Emergency Oxygen for Scuba Diving Injuries (EO2)

Version 3.0

Emergency Oxygen for Scuba Diving Injuries (EO2)

Getting Started

- Introductions
  - Instructor and Staff
  - Students
- Emergency Oxygen Provider Registration Form
  - Statement of Understanding
  - Exam Answer Sheet
  - Skill Development Checklist
- Course Logistics

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Emergency Oxygen for Scuba Diving Injuries (EO2)

Course Overview

- Atmospheric Gases
- Respiration and Circulation
- Decompression Illness
- Oxygen and Dive Injuries
- Handling Oxygen Safely
- Oxygen Delivery Systems and Components
- Skill Development
- Final Assessment and Review

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Emergency Oxygen for Scuba Diving Injuries (EO2)

Overview of Atmospheric Gases

Oxygen (O_2)

- Colorless, odorless, tasteless gas
- Approximately 21% of the Earth's atmosphere
- Essential for life
- Transported throughout the body by red blood cells
- Exhaled air is approximately 16% oxygen

Carbon Dioxide (CO_2)

- Normal air contains 0.04% CO_2
- A waste product of cellular metabolism
- Eliminated from the body via respiration (exhalation)
- Exhaled air is approximately 4-5%
  - but has no impact on rescue breathing
- Elevated levels can cause shortness of breath, drowsiness, dizziness and unconsciousness

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Overview of Atmospheric Gases

Nitrogen (N_2)

- Approximately 78% of the Earth's atmosphere
- An inert gas (is not involved in cellular metabolism)
- Does not interfere with resuscitation efforts

Carbon Monoxide (CO)

- Interferes with oxygen delivery to body tissues
- Binds to hemoglobin, inhibiting the uptake of O_2 and its delivery to tissues
- Small amounts within a scuba tank can become toxic when breathed under pressure

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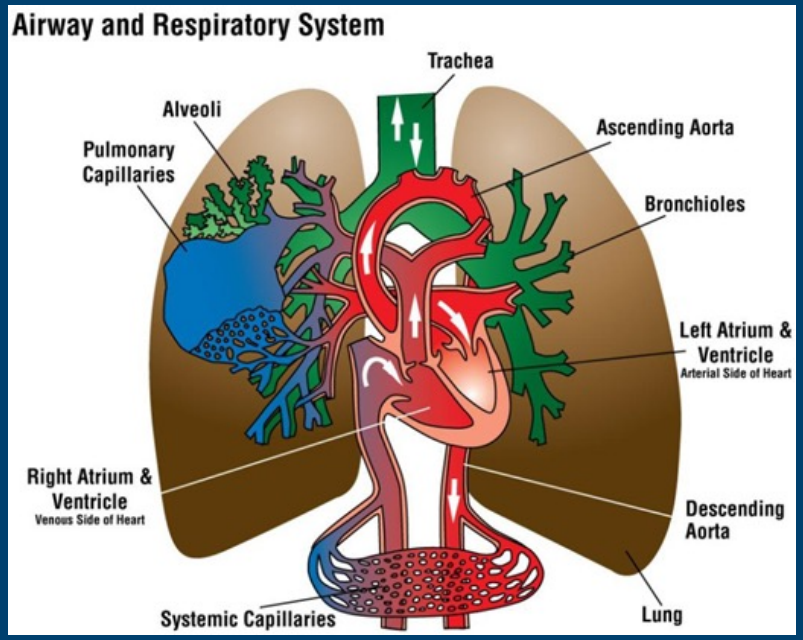

Respiration and Circulation

Oxygen is essential for life and cellular function

- Hypoxia is oxygen deficiency
- Anoxia is the absence of oxygen

Respiratory system provides the interface between the atmosphere and the bloodstream for gas exchange

- Intake of oxygen
- Removal of CO_2

Respiratory system is comprised of the upper airway (mouth, nose, pharynx), trachea, and lungs

