Monitoring Pulse Oximetry by Emergency Medical Technicians

Table of Contents

OBJECTIVES LEGEND

C=Cognitive P=Psychomotor A=Application

1=Knowledge
2=Application
3=Problem Solving Level

LESSON TERMINAL INSTRUCTIONAL OBJECTIVE

At the completion of this lesson, the EMT-Basic student will be able to utilize the information provided by pulse oximetry monitoring to enhance patient assessment skills and provide optimal interventions in the care of patients.

COGNITIVE OBJECTIVES

Upon completion of this module, the EMT-Basic will be able to:

1. Review and understand the applicable Kansas regulation relative to monitoring pulse oximetry by the EMT-Basic. (C-2)
2. Review the signs and symptoms of respiratory compromise. (C-1)
3. Review and understand the importance of adequate tissue perfusion. (C-2)
4. Describe how oxygen is carried by the blood. (C-3)
5. Define hypoxemia and describe the clinical signs and symptoms. (C-2)
6. Describe the technology of the pulse oximeter (C-2)
7. Define normal parameters of oxygen saturation (C-1)
8. Describe the relationship between oxygen saturation and partial pressure oxygen. (C-3)
9. Describe the significance of the information provided by pulse oximetry. (C-3)
10. Describe monitoring pulse oximetry during patient assessment. (C-3)

11. Describe the use of pulse oximetry with pediatrics. (C-3)

12. Describe patient conditions that may affect pulse oximetry accuracy. (C-3)

13. Describe patient environments that may affect pulse oximetry accuracy. (C-3)

14. Describe the evaluation and documentation of pulse oximetry monitoring. (C-3)

AFFECTIVE OBJECTIVES

Upon completion of this module, the EMT-Basic will be able to:

15. Recognize and value of pulse oximetry monitoring as an adjunct in the assessment of the pre-hospital patient.(A-2)

16. Demonstrate appreciation for additional information in developing accurate field impressions of the pre-hospital patient. (A-2)

17. Understand the limitations of pulse oximetry monitoring and the importance of clinical assessment. (A-3)

PSYCHOMOTOR OBJECTIVES

Upon completion of this module, the EMT-Basic will be able to:

18. Demonstrate a comprehensive patient assessment utilizing pulse oximetry. (P-2)

19. Demonstrate appropriate interventions for patients given simulated conditions and injuries along with pulse oximetry readings.(P-3)

20. Trouble-shoot problems that may occur when monitoring pulse oximetry (P-3)

21. Demonstrate proper documentation of pulse oximetry monitoring. (P-3)

PRESENTATION

DECLARATION

I. Introduction

Pulse oximetry has become the standard method for non-invasive monitoring of peripheral arterial oxygen saturation in most health-care areas. Recent technological developments have produced pulse oximeters without many of the problems that initially limited their use in the pre-hospital arena. Pulse oximetry now offers the pre-hospital care provider with an exceptional resource to monitor patients in the field.

The Kansas Board of Emergency Medical Services recently adopted "EMT-Basic Advanced Initiatives" by regulation 109-6-4 that essentially allows Emergency Medical Technicians, with appropriate physician oversight, by either on-line medical control or written protocol to (1) administer aspirin for chest pain, (2) monitor saturation of arterial oxygen levels of the blood by way of pulse oximetry, (3) administer bronchodilators by nebulization, and (4) monitor blood glucose levels. In order for each Emergency Medical Technician to perform any of the above activities, the Emergency Medical Technician must complete a course of instruction in each of the above listed areas.

II. Pulse Oximetry Monitoring

A. Introduction

1. Signs and symptoms of respiratory compromise
    a. Dyspnea
    b. Accessory muscle use
    c. Inability to speak in full sentences
    d. Adventitious breath sounds
    e. Irregular breathing pattern
    f. Abdominal breathing only
    g. Increased or decreased breathing rate
    h. Shallow breathing
    i. Flared nostrils or pursed lips
    j. Upright or tripod position
    k. Unusual anatomy (barrel chest)
2. Hypoxemia
    a. Decreased oxygen in arterial blood
        (1) Results in decreased cellular oxygenation
        (2) Anaerobic metabolism
        (3) Loss of cellular energy production
3. Hypoxemia Etiology

a. Inadequate External Respiration
b. Inadequate Oxygen Transportation
c. Inadequate Internal Respiration

