 Neonatal Nursing Education Brief: Hypotension in the Neonate

http://www.seattlechildrens.org/healthcare-professionals/education/neonatal-nursing-education-briefs/

Neonatal hypotension is common in the NICU and has serious side effects. Maintaining an adequate blood pressure is critical for organ and tissue perfusion. Optimal outcomes depend on treating the underlying cause. A complete infant assessment should occur. Optimal treatment should be based on optimal cardiac output, not a blood pressure number.

Hypotension, NICU, autoregulation, cardiovascular system, poor perfusion

Hypotension in the Neonate

Purpose and Goal: CNEP #

- Learn about hypotension in the neonate.
- Learn about best practices for treating hypotension.

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Requirements for successful completion:

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

Date

- December 2017 – December 2019
Learning Objectives

- Describe the pathophysiology of neonatal hypotension.
- Describe the risk factors for routine use of volume expansion.
- Describe at least 2 approaches for the treatment of neonatal hypotension.

Introduction

- Hypotension is common in preterm infants
  - It is less common in term infants
- There is no standard definition of hypotension
- Maintaining effective blood pressure is critical
- Untreated hypotension is associated with:
  - Significant morbidity
  - Significant mortality

Neonatal Hypotension

- Neonatal hypotension is a complex issue
- Hypotension by itself is not a pathologic condition
- It can be caused by several issues:
  - Hypovolemia
    - From fetal-to-fetal transfusion
    - From fetal-to-maternal transfusion
    - From an umbilical cord accident
  - Infection
  - Fetal arrhythmia
    - Leading to altered cardiac output
  - Maternal anesthesia
  - Pneumothorax
• Asphyxia and hypoxemia
• Treatment of the underlying cause may improve blood pressure without any other intervention
• If a reversible cause cannot be found
  • Intervention should be timely
    • To avoid irreversible shock
    • To prevent possible death

Definitions of Hypotension

• There is no standard definition of hypotension
• Experts believe there are 3 levels of alteration
  • These can be used to refine the definition
    • Loss of blood flow autoregulation
    • Loss of vital organ function
    • Loss of tissue integrity
• Many unanswered questions remain re: pathology
• It is unclear how to determine BP parameters
  • That indicate pathology in each level
  • That lead to morbidity, mortality, or poor outcomes
• In general, two common parameters are used
  • During the first 3 days of life
    • A BP that falls below a MAP of 30
    • A MAP lower than the gestational age
  • During the neonatal period (greater than 3 days)
    • There is no consistent evidence
    • There are no “treatable” BP numbers
• The most accepted definition is:
  • The point at which autoregulation is lost
    • Leading to cerebral function compromise
    • Leading to tissue ischemia
• Despite a definition, BP remains the primary measure
  • BP indirectly measures several parameters:
• Cardiac stability
• Systemic blood flow
• Tissue and organ perfusion

• The challenge is to look at the entire clinical picture
  • Is there cardiovascular stability?
  • Are there abnormal indicators?
    • Abnormal pulses
    • Abnormal heart rate
    • Abnormal capillary refill
    • Abnormal acidosis
    • Abnormal oxygenation
    • Abnormal urine output

• A comprehensive assessment must be made

**Pathophysiology of Hypotension**

• Blood pressure is affected by several factors
  • Structure and function of myocardium
    • Ability of heart to pump blood
  • Elasticity of blood vessels
  • Circulating blood volume
  • Circulating blood viscosity

• The autonomic nervous system is important
  • In maintaining adequate organ perfusion

