Managing Oxygen Therapy in the Neonate

Purpose and Goal: CNEP # 2087

- Learn about the effects of oxygen on the neonate.
- Learn about the importance of minimizing oxygen exposure.

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Requirements for successful completion:

- Successfully complete the post-test
- Complete the evaluation form
Date

- November 2018 – November 2020

Learning Objectives

- Describe the harmful effects of oxygen therapy.
- Describe the effects of oxygen free radical formation.
- Identify 2 approaches for the prevention of oxygen toxicity.

Introduction

- Oxygen is essential to sustain developing infants
- Supplemental use of oxygen is common in the NICU
  - It is the most commonly used drug
- Excessive or inappropriate use of oxygen may be harmful
  - It has been associated with cell injury
  - It has been shown to cause complications
- The most common negative effect is chronic lung disease

The History of Neonatal Oxygen Use

- 377 BC Hippocrates
  - Believed there was something in air
  - That entered the heart → body
- 1674 John Mayrow
  - Believed dark venous blood
  - Became red through absorption of air
- 1680 Robert Boyle
  - Believed air contained a vital substance
  - Which that served to refresh the spirit
- 1774 Joseph Priestly
  - Discovered oxygen
  - By heating mercuric oxide
  - He called it “dephlogisticated air”
- 1778 Antoine-Laurent Lavoisier
  - First coined the term “oxygen”
  - Showed that lungs take in oxygen
  - And eliminate carbon dioxide
- 1891 Docteur Esrasme Bonnaire
  - A French OB who noted
  - First gave oxygen to an infant
  - First noted that
    - A lack of oxygen led to hypoxia
    - Described an infant as a “blue baby”
- 1917 Scott Haldane
  - First published guidelines
  - “The Therapeutic Administration of Oxygen”
- 1950 Retinopathy of Prematurity
  - Oxygen accepted as a cure for everything
  - First used in infants with respiratory failure
  - Free flow oxygen given in incubators
  - Resulted in Retrolental Fibroplasia and blindness
- 1953 First Multi-Center Trial
  - 18 hospitals participated
  - First noted that:
    - >50% oxygen → death
    - <40% oxygen → “safe”
    - 40% oxygen → no ROP
- 1960s Higher Rates of Mortality
  - A more conservative approach
  - But resulted in higher rates of mortality
  - Despite a prevention of blindness
- 1970s Higher Rates of Morbidity
  - A more selective approach
  - Higher rates of dysplagia
  - Higher rates of lung disease noted
  - Especially when used with ventilation
- 1980s Advent of Pulse Oximetry
Developed to monitor oxygen saturations
American Academy of Pediatrics
  • Developed guidelines for use
  • Significantly ↓ risks of complications

1992 The Formation of ILCOR
  • International Committee on Resuscitation
  • Facilitated consensus recommendations

2000 ILCOR Published Guidelines
  • First set of guidelines for CPR

2010 ILCOR Updated CPR Recommendations
  • Guidelines are reviewed every 5 years
  • Current guidelines reflect evidence-based practice

Oxygen (O2) Use in the Neonate

• Oxygen is a drug and is essential
  • To sustain life itself
  • To sustain biological processes

• Most drugs have clear guidelines for use
  • O2 does not have clear guidelines
  • Except for neonatal resuscitation

• O2 is commonly used for infants in the NICU
  • Neonates experience distress
  • When oxygen levels are too low

• Low oxygen levels can lead to tissue damage
• Supplemental O2 is used to improve oxygenation
• The therapeutic use of oxygen
  • Requires a delicate balance
  • Maximizing and minimizing risks

• Recent studies show O2 can be toxic
  • Too little oxygen
  • Too much oxygen
  • Swings in O2 saturations

• Levels at which O2 becomes toxic are not well defined
Pulse Oximeter Monitoring of O2 Levels

- Continual oxygen monitoring is important
- The use of pulse oximeters is standard care
  - First developed in the 1980s
  - Peripheral capillary saturation monitoring
  - Monitors percentages of O2 bound hemoglobin
- Pulse oximeter measurements are helpful
  - In assessing oxygen levels in blood
- Pulse oximeter measurements are not helpful
  - In assessing oxygen levels in tissues
  - In assessing the oxygen needs of tissues
- There are numerous variables that dictate O2 needs
- Pathological conditions can elevate oxygen demands
  - Fever
  - Sepsis
  - Infections
- Motor activity can also elevate O2 demands
  - Agitation
  - Shivering
  - Seizures
- In contrast, some drugs can decrease O2 demands
  - Sedatives
  - Paralytics
- Therapeutic hypothermia also decreases O2 demands
- The use of O2 needs to be weighed against:
  - O2 saturation levels
  - Tissue O2 demand levels
- The use of O2 in an infant with high saturations
  - With low O2 demands
  - Can lead to hyperoxia
  - Can lead to complications
- The use of O2 in an infant with high saturations
  - With high O2 demands
  - Can lead to normoxia
  - Can lead to fewer complications
- The use of O2 in an infant with low saturations
• With low O2 demands
• Can lead to normoxia
• Can lead to fewer complications
• The use of O2 in an infant with low saturations
• With high O2 demands
• Can lead to hypoxia
• Can lead to complications

The Harmful Effects of Oxygen

• Too much O2 can have negative effects
  • On developing brains
  • On developing eyes
  • On developing lungs
• The fetus is exposed to a low O2 environment
• The neonate is exposed to a sudden high O2 environment
• NICU infants are at risk for oxygen toxicity
  • Due to increased exposure to O2
  • Due to free oxygen radical formation
  • Due to reduced antioxidant defenses
• Antioxidant systems are important
  • They do not develop until the third trimester
  • They prevent overproduction of O2 free radicals
• Underdeveloped antioxidant systems
  • Place infants at risk for:
    • Retinopathy of Prematurity
    • Necrotizing Enterocolitis
    • Intraventricular Hemorrhage
    • Bronchopulmonary Dysplasia
    • Chronic Lung Disease

