Neonatal CCRN/CCRN-K Certification Review Course: Cardiovascular

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Testable Nursing Actions

- Apply leads for cardiac monitoring
- Identify, interpret, and monitor cardiac rhythms
- Monitor hemodynamic status and recognize signs and symptoms of hemodynamic instability
- Recognize normal fetal circulation and transition to extrauterine life
- Recognize indications for and manage patients requiring
  - 12-lead ECG
  - Arterial catheter
  - Cardiac catheterization
  - Cardioversion
  - Central venous pressure monitoring
  - Invasive hemodynamic monitoring
  - Umbilical catheter

Fetal Circulation
Transitional Circulation

- Closing of fetal shunts
- Once the baby is delivered:
  - The placenta no longer oxygenates the blood
  - The lungs facilitate gas exchange in the infant

Newborn Circulation
Cardiac Output

- Volume of blood ejected by the heart in 1 minute
- Normal 120–200 mL/kg/min
- \( CO = SV \times HR \)

Preload

- Volume of blood in ventricles before the heart contracts
- Delayed cord clamping
Afterload

- The resistance of blood leaving the ventricle
- Afterload is dependent on systemic vascular resistance and pulmonary vascular resistance

Shock

- Hypovolemic
- Distributive
- Cardiogenic
Most Common Dysrhythmias

- Sinus tachycardia
- Sinus bradycardia
- Supraventricular tachycardia
- Complete heart block
- Atrial flutter
- Hyperkalemia

Placement of Cardiac Leads

- Lead 1 is best lead for changes in P waves
Sinus Tachycardia

- HR = 180–220
- Brief episodes can be normal
- Common causes:
  - Hypovolemia
  - Hyperthermia
  - Pain
  - Infection
  - Shock
  - Hydrops

Sinus Tachycardia Treatment

- No treatment if the condition is transient
- Treat the underlying cause of shock or respiratory failure
Sinus Bradycardia

- HR <90
- Responsible for 30% of arrhythmias in infants
- Most common in premature infants
- Common causes:
  - Immaturity of central nervous system
  - Vagal stimulation
  - Apnea
  - Medication
  - Heart disease
  - Sinus node disease

Sinus Bradycardia Treatment

- Important to assess infant’s respiratory status
- Stimulate or provide respiratory support
- If bradycardia continues, begin resuscitation based on NRP guidelines
- Bradycardia is most often the result of hypoxia causing a depression of the myocardium or slowing of the heart rate

Supraventricular Tachycardia

- HR >220
- Most common dysrhythmia in newborns
  - Occurs in 1.5–4/1,000 neonates
- Causes
  - Cardiac defects
  - Wolff-Parkinson-White Syndrome
  - Myocarditis

Supraventricular Tachycardia Treatment

- Determine stable vs unstable supraventricular tachycardia (SVT)
- If stable, consider vagal maneuver and/or adenosine
- If unstable or vagal maneuver unsuccessful, treat with adenosine, propranolol, procainamide, or amiodarone
- Infants who are in shock or congestive heart failure need rapid treatment of SVT
  - IV adenosine if IV access
  - Synchronized cardioversion

Complete Heart Block

- 1 in 22,000 births
- Mothers with lupus
- Complete blockage of impulse between atria and ventricles
Complete Heart Block

- Causes
  - Infections
  - Congenital heart defects
  - Myocarditis
  - Trauma
  - Lupus
  - Genetic

- Treatment
  - Temporary or permanent pacing
  - Isoproterenol
Atrial Flutter

- Sawtooth appearance on EKG
- Causes
  - Damage to sinus node
  - Congenital heart disease
  - Cardiac catheterization
  - Digoxin toxicity
- Occurs most often in structurally normal heart

Atrial Flutter

- Treatment
  - Digoxin
  - Propranolol
  - If unstable, then cardioversion
Hyperkalemia

- Serum potassium >6.5 meq/L
- Causes
  - Hemorrhage
  - Bruising
  - Prematurity
  - Acidosis
  - Renal failure

Hyperkalemia

- Causes tall tented T wave and disappearance of P wave and widening of the QRS
  - This is abnormal conduction through the ventricle
  - Appears like v tach but is NOT
- Treatment
  - Diuretic depletes potassium; secretion of potassium from urine
  - IV calcium
  - Glucose/insulin infusion to push potassium into cell
  - Sodium bicarbonate to correct acidosis
  - Albuterol pushes potassium into cell
  - Sodium polystyrene sulfonate (Kayexalate) removes potassium
  - CARDIOVERSION DOES NOT WORK
Cardiac Defects

- Cyanotic
  - Tetralogy of Fallot (TOF)
  - Transposition of the greater arteries (TGA) or vessels (TGV)
  - Truncus arteriosus
  - Tricuspid Atresia
  - Hypoplastic Left Heart Syndrome (HLHS)

- Acyanotic
  - Patent ductus arteriosus (PDA)
  - Atrial septal defect (ASD)
  - Ventricular septal defect (VSD)
  - Atrioventricular canal (AVC)
  - Pulmonic stenosis (PS)
  - Aortic stenosis (AS)
  - Coarctation of the aorta
Tetralogy of Fallot

- 1 in 5,000 live births
- Accounts for 10% of all defects
- Combination of four defects:
  - Pulmonary stenosis
  - VSD
  - Overriding aorta
  - Right ventricular hypertrophy


Tetralogy of Fallot

- Presentation depends on the degree of pulmonary stenosis (pink TOF vs blue TOF)
- Cyanosis, hypoxia, and dyspnea present with severe obstruction
- Tachypneic
- Murmur detected
- CXR will show a “boot-shaped heart”

Tetralogy of Fallot

- Treatment
  - Propranolol
  - PGE1 infusion to maintain duct patency
  - Careful use of oxygen therapy
  - Blalock-Taussig procedure—palliative surgery
  - Corrective surgery
    - Prognosis is poor without surgery


Transposition of the Greater Arteries or Vessels

- Occurs in 1 per 5,000 births (predominantly male)
- Most common cause of cyanosis
- Position of the main arteries is reversed
- Ductal dependent defect
- Diagnosis usually made within the first week of life

Transposition of the Greater Arteries or Vessels

- Cyanosis is present and becomes more prevalent
- No murmur unless VSD is present
- CXR may show “egg on a string” appearance
- Echocardiogram is the standard diagnostic tool
- This is a cardiac emergency

Treatment/management

- Correction on metabolic acidosis
- Prostaglandin (PGE1) to maintain duct patency (mixing)
- Balloon septostomy
- Blade septostomy
- Pulmonary artery banding
- Corrective surgery
  - Arterial switch operation (Dr. Jatene and Dr. Yacoub)
  - Mustard and Senning procedure
  - Rastelli procedure
Truncus Arteriosus

- 1 per 33,000 births
- Artery arises from both ventricles and overrides VSD
- Three types
  - Type I: Most common; short pulmonary artery from base of the trunk which divides to the right and left arteries
  - Type II: The left and right pulmonary arteries arise from the posterior side of the trunk
  - Type III: The right and left pulmonary arteries arise from different origins of the lateral side of the trunk


Truncus Arteriosus

- Clinical manifestations
  - Bounding pulses
  - Widened pulse pressure
  - Signs and symptoms of CHF
  - Harsh murmur
  - CXR will show cardiomegaly and pulmonary markings
- Echocardiogram and Doppler are the standard diagnostic tools
Truncus Arteriosus

- Treatment
  - Manage CHF
    - Diuretics
    - Digoxin
    - ACE inhibitors
  - Surgical repair
    - Homograft
    - Patch to close VSD
    - Separation of the arteries from the trunk

Tricuspid Atresia

- 1 per 18,000 live births
- Failure of the development of the tricuspid valve
- Associated with a PFO or VSD
- Pulmonary stenosis or atresia may also be present

Tricuspid Atresia

- Clinical manifestations
  - Cyanosis
  - Dyspnea
  - CHF
  - Murmur if associated with VSD, PDA, or stenosis

- Management
  - Balloon septostomy to improve mixing of blood
  - Oxygen
  - Bicarbonate
  - PGE1
  - Blalock-Taussig procedure
  - Pulmonary artery banding
  - Fontan or modified Fontan procedure
  - Bidirectional Glenn procedure on or off bypass
Hypoplastic Left Heart Syndrome

- 2–2.6 per 10,000 births
- Obstruction of blood to left side of the heart
- Hypoplastic left ventricle
- Absent or small mitral valve
- Absent or small aortic valve
- Ascending aorta is small
- May have ASD
- Pulmonary congestion and edema


Hypoplastic Left Heart Syndrome

- Clinical manifestations
  - Tachypnea
  - Dyspnea
  - CHF
- Become rapidly ill as the PDA begins to close
  - Mottling
  - Gray pallor
  - Diminishing pulses
  - Shock
- CXR will show cardiomegaly
- Echocardiogram done to diagnose; detected prenatally

Hypoplastic Left Heart Syndrome

- Management/treatment
  - Initial Management includes:
    - PGE1
    - Managing acidosis
    - Sedation
    - Balloon septostomy
    