Certified Hyperbaric Technologist

Approved Training Course Contents

August 2009

National Board of Diving & Hyperbaric Medical Technology
NBDHMT.org

Competency Standards

This document describes the minimum general requirements and competency levels required of a CHT.

Minimum General Requirements

Understand:

1. Physics related to pressure exposures
2. Basic calculations for the conversion of common units used in diving and hyperbaric practice (examples include feet/meters, psi/bar/Pa, Kg/pound etc.)
3. Basic physical units used in diving and hyperbaric practice
4. Boyle's Law (calculating air volumes and air consumption)
5. Dalton's Law (partial pressure of gases at various depths)
6. Charles' Law (the relationship between pressure changes and temperature changes)
7. Henry's Law (the effect of partial pressures on the solubility of various gases in liquids and their corresponding effects on decompression)
8. The principles of heat transfer by conduction, convection and radiation
9. Mechanism of action for all UHMS approved hyperbaric oxygen indications
10. Direct effects of pressure change; how and where barotrauma occurs
    a. Ear
    b. Sinus
    c. Dental
    d. Pulmonary
11. Signs and symptoms of decompression illness (DCI)
12. Relevant aspects of anatomy and physiology pertaining to these systems:
    a. Musculoskeletal
    b. Neurological
    c. Integumentary
    d. Cardiovascular
    e. Respiratory
    f. Endocrine
    g. Gastrointestinal
    h. Hematologic

Possess the capability to provide clinical support and assist in the prevention and/or management of pressure related problems:

1. Ear squeeze and other barotraumas
2. Carbon Dioxide (CO2) retention
3. Carbon Monoxide (CO) poisoning
4. Hyperbaric chamber atmosphere contamination
5. Built in breathing system (BIBS) contamination
6. Oxygen (O2) toxicity
7. Anoxic and hypoxic events
8. Nitrogen (N2) narcosis
9. Decompression illness (DCI)
10. Hypothermia and hyperthermia events

Gas Systems
Understand and/or conduct procedures for chamber operations and life support systems

1. Test for purity of gases
2. Elemental gas schematics and their interactions when mixed
3. Mathematical calculations of gas usage
4. The principles and use of gas analyzers
5. Methods of identifying gas impurities
6. The importance of oxygen purity in a gas delivery system
7. Gas line filtration
8. Calibrate gas analyzers
    a. Delivery of multiple gases during hypo/hyperbaric operations
    b. Monitor the chamber for depth, temperature and humidity using available types of equipment
    c. Calibrate analyzing equipment
9. Rationale for gas stratification and its prevention
10. Maintain a legible and accurate record of all aspects of a hyperbaric delivery system
11. Maintain a gas status board showing gas reserves and mixtures

Chamber Operations and Environment
Understand:

1. Procedures for operating a hypo/hyperbaric chamber
2. Inside attendants' responsibilities in a hypo/hyperbaric chamber
3. The conduct of a post-exposure therapeutic recompression
4. The system checks and user maintenance needed after using a hypo/hyperbaric chamber
5. Pre and post dive checks of a hypo/hyperbaric chamber complex using specific checklists
6. The operation and design of medical locks, including various types of interlocks and safety devices
7. The principles of operation of various items of equipment used in a typical hyperbaric system, such as compressors, fire suppression systems, oxygen scrubbing and gas reclaim equipment
8. The characteristics of and maintenance requirements for acrylic viewports
9. The monitoring of internal chamber operations
10. The monitoring of internal/external chamber gas quality and gas system quality
11. The operation, function testing and selection of gas supplies for BIBS and overboard dump systems, including routine maintenance and repairs
12. Compression and decompression procedures for multiple indications
13. The construction and purpose of valves, fittings, gauges, regulators, hoses and pipe work
14. How to carry out normal operations, maintenance and basic repairs on gas and fluid systems
15. The differences between various thread forms and rationale
16. The principles of chamber life support systems with priority on pre-operational checklists, monitoring during use, routine maintenance and basic repairs
17. Proper identification of various gas cylinders; mandatory hospital grade gases

18. Proper handling and storage of gas cylinders
19. Emergency preparedness for fire, loss of oxygen, medical complications
20. The use of various types of fire suppression systems including routine maintenance and operational checks
21. The various substances and materials, which are prohibited inside a chamber, such as medical preparations, combustible materials, etc.
22. Operate telephone emergency signals and other communications systems
23. Risks/benefits involved with emergency decompression
24. Appreciate the unique differences between monoplace and multiplace chambers
25. Familiarity with the following regulatory agencies and related organizations: Food and Drug Administration (FDA), Centers for Medicare and Medicaid Services (CMS), Occupational, Safety and Health Administration (OSHA), Centers for Disease Control and Prevention (CDC), National Fire Protection Association (NFPA), American Society of Mechanical Engineers (ASME), American Society of Mechanical Engineers' Committee on Pressure Vessels for Human Occupancy (ASME PVHO), Association of Diving Contractors International (ADCI), Joint Commission (JC) and the Undersea and Hyperbaric Medical Society (UHMS)

Clinical Skills (supervised)

Have a basic understanding in the operation of biomedical devices within the department

Be able to carry out relevant diagnostic and clinical procedures such as:

1. Ability to report to nurse or physician an accurate medical history
2. Assess patient for pain and document findings
3. Obtain vital signs (pulse, respiratory rate, body temperature, and blood pressure)
4. Observe for changes in neurological status
5. Know when to use appropriate clean or sterile techniques
6. Collection and removal of patient waste products
7. Assist in patient care procedures; dressing changes
8. Basic EKG recognition; set alarm parameters; print and post strip
9. Ability to safely operate all stretchers, gurneys, wheelchairs, beds and other assistive devices
10. Comply with quality control (QC) measures; glucometer
11. Prepare patient for treatment
    a. Body positioning of patients
    b. All cotton garments or other approved materials only for in chamber
    c. EKG placement on patient, as ordered
    d. Age specific patient education on fundamentals of HBO treatment; equalizing ear pressure
    e. Provide comfort measures with approved safety constraints.

Generalized Clinical Knowledge

Have a basic understanding of the risks, side effects and hazards of certain medications in the hyperbaric chamber.

1. Maintain CPR, ability to establish an airway
2. Describe the signs, symptoms and treatment of hyper- and hypothermia
3. Describe the effects of gases on the body and their limits under pressure
4. Describe the effects of pressure on the body and the principles of decompression and therapeutic procedures

5. Proper body mechanics to protect self from injury
6. Communication with all levels of hyperbaric medical team
7. Reinforce age-specific teaching
8. Perform transcutaneous oximetry (TCOM), as ordered
9. Basic medical terminology
10. Proper use and application of restraints when ordered by physician; assess circulation
11. Patient privacy and confidentiality; observe HIPPA requirements
12. Medical record keeping; secure

Infection control measures

1. Universal precautions
2. Use of approved disinfectants for chamber and equipment; recognizing the risks associated with off gassing of chemicals in the chamber
3. Hand washing
4. Personal protective equipment (PPE)

Transcutaneous Oxygen (TCOM) Monitoring Module

Background
CHT's and 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 CHT's and 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 CHT's and 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

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
   ii. Skin characteristics
   iii. 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 should be able to inspect the equipment needed to conduct a tcpO2 study
   i. Monitor
   ii. Electrode
   iii. Ancillary Equipment
      a. Oxygen source
      b. Oxygen delivery device
      c. Calibration gas (if applicable)

J. Trainee should be able to contact a tcpO2 test that is consistent 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			