4. External Respiration
    a. Exchange of gases between alveoli and pulmonary capillaries
    b. Oxygen must be available to diffuse across alveolar and capillary membranes at the pulmonary level
5. Inadequate External Respiration
    a. Decreased oxygen available in the environment
        (1) Smoke inhalation
        (2) Toxic gas inhalation
        (3) High altitudes
        (4) Enclosures without outside ventilation
    b. Inadequate mechanical ventilation
        (1) Pain
            (a) Rib fractures
            (b) Pleurisy
        (2) Traumatic injuries
            (a) Tension pneumothorax
            (b) Hemothorax
            (c) Open pneumothorax
            (d) Flail chest
            (e) Crushing neck and chest injuries
    c. Other conditions
        (1) upper airway obstruction
        (2) lower airway obstruction
    d. Hypoventilation
        (1) Muscle paralysis
            (a) Spinal injuries
            (b) Paralytic drugs
        (2) Drug overdose
        (3) Brain stem injuries
6. Inadequate Oxygen Diffusion
    a. Pulmonary edema
        (1) Fluid between alveoli and capillaries
        (2) Inhibits adequate diffusion of oxygen
    b. Pneumonia
        (1) Consolidation reduces surface area of respiratory membranes
        (2) Reduces the ventilation-perfusion ratio
    c. COPD
        (1) Air trapping in alveoli
        (2) Loss of surface area of respiratory membranes
    d. Pulmonary emboli
        (1) Areas of lung is ventilated but hypoperfused

(2) Loss of functional respiratory membranes

7. Oxygen Transport
   a. Most of the oxygen is saturated on hemoglobin
   b. Adequate number of RBCs with adequate hemoglobin
   c. Sufficient circulation to transport oxygen
8. Inadequate Oxygen Transport
   a. Anemia
      (1) Reduces red blood cells
      (2) Inadequate hemoglobin
   b. Poisoning
      (1) Carbon monoxide prevents oxygen saturation
   c. Shock
      (1) Low pressure results in inadequate oxygen transport
9. Internal Respiration
   a. Exchange of gases from the systemic capillaries to the tissue cells
   b. Oxygen must be able to off-load at cellular level
10. Inadequate Internal Respiration
   a. Shock
      (1) Massive vasoconstriction or micro-emboli prevent oxygen from reaching cells
   b. Cellular environment is not conducive to off-loading oxygen
      (1) Acid base balance
      (2) Lower than normal temperatures
   c. Poisoning
      (1) CO will reduce the oxygen available at the cellular level
11. Signs and symptoms of hypoxemia
   a. Restlessness
   b. Altered or deteriorating mental status
   c. Increased pulse rate
   d. Increased or decreased respiratory rate
   e. Cyanosis (late sign)

B. Pathophysiology

1. Oxygen transportation
   a. Diffusion-gases moving from higher concentrations to lower concentrations
   b. Oxygen content of blood
      (1) Bound to hemoglobin
      (2) Dissolved in plasma
   c. Approximately 97% of total O2 is bound to hemoglobin
   d. O2 saturation

(1) % of hemoglobin saturated
(2) Normal SpO2 is 95- 98%
(3) Less than 95% suspect cellular perfusion compromise
(a) Provide appropriate airway and supplemental oxygen
(b) Monitor carefully for further changes
(4) SpO2 less than 90%, suspect severe cellular perfusion compromise
(a) Positive pressure ventilations
(b) High flow oxygen administration

e. Oxygen in the blood
(1) SpO2- bound to hemoglobin
(2) PaO2- dissolved in plasma

2. Oxygen saturation and partial pressure of oxygen
a. Normal PaO2 is 80-100 mm Hg
(1) 80-100 mm Hg corresponds to 95-100% SpO2
(2) 60 mm Hg corresponds to 90% SpO2
(3) 40 mm Hg corresponds to 75% SpO2

C. Technology

1. Light-emitting diodes (LEDs) produce red and infrared light
2. LEDs and detector on opposite side of sensor
3. Require physiological pulsatile activity at sensor site
a. Measures saturation of hemoglobin during pulsation
b. Requires a pulse or a pulse wave to measure saturation
4. Oxygenated blood and deoxygenated blood absorb different sources of light
a. Oxyhemoglobin absorbs more infrared light
b. Reduced hemoglobin absorbs more red light
c. Pulse oximetry reveals arterial saturation by measuring this difference
5. SpO2 is very close to SaO2 determined by laboratory tests.