- The smallest structures are the alveoli

Pulmonary gas exchange takes place at the alveolar-capillary membrane

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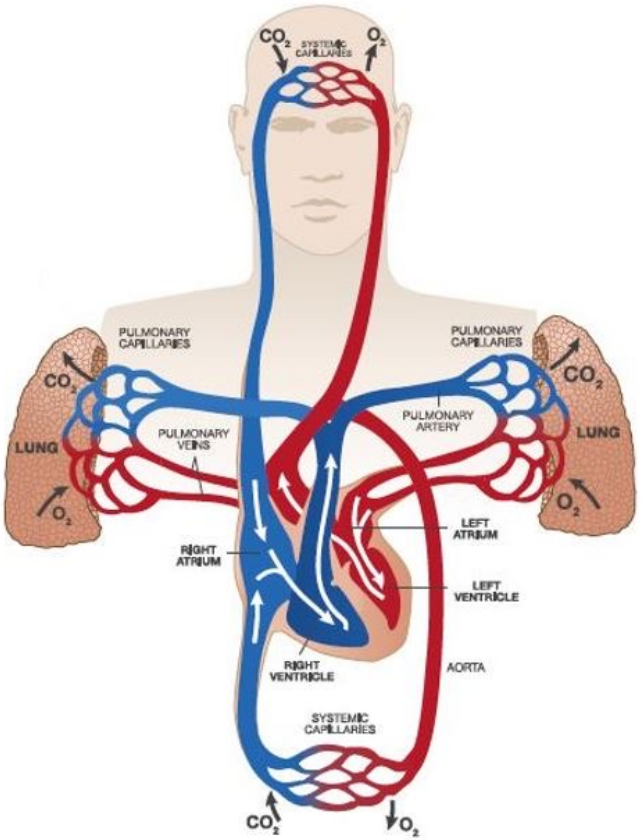

Respiration and Circulation

Circulatory System

- Includes the heart and blood vessels
- Primary function is pumping blood, transporting oxygen and nutrients to tissues and removing waste products

Arteries

- Carry blood from the heart to the body tissues

Veins

- Carry blood from the body to the heart

Capillaries

- The smallest blood vessels where nutrients and waste products are exchanged at the tissue cellular level

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Decompression Illness (DCI)

Decompression Illness (DCI) encompasses two different processes related to decompression

- Arterial gas embolism (AGE)
- Decompression sickness (DCS)

First-aid treatment for both AGE and DCS is exactly the same

Most important initial action is early recognition and the use of supplemental oxygen

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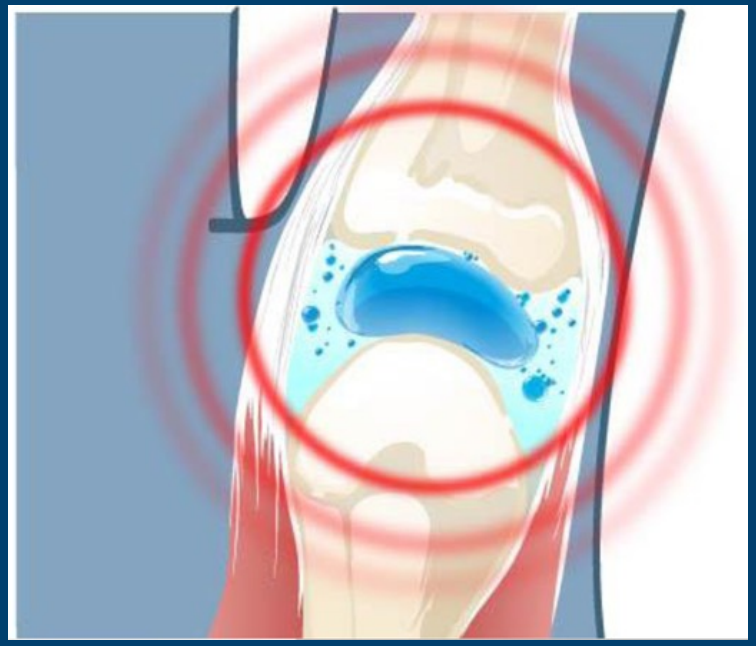
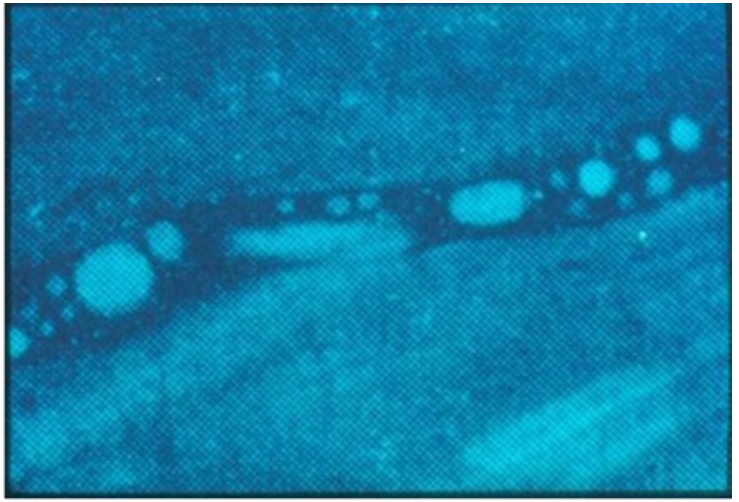