• The hemodynamic changes during transition are important

• Specific factors contributing to hypotension include:
  • Immature myocardium $\rightarrow$ decreased contractility
    • Immature heart has less contractility
    • Immature heart cannot increase cardiac output
  • Transition from fetal circulation $\rightarrow$ increased SVR
    • Maladaptation can easily occur
    • Immature heart cannot overcome resistance
• PDA → left to right shunt → ‘steal’ syndrome
  • A PDA causes decreased systemic blood flow
  • The PDA is open during systole and diastole
    • Creating a ‘steal’ syndrome
    • Which leads to decreased blood flow
• Perinatal hypoxia/asphyxia → neuroendocrine changes
  • A hypoxic insult leads to myocardial dysfunction
  • Hypoxia interrupts normal neuroendocrine changes
    • Which leads to a decrease in systemic blood flow
• Positive Pressure Ventilation → decreased venous return
  • Ventilation increases intrathoracic pressure
  • Which leads to decreased systemic blood flow
• Sepsis → inflammatory mediator release → vasodilation
  • Sepsis leads to release of inflammatory mediators
  • Inflammatory mediators lead to:
    • Peripheral vasodilation
    • Increased vascular permeability
    • Hypovolemia and hypotension
• Adrenal insufficiency → insufficient cortisol during stress
  • Preterm infants are at highest risk
    • Due to an immature adrenal gland
    • And limited ability to produce cortisol

Risks Associated with Hypotension

• Many studies show an association
  • Between hypotension
  • And poor neurodevelopmental outcomes
• Hypotension leads to impaired cerebral blood flow
  • Especially in preterm infants
  • Due to immature cerebral autoregulation
• Cerebral autoregulation is important
• Arteries constrict in response to increased pressure
• Arteries dilate in response to decreased pressure
• Cerebral autoregulation is critical to ensure constant blood flow
• Impaired autoregulation has been shown to be predictive
  • Of germinal matrix hemorrhage
  • Of intraventricular hemorrhage
  • Of periventricular leukomalacia
• The ability to autoregulate is immature in preterm infants
  • Making them more susceptible to ischemia
• Term infants are more tolerant of low blood pressures
  • Hypotension is more likely associated with
    • Sepsis
    • Asphyxia
    • Severe blood loss
    • Necrotizing enterocolitis
    • Persistent pulmonary hypertension

Risks Associated with Volume Expansion

• Many studies show problems associated with volume
• Extracellular body weight is elevated in the infant
  • As a percentage of body weight:
    • 60% at 20 weeks
    • 40% at 40 weeks
    • 20% in the adult
• Attempts to increase blood pressure through volume
  • Are frequently futile
  • May have adverse consequences
• The relationship between volume and BP is not straightforward
• Many studies show volume is not always beneficial
  • Administering fluid presumes low volume is the cause
  • Administering fluid can increase the incidence of IVH
• Administering fluid can also increase risks of:
  • BPD
  • NEC
  • PDA
  • Death
• Best practice is to evaluate the infant for adequate perfusion
  • Treatment should be based on perfusion status
    • As well as assessment of cardiac output
  • Treatment should not be based solely on blood pressure

Near-Infrared Spectroscopy or NIRS

• Methods for assessing cardiac output
  • Are limited in the neonatal population
    • Due to shunting through the PDA
    • Due to shunting through the PFO
• The use of ECHO to evaluate output is accurate
  • But not generally feasible
• The use of EEG to evaluate output is accurate
  • But not generally feasible
• Methods for assessing organ blood flow
  • Are being actively studied
  • Can help determine systemic blood flow
• NIRS is one method that is easily applicable
• NIRS helps determine blood flow
  • By measuring oxygen dependent compounds
    • That absorb light by passage through the brain
    • The compounds can be measured and calculated
  • Cerebral blood flow is measured using the calculations