D. Patient Assessment

1. Perform the Scene Size-up and Initial Assessment
a. Apply oxygen when appropriate
(1) General Impression of respiratory inadequacy
(2) Altered mental status
(3) Airway, Breathing, Circulation compromise
b. Initiate pulse oximetry immediately prior to or concurrently with oxygen administration.
2. Perform a Rapid Trauma Assessment or Focused History and Physical
3. Assess a full set of Vital Signs

a. Inadequate blood pressure will not support tissue oxygenation, regardless of oxygen saturation
b. Tachycardia is a sign of hypoxia
c. Pale or cyanotic skin, and diaphoresis indicate hypoxia/hypoxemia

4. Detailed assessment
5. Ongoing assessment
   a. Continuous monitoring of pulse oximetry
      (1) Monitor current oxygenation status and response to oxygen therapy
      (2) Monitor response to nebulized treatments.
      (3) Monitor patient following intubation.
      (4) Decreased circulating oxygen in the blood may occur rapidly without clinical signs and symptoms
6. Pulse oximetry is not intended to replace a complete initial and detailed assessment.
   a. A useful adjunct in assessing patients and monitoring patient treatment procedures.

E. Use of pulse oximetry in pediatrics

1. Use appropriate sized sensor
   a. Adult sensors may be used on arms or foot.
2. Active movement may cause erroneous readings.
   a. Pulse rate on oximeter must coincide with palpated pulse rate.
3. Poor perfusion will cause erroneous readings
   a. Treat according to clinical status.
   b. Pulse oximetry is useless in cardiac arrest.

F. Conditions that may affect the accuracy of pulse oximetry

1. Patient conditions
   a. Carboxyhemoglobin
      (1) Carbon monoxide has 200-250 greater affinity for the hemoglobin molecule than oxygen and binds to same sites
      (2) Carboxyhemoglobin can not be distinguished from oxyhemoglobin
      (3) Smoke inhalation, heavy cigarette smoking, accidental or intentional CO poisoning
   b. Anemia
      (1) Low quantity of erythrocytes or hemoglobin
         (a) Normal values are 11-18 g/dl
         (b) Values as low as 5 g/dl may register SpO2 100%.

c. Hypovolemia/ Hypotension
    (1) Adequate oxygen saturation but reduced oxygen-carrying capacity.
    (2) Vasoconstriction or reduction in cardiac output may result in loss of detectable pulsatile waveform at the sensor site
    (3) Patients in shock or receiving vasoconstrictors may not have adequate perfusion to be detected by oximetry.
    (4) Always administer oxygen to patients with poor perfusion.
d. Hypothermia
    (1) Severe peripheral vasoconstriction may prevent oximetry detection.
    (2) Shivering may result in erroneous oximetry reading
    (3) Treat the patient according to hypothermic protocols

2. Patient environments
    a. Ambient light
        (1) Any external light exposure to the vascular bed where sampling is occurring may result in erroneous reading
        (2) Most sensors are designed to prevent light from passing through shell
        (3) Shield the sensor from bright lights
    b. Motion
        (1) New technology filters out motion artifact
        (2) Pulse rate must coincide with palpated pulse rate.
3. Other problems with pulse oximetry
    a. Fingernail polish and pressed on nails
        (1) Most commonly used nail polished does not affect oximetry readings.
        (2) Remove fingernail polish that contains metallic flakes.
        (3) Place oximeter sensor on ear if you suspect erroneous readings.
    b. Skin pigmentation
        (1) Apply sensor to fingertip in darkly pigmented patients

G. Interpreting oximetry readings

1. Assess and treat the patient not the oximetry
    a. Use oximetry as an adjunct to patient assessment
    b. Never withhold oxygen if the patient has signs or symptoms of hypoxia or hypoxemia irregardless of oximetry readings.
2. Pulse oximetry measures oxygenation not ventilation

a. Does not indicate the removal of carbon dioxide from blood.

H. Documentation of pulse oximetry monitoring.

1. Pulse oximetry is usually documented as SpO2
2. Document the oximetry reading as frequently as other vital signs.
   a. When pulse oximetry is initiated prior to supplemental oxygen, indicate the reading as “room air”.
   b. When oxygen administration is changed, document the evaluation of pulse oximetry.

   c. When treatments provided may affect respiration or ventilation, document pulse oximetry.
      (1) Spinal immobilization
      (2) Shock positioning
      (3) Fluid administration

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