Decompression Sickness (DCS)

Results from bubbles formed within tissues or blood from inert gas (nitrogen or helium)

Bubble Formation can cause:

- Tissue distortion and interruption of blood flow
- Blood clotting, inflammation, circulatory system fluid leakage, and vasoconstriction



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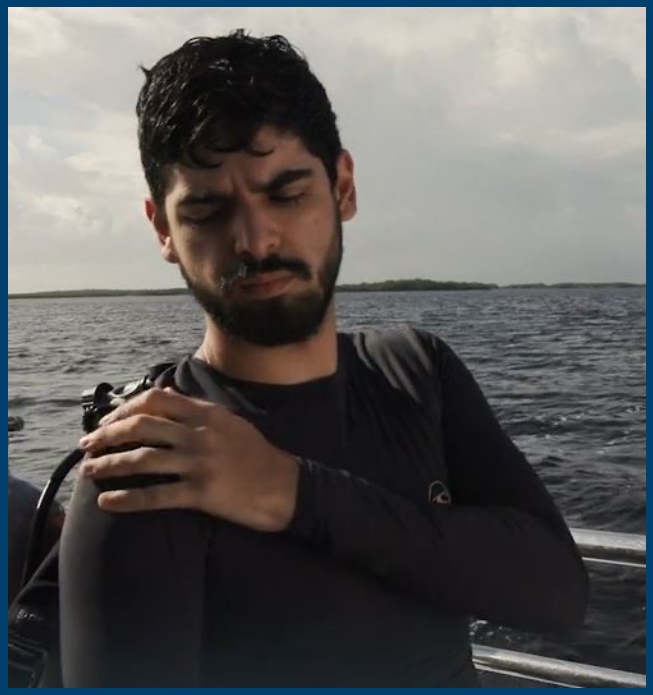

Decompression Sickness (DCS)

Symptoms may include:

- Pain, Numbness
- Constitutional (fatigue, nausea)
- Vertigo, Dizziness
- Motor weakness
- Skin rash

First Aid:

Early treatment with high concentrations of O_2 (as close to 100% as possible)

Definitive treatment should be sought even if symptoms disappear

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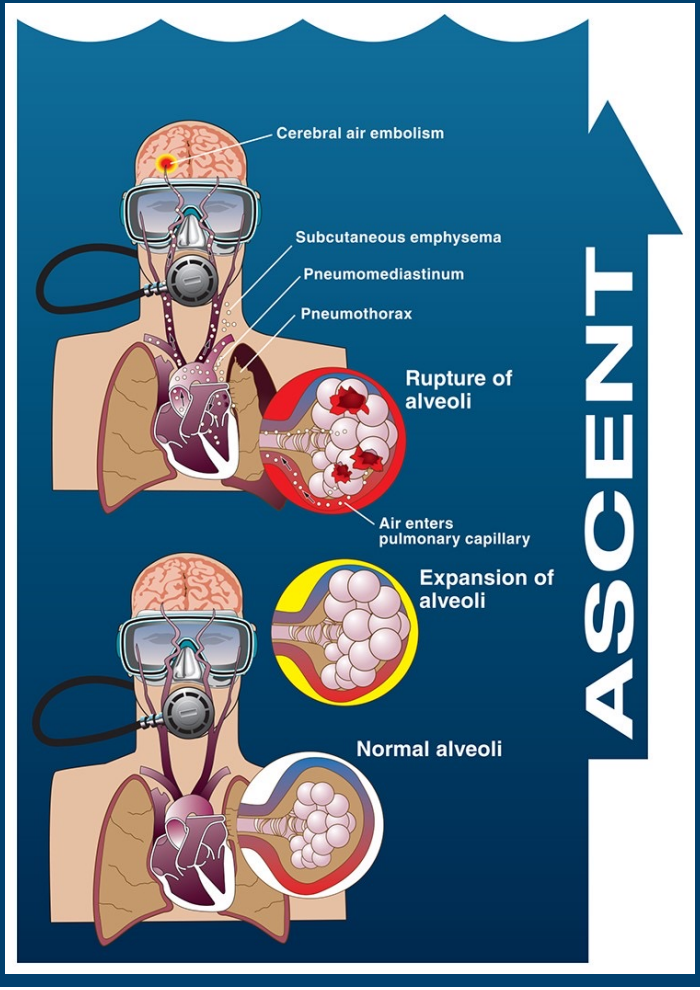

Arterial Gas Embolism (AGE)

AGE typically results from a lung overexpansion injury

AGE allows gas from the lungs to get into the blood stream

- If transported to the brain can cause dramatic effects rapidly

Primary risk factor is breath hold during ascent

- Can occur in as little as 4 feet (1.2m)

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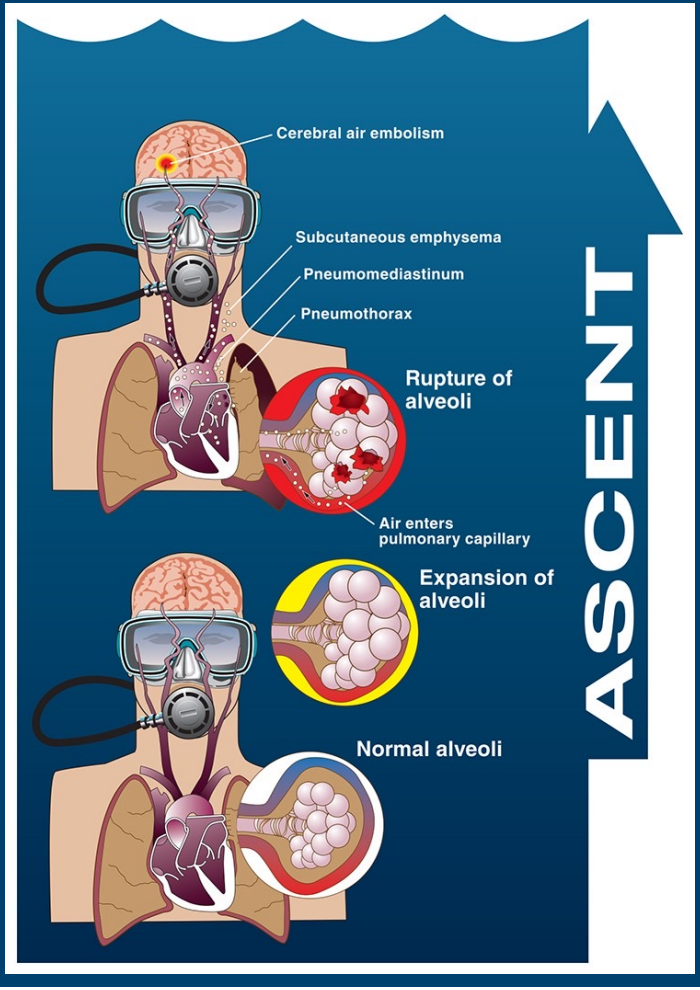

Arterial Gas Embolism (AGE)

Other potential risk factors:

- Lung infections
- Asthma
- Other pre-existing condition(s)

Other forms of pulmonary barotrauma

- Pneumothorax
- Subcutaneous emphysema
- Mediastinal emphysema
- Pneumopericardium

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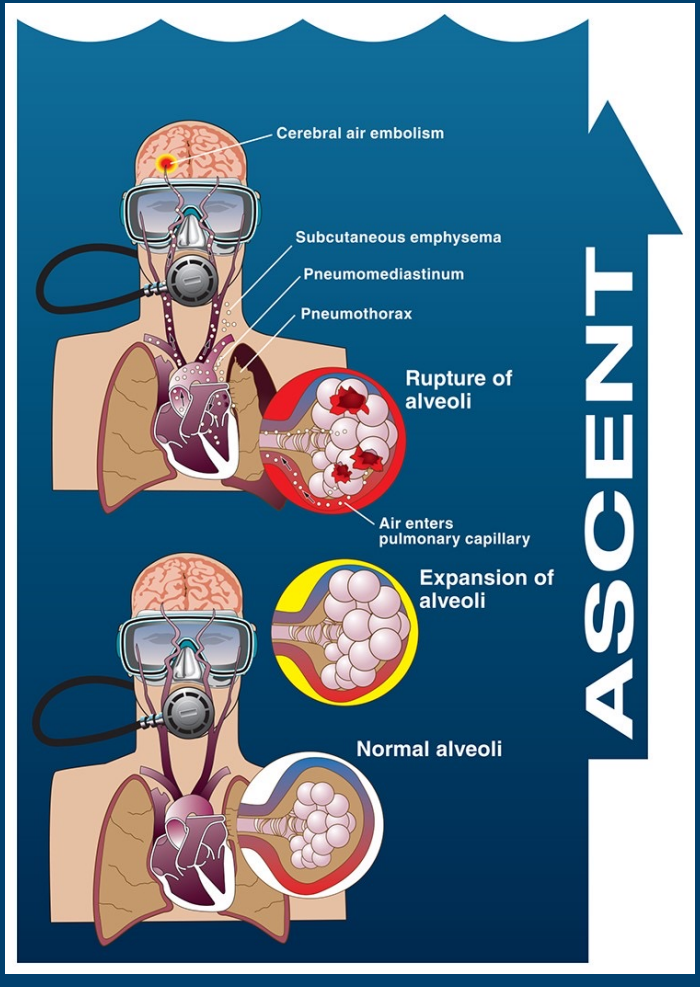

Arterial Gas Embolism (AGE)

Signs and Symptoms:

- Chest pain
- Changes in voice pitch
- Difficulty breathing or swallowing
- Gas bubbles felt under the skin
- Cyanosis, bluish coloration of the skin

First Aid:

Early treatment with high concentrations of O_2 (as close to 100% as possible)

Access into EMS as soon as possible for advanced medical evaluation and treatment

Call DAN Emergency Hotline

+27 828 10 60 10

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Decompression Illness (DCI)

Medical Evaluation is recommended for all suspected cases of DCI

- Symptoms may recur
- Risk of recurrence is reduced with hyperbaric treatment
- Prolonged delays may reduce effectiveness of treatment

Signs and Symptoms (most frequent):

- Pain, especially joint or muscle
- Paresthesia/Numbness
- Fatigue/Malaise, Nausea
- Vertigo/Dizziness
- Motor Weakness
- Skin Rashes
- Altered mental status

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Decompression Illness (DCI)

Symptom onset varies

- DCS complaints begin within 6 hours
  - May be delayed as much as 24 hours
- AGE symptoms present immediately upon surfacing or within 15 minutes
  - May show a more dramatic array of symptoms

Residual symptoms

- Not uncommon, especially in severe cases or when considerable delay to treatment occurs

Return to diving

- Should be made in consultation with a physician knowledgeable in dive medicine

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Emergency Oxygen for Scuba Diving Injuries (EO2)

Oxygen and Dive Injuries

Benefits of oxygen administration

- Acceleration of inert gas elimination
- Reduces bubble size and improves circulation
- Enhances oxygen delivery to tissues
- Reduces pain and swelling

Primary goal of emergency oxygen administration:

- Deliver the highest percentage of inspired oxygen possible

Delivery Device	Flow Rate	Inspired Fraction+
Oronasal mask (pocket mask)	10 lpm	≤ 0.5–0.6 (50%–60%)*
Nonrebreather mask	10-15 lpm	≤ 0.8 (80%)**
Bag valve mask	15 lpm	≤ 0.9–0.95 (90%–95%)
Demand valve (MTV)	N/A	≤ 0.9–0.95 (90%–95%)

** May vary with respiratory rate **Less variation with changes in respiratory rate*
+Delivery fractions vary with the equipment and techniques used. This table summarizes various oxygen-delivery systems and potential values of inspired oxygen with their use.

Emergency Oxygen for Scuba Diving Injuries (EO2)

Oxygen and Dive Injuries

Variables impacting delivered oxygen concentrations:

- Mask fit and flow rate
  - Enhanced flow rates are inefficient compensation for poor mask fit

Priority of oxygen delivery in remote areas:

- Deliver highest inspired fraction of oxygen

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Emergency Oxygen for Scuba Diving Injuries (EO2)

Oxygen and Dive Injuries

Oxygen toxicity is **not** a concern in rendering first aid

Two forms of oxygen toxicity

- **Central Nervous System toxicity** occurs when breathing oxygen at pressures usually greater than 1 ATM
  - A concern for divers using diving gases with higher concentrations of oxygen (> 21%)
- **Pulmonary Oxygen Toxicity** initial symptoms may occur after 12-16 hours of breathing high concentrations of oxygen for prolonged periods at the surface

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Emergency Oxygen for Scuba Diving Injuries (EO2)

Oxygen and Dive Injuries

Non-fatal drowning: situation when someone almost died from submersion

- Oxygen first aid is crucial
- Lung complications common and require medical attention

Signs and symptoms of non-fatal drowning:

- Difficulty breathing
- Bluish discoloration of lips
- Abdominal distension
- Chest pain
- Confusion
- Coughing up pink, frothy sputum
- Irritability
- Unconsciousness

First Aid:

- Monitor vital signs
- Provide supplemental oxygen
- Transport to nearest medical facility

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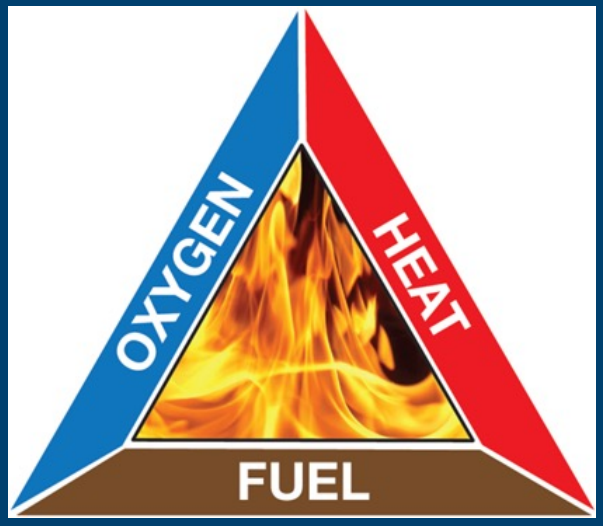

Handling Oxygen Safely

Oxygen is not flammable, but all substances need oxygen to burn and may burn violently in an environment of pure oxygen.

Fire Triangle is made up of three elements:

- Oxygen
- Heat
- Fuel

Reduce risks of handling oxygen by

- Avoid fuel deposits (oil, hydrocarbons, lubricants)
- Avoid heat from direct sun
- Avoid rapidly opening cylinder valve

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Emergency Oxygen for Scuba Diving Injuries (EO2)

Handling Oxygen Safely

Oxygen Grades

- Aviator-grade oxygen
- Medical-grade oxygen
- Industrial-grade oxygen

Each must be 99.5 % pure oxygen

NOTE: differences exist in how cylinders are filled which affects overall purity of the oxygen.

Industrial-grade oxygen is not recommended for use with dive injuries.

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Emergency Oxygen for Scuba Diving Injuries (EO2)

Handling Oxygen Safely

Safety Precautions When Using Oxygen

Oxygen cylinders require the same care as scuba cylinders with a few additional precautions:

- Do not allow the use of any oil or grease on any cylinder or device that comes in contact with oxygen.
  - The result may be a fire or explosion
- Oxygen cylinders should not be exposed to temperatures higher than 125°F (52°C) in storage (for example, in a car trunk).
- Do not allow smoking or an open flame around oxygen and oxygen equipment.

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Emergency Oxygen for Scuba Diving Injuries (EO2)

Standard ‘O’ ring O_2 Washer

Handling Oxygen Safely

- Open valves slowly to pressurize system.
- Only open one full turn once pressurized for quick shut off if necessary
- Remember to provide adequate ventilation when using oxygen.
- Confined, poorly ventilated spaces (the cabin of a boat, for example) may allow build up of oxygen concentration and create a fire hazard.
- Use only equipment (cylinders, regulators, valves and gauges) made to be used with oxygen.
- Avoid adapting scuba equipment for use with oxygen.

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Handling Oxygen Safely

- Visually inspect the condition of valve seats and oxygen washers, and make sure the materials are compatible for oxygen use.
- Keep the valves closed with the system purged when the unit is not in use. Close valves on empty cylinders. Empty cylinders should be refilled immediately after use.
- An oxygen cylinder should always be secured so that it cannot fall.
- When transporting an oxygen cylinder in a car, secure and block the cylinder so it cannot roll.
- When carrying an oxygen cylinder by hand, carry it with both hands and avoid holding it by the valve or regulator.

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Emergency Oxygen for Scuba Diving Injuries (EO2)

Handling Oxygen Safely

Obtaining Oxygen cylinder fills

- Prescription
  - Most common method
  - *Prospective* prescription allows for administration by trained provider
- Documentation of current training in use of emergency oxygen
  - DAN Emergency Oxygen for Scuba Diving Injuries provider
  - Retraining required every two years

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Handling Oxygen Safely

Oxygen Unit Storage and Maintenance

- Keep unit in its storage case
  - Fully assembled
  - Turned off
  - Depressurized
- Check components and cylinder pressure before every outing
- Clean removable plastic parts after every use

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Oxygen Delivery Components

Oxygen Delivery Systems

Include the following components

- Oxygen cylinder
- Pressure reducing regulator
- Hose
- Face mask

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Emergency Oxygen for Scuba Diving Injuries (EO2)

Green shoulder, unpainted, and white shoulder cylinders

Oxygen Delivery Components

Oxygen Cylinders

- Should provide enough continuous delivery of oxygen from time of injury from farthest possible dive site to next level of emergency response
  - Factors affecting delivery time
    - size of cylinder
    - oxygen flow rate
    - delivery device

Color coding of cylinders

- White – Is the international designation
  - But not universally used
- Green – United States, Canada and many Latin America countries
- Black with White or black/white checkerboard shoulder – this is an older pattern but may still be seen occasionally.

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Emergency Oxygen for Scuba Diving Injuries (EO2)

Oxygen Delivery Components

Choosing and Maintaining an Oxygen Cylinder

- To determine oxygen delivery time

  Capacity in liters / flow in liters per minute = approximate delivery time

- Change cylinder when pressure drops to 200 psi (14 bar)
  - If another cylinder is not available, use until oxygen is depleted
- Cylinders are subject to periodic hydrostatic testing
  - Hydrostatic testing 1 -10 years
    - U.S. is 5 years

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Oxygen Delivery Components

Oxygen Pressure Regulator

- Constant Flow
- Demand
- Multi-function - preferred
  - Can provide oxygen to two injured divers

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Emergency Oxygen for Scuba Diving Injuries (EO2)

Oxygen Delivery Components

Oxygen Regulators

- Reduces cylinder pressure to safe working pressure
- Pins engage some regulators
  - Pin alignment is specific for each gas
  - Prevents oxygen regulator from being placed on a cylinder containing a different gas
- Threaded gas-outlet valves specific for oxygen also used in some areas. Or where a specific regulator is used by code.

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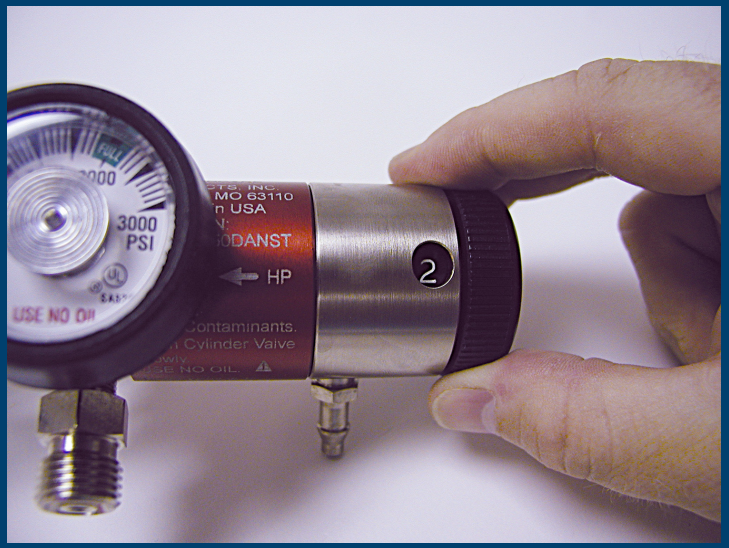

Oxygen Delivery Components

Oxygen Regulator Features

- Pressure gauge
  - Provides ability to monitor oxygen consumption
- Flow meter
  - Provides adjustable flow rate (0.5 – 25 lpm)
- Adapters may be available for travel to other areas
  - Must be oxygen clean

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Oxygen Delivery Components

Hoses and Tubing

- Intermediate pressure hose (demand)
  - Green or White – depending on region
- Clear plastic tubing (constant flow)

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Emergency Oxygen for Scuba Diving Injuries (EO2)

Oxygen Delivery Components

Oxygen mask

- Oronasal mask
  - With demand valve can provide up to 95% oxygen concentration
- Nonrebreather masks
  - Variable oxygen delivery (up to 80%)

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Emergency Oxygen for Scuba Diving Injuries (EO2)

Oxygen Delivery Components

Demand Inhalator Valve with Oronasal Mask

- Similar to scuba second stage
- Delivers oxygen upon inhaling
- Oxygen delivery can reach 95% with good mask seal
- Clean after each use

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Emergency Oxygen for Scuba Diving Injuries (EO2)

Oxygen Delivery Components

Nonrebreather Mask

- Contains 3 non-return valves and reservoir bag
- Use when treating more than one injured diver
- Requires large supply of oxygen
- Second choice of delivery as concentration of oxygen delivered is lower
- Single use/disposable

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Oxygen Delivery Components

Bag Valve Mask (BVM)

- Delivers rescue breaths by squeezing a ventilation bag
- Can be used with room air or oxygen
- Requires two rescuers for effective use
- Avoid over ventilation
- Single use/disposable

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Emergency Oxygen for Scuba Diving Injuries (EO2)

Oxygen Delivery Components

Manually Triggered Ventilator (MTV)

- Delivers rescue breaths by activating a button similar to a scuba regulator purge button
- Can function as a demand valve
- Requires two rescuers for effective use
- Avoid over-ventilation
- Clean after each use

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Emergency Oxygen for Scuba Diving Injuries (EO2)

Oxygen Provider Skills

Oxygen Equipment Assembly and Disassembly

Scene Safety Assessment

Initial Assessment with Basic Life Support

Demand Inhalator Valve

Nonrebreather Mask

Resuscitation with a Bag Valve Mask

Using an MTV

Providing Oxygen to Two Injured Divers (optional skill)

Emergency Assistance Plan

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Questions?

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