Retinopathy of Prematurity

• Retinopathy of Prematurity
  • Is also known as ROP
• Previously known as RFP
  RFP = Retrolental Fibroplasia
• ROP is a vascular disorder of the eyes
• Recognized as causing blindness in 1940
• It is associated with:
  • Low birth weight
  • Low gestational age
  • Supplemental O2 therapy
• Evidence suggests the cause of ROP
  • Is associated with retinal immaturity
  • Is associated with ↑ retinal arterial O2
• Wide fluctuation in O2 saturations
  • Affect the developmental of ROP
  • Affect the progression of ROP
• Controlled administration of O2
  • Decreases the incidence of ROP
• Laser or cryotherapy treatments
  • Can have complications
  • Can lead to strabismus
  • Can lead to future myopia
• Prevention of ROP is the best approach

Chronic Lung Injury

• Chronic lung injury is multifactorial
  • Underventilation
    • ↓ alveolar recruitment
    • Loss of alveolar recruitment
  • Overventilation
    • Barotrauma
    • Volutrauma
• The fetal lung develops in a low O2 environment
• Exposure to a high neonatal O2 environment
  • Causes lung damage
    • Inhibits lung growth
    • ↑ production of free radicals
• Damages airways and lungs
  • Leads to Bronchopulmonary Dysplasia
  • Leads to Chronic Lung Disease
• Underdeveloped antioxidant systems
  • Interfere with normal lung development
  • Lead to O2 free radical lung injury
    • Inflammation
    • Diffuse alveolar damage
    • Progressive pulmonary dysfunction
• Minimizing invasive ventilation and O2
  • Are the best approach
  • To minimize lung damage

**Oxygen Free Radicals**

• Oxygen free radicals are derived from O2
• They are highly reactive chemical molecules
  • Produced by cell metabolism
  • Made up of unpaired electrons
  • Very unstable and short lived
• Free radicals are essential for growth
• Excess free radicals → oxidative stress
• The neonatal period is a time of oxidative stress
  • Excess free radicals
    • Can result from hypoxia
    • Can result from hyperoxia
      • Progressive ↑ free radicals
      • Increased cell damage
    • Can lead to inflammation
      • Increased tissue damage
      • Increased cell death
• Even a duration of high oxygen levels
  • Can lead to oxidative stress
  • Can lead to production of free radicals
• Normally there is a balance in the body
  • Between free radical formation
Between defense mechanisms
Antioxidants are defense mechanisms
- Prevent formation of free radicals
- Delay formation of free radicals
There are many well-known antioxidants
- Intracellular
  - Catalase
  - Glutathione
  - Superoxide dismutase
- Extracellular
  - Bilirubin
  - Transferrin
  - Vitamin A
  - Vitamin C
  - Vitamin E
  - Beta-carotene
Antioxidant systems are limited in the neonate
- They develop in the third trimester
- Preterm infants are at highest risk
  - Immature antioxidant systems
  - Decreased antioxidant enzymes
  - Decreased defense mechanisms
  - Increased risk of O2 toxicity

Clinical Approach to O2 Management

- O2 should be treated like a drug
- The most important strategy is to limit O2
  - There is currently no clear consensus
  - On the use of specific limits for use
- Current standards of care:
  - Using room air for resuscitation
  - Using an O2 blender at delivery
  - Using an O2 blender in the NICU
  - Limiting invasive ventilation
    - Increased use of CPAP
• Noninvasive Minute Ventilation
• High Flow Humidified Nasal Cannula
• Using pulse oximetry to titrate oxygen
  • Oxygen saturations
    • 88-93% <32 weeks
    • 90-95% >32 weeks
    • >95% only as needed
• Promoting prone positioning
• Decreasing free radical production
  • Preventing infection
  • Using fresh breastmilk
  • Preventing inflammation
  • Protecting TPN from light
    • Decreasing photo-oxidation
  • Decreasing blood transfusions
    • Decreasing oxidant load
• Limiting medications
  • Antibiotics
  • Analgesics
  • Anticonvulsants
• Supplementing antioxidants
  • Adequate nutrition
• Possible future standards of care:
  • Immune modulators
  • Interleukin-11

Factors Affecting Clinical Decision-Making

• There are several factors that influence care
• Clinical knowledge
  • Clinical experience
  • Advanced knowledge
  • Research knowledge
• Clinical expertise
  • Timely education
  • Previous experience
• Content specific education
• Infant focused case studies

• Use of current research
  • Conflicting study results
  • Confusing research reports
  • Transferability of research findings

• Use of intuition
  • Subjective judgements
  • Evidence-based practices

• Individual factors
  • Attitudes and beliefs
  • Questioning current practices
  • Information seeking behaviors

• Organizational factors
  • Staff resources
  • Infant acuity and workload
  • Multidisciplinary approach
  • Inconsistent provider practices

• Decision-making is complex and easily influenced
• Each NICU culture must balance multiple variables
  • Personal, social, historical, political
  • To enhance use of current research
  • To enhance ongoing nursing education
  • To provide optimal NICU care

Summary

• Supplemental O2 is common in the NICU
• Negative effects of O2 have been identified
  • The safest duration of O2 is not known
  • The safest O2 concentration is not known
• Infants should always be provided minimal O2
  • To avoid complications
  • To promote optimal outcomes
References


