenge with 100% oxygen
   v. Record the data
      a. Complete data sheet or input information to computer
      b. Calculate RPI
   vi. Remove Electrode
      a. Remove adhesive device
      b. Clean electrode
      c. Store electrode

SAMPLE TCOM COMPETENCY SKILLS CHECKLIST

Technical Knowledge of Transcutaneous Oxygen Monitor and Sensor Electrode

Name _____ Instructor _____
as it appears on government issued I.D.

Demonstrate knowledge of the following

☐	Principles of transcutaneous oximetry
☐	Application for tcpO2
☐	Operating functions of the monitor
☐	Settings
☐	Adjustments
☐	Calibration procedure
☐	Procedure for maintaining membrane & electrode
☐	Troubleshooting procedures for alarms and error codes
☐	Anatomy of common tcpO2 sites
☐	How to select tcpO2 site
☐	How to prepare tcpO2 site
☐	How to perform a tcpO2 study
☐	Why reference information is obtained
☐	Anticipated normal tcpO2 values
☐	How to calculate a regional perfusion index (RPI)
☐	Three common testing errors and their effect on tcpO2
☐	How to obtain the subjects consent for tcpO2 procedure

Demonstrate procedure for inspection of the equipment

	Monitor
☐	Site temperature setting
☐	pO2 setting
☐	pCO2 (if applicable)
☐	O2 alarm limits
☐	CO2 alarm limits (if applicable)
	Electrode
☐	Cable in intact
☐	Membrane change
☐	Timing of changes
☐	Technique
	Ancillary Equipment
☐	O2 source (HP cylinder, wall O2)
☐	O2 delivery (mask or hood assembly)
☐	Calibration gas (if applicable)

Demonstrate test procedure

Conduct tcpO2 Study (3 patients/subjects)	**1**	**2**	**3**
Set up oxygen monitor			
Set up temperature			
Set pO2/pCO2 (if applicable)			
Re-membrane electrode (1 time)			
Calibrate electrode (if applicable)			
Prepare the patient/subject			
Brief the patient/subject			
Obtain consent			
Position patient/subject for test			
Prepare the site			
Select the site			
Remove hair and loose skin			
Clean the site			
Attach electrode to skin			
Collect data			
Baseline tcpO2 air			
Physiologic challenge (any 2 of the following)			
Elevated limb			
Ambient pressure 100% O2			
Hyperbaric pressure with 100% O2			
Record data			
Data sheet or computer			
Calculate RPI			
Remove electrode			
Remove adhesive device			
Clean electrode			
Store electrode			
Perform tcpO2 mapping (3 patients/subjects)			
Troubleshoot equipment			
Alarms			
Error codes			

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. E P 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 affect 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

Hyperbaric 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. E P 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 C F, Smart D R, Sheffield P J, et al. **Transcutaneous Oximetry in Clinical Practice. Consensus Statements Based on Evidence.** *UHM 2009; 36(1):43-53.*

Smart D R, Bennett M H, Mitchell S J. **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.*

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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 cognitive)

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

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