Treatment of Hypotension
- The treatment of hypotension is controversial
- Hypotension should be treated based on the etiology
- The use of volume expansion is not generally recommended
  - The evidence for use of volume is insufficient
  - The evidence for best type of volume is insufficient
    - Blood
    - Albumin
    - Normal saline
    - Fresh frozen plasma
    - Plasma substitute
- The majority of infants are not hypovolemic
  - They have normal circulating blood volume
  - They would not benefit from volume expansion
- Studies show negative outcomes with routine use
  - Pulmonary
  - Cardiovascular
  - Gastrointestinal
  - Central nervous system
- The use of volume is indicated with evidence of blood loss
  - Evidence of blood loss includes:
    - Fetal anemia
    - Placenta previa
    - Placenta abruption
    - Umbilical cord accident
    - Fetal-Maternal transfusion
  - Effective circulating volume may be decreased
  - Volume expansion in this situation can:
    - Restore intravascular volume
    - Increase cardiac preload
    - Increase cardiac output
  - The administration of a volume expander
    - Normal saline
    - Ringers lactate
• O-negative blood
  • The initial dose should be 10 ml/kg over 5-10 minutes
    • This dose may be repeated as needed
    • Dopamine should be started at this point
• The use of Dopamine should be considered as first line therapy
  • Especially in premature infants
  • Especially when the etiology is unknown
  • Dopamine is the most commonly used inotropic drug
    • It is a naturally occurring endogenous catecholamine
    • Dopamine effects multiple systems:
      • Renal
      • Endocrine
      • Cardiovascular
      • Central nervous system
    • It exerts its effects by dose dependent stimulation of alpha- and beta-adrenergic and dopaminergic receptors
    • At low doses (2-4 mcg/kg/min) it dilates renal vessels
    • At moderate doses (5-10 mcg/kg/min) it increases both cardiac contractility and heart rate
    • At high doses (10-20 mcg/kg/min) it increases peripheral vascular resistance by peripheral vasoconstriction
• Dopamine should be carefully titrated for optimum response
• Dopamine is more effective than Dobutamine
  • It does not appear to affect the incidence of:
    • Tachycardia
    • Periventricular hemorrhage
    • Periventricular leukomalacia
• Cautious stepwise increases are not associated with:
  • Abnormal neurological outcomes
  • Combined adverse outcomes
    • Death
    • Cerebral palsy
    • Developmental delay
• Severe neurodevelopmental delay
• The use of Dobutamine should be used with poor cardiac output
  • Especially in the first few days after birth
    • When peripheral vascular resistance is high
    • When an immature myocardium cannot pump against increased systemic resistance
• Dobutamine is a synthetic, relatively cardioselective inotrope that works on the alpha- and beta-adrenergic receptors
  • It increases cardiac contractility
  • It increases cardiac output
  • It is the treatment of choice for infants with myocardial dysfunction due to perinatal asphyxia
• Cautious stepwise increases are associated with:
  • Increased cardiac output
  • Increased systemic vasodilation
  • Improved systemic blood flow
• If hypotension increases after starting Dobutamine, low dose Dopamine may be added to the treatment plan
• The use of epinephrine should be considered with sepsis
  • Dopamine would remain the first line treatment
  • But epinephrine can help support cardiac function
    • Sepsis causes systemic vasodilation
    • Dopamine promotes vasoconstriction
    • Epinephrine promotes myocardial function
• Epinephrine is an endogenous catecholamine that is released by the adrenal gland in response to stressful stimulation
  • It has potent nonselective alpha-agonist action
  • It causes activation of beta-adrenergic receptors
  • It increases systemic vascular resistance
  • It increases cardiac output
  • At low doses (0.01-0.1 mcg/kg/min) it increases cardiac contractility and peripheral vascular resistance
- At higher doses (>0.1 mcg/kg/min) it causes peripheral vasoconstriction and increases systemic resistance.
- Epinephrine causes disturbances in carbohydrate metabolism
  - Which can lead to increased hyperglycemia.
- Cautious stepwise increases are not associated with:
  - Abnormal neurological outcomes
  - Combined adverse outcomes
    - Death
    - Cerebral palsy
    - Developmental delay
    - Severe neurodevelopmental delay.
- The use of vasopressin may be helpful in neonatal shock
  - Vasopressin is an antidiuretic hormone
    - It is formed in the hypothalamus
    - Then secreted by the pituitary gland
  - It is used to treat vasodilatory shock
    - In adults and children
  - No large randomized controlled trial has been conducted in the neonatal population to date.
- The use of milrinone is not currently supported
  - Milrinone is a selective phosphodiesterase III inhibitor
  - It exerts its effects by increasing cAMP
    - cAMP is cyclic adenosine monophosphate
    - Which is a derivative of adenosine triphosphate (ATP)
  - Which enhances cardiac contractility
    - Without raising myocardial O2 consumption
    - Without increasing cardiac afterload
  - Milrinone is increasingly being used in the NICU
    - To treat hypotension after cardiac surgery
    - To treat persistent pulmonary hypertension
    - As an adjunct to inhaled nitric oxide therapy
  - Studies have shown no adverse effects
    - Thrombocytopenia may be seen.
• The use of hydrocortisone should be very limited
  • Hydrocortisone is as effective as Dopamine
  • It has been shown to improve:
    • Hypotension
    • Tissue perfusion
    • Risk of tissue ischemia
• It exerts its effects by:
  • Upregulation of cardiovascular adrenergic receptors
    • Which leads to vasoconstriction
    • Which increases cardiac output
    • Which increases blood pressure
  • Upregulation of angiotensin II receptors
  • Inhibition of nitric oxide and prostaglandin actions
  • Inhibition of catecholamine metabolism
  • Increased intercellular calcium concentrations
• In general, information about long-term safety is lacking
• Poor neurodevelopmental outcomes have been noted
• Its use should be reserved for refractory hypotension
• Of note: hydrocortisone acts as a hormone replacement
  • Critically ill term and preterm infants lack cortisol
  • Cortisol levels are inversely related to gestational age
  • They also tend to be low in infants treated with inotropes
  • Hydrocortisone can be used to treat infants on Dopamine
  • It should not be used in conjunction with Indomethacin

Summary

• Maintaining effective blood pressure is critical
  • It is critical for adequate organ perfusion
  • It is critical for adequate tissue perfusion
• Many risks have been associated with hypotension
• Careful evaluation prior to starting treatment is important
  • Many treatments have negative side effects
• Treatment of neonatal hypotension is multifactorial
  • Success depends on treating the underlying cause

References


Evaluation

- Required fields

Your information
*Your name

*Your email address

*Your Seattle Children's ID

*Your hospital
○ Seattle Children's Hospital
○ Providence Regional Medical Center Everett
○ Overlake Medical Center
○ St. Joseph Medical Center
○ St. Francis Hospital
○ Harrison Medical Center
○ Valley Medical Center
○ Other Hospital, Medical Center, or Clinic

Test

- Neonatal hypotension can be defined as a mean arterial pressure or MAP less than gestational age in weeks.
  ○ True
  ○ False

- If an infant’s gestational age is 34 weeks, the mean arterial blood pressure should be at least 34 mm Hg.
• Measurements of cardiac stability in infants include heart rate, capillary refill time, urine output, and temperature.
  ○ True
  ○ False

• When treating hypotension, health care providers should be cautioned to treat a specific blood pressure number.
  ○ True
  ○ False

• If there is evidence of myocardial dysfunction, the next step is to administer dobutamine.
  ○ True
  ○ False

• The first line treatment for sepsis related hypotension is epinephrine.
  ○ True
  ○ False

**Evaluation**

We hope you found this educational offering both interesting and informative. We’d like to hear from you and appreciate you taking the time to answer these evaluation questions.

*Were you able to complete this activity in the allotted time?*
  ○ Yes
  ○ No

Were you informed of the following disclosures?
*Purpose of learning activity
  ○ Yes
  ○ No

*Requirements for successful completion of this CNE activity
  ○ Yes
  ○ No

*Presence or absence of conflict of interest of planning committee members
  ○ Yes
  ○ No

*Presence or absence of conflict of interest of content specialist(s)/author(s)/feedback person(s)
  ○ Yes
  ○ No

*Were your personal objectives successfully achieved?
  ○ Yes
  ○ Somewhat
  ○ No
  If not, why not?

*What one thing might you do differently in your practice after this session?

Please evaluate the brief:

*Presentation organized
  ○ Excellent
  ○ Very good
Materials offered relevant content
- Excellent
- Very good
- Good
- Fair
- Poor

Assistance provided as needed
- Excellent
- Very good
- Good
- Fair
- Poor
- Not applicable

Overall strength of presentation
- Excellent
- Very good
- Good
- Fair
- Poor

Stated objectives achieved?

*Describe the pathophysiology of neonatal hypotension.
- Excellent
- Very good
- Good
*Describe the risk factors for routine use of volume expansion.

- Excellent
- Very good
- Good
- Fair
- Poor

*Describe at least 2 approaches for the treatment of neonatal hypotension.

- Excellent
- Very good
- Good
- Fair
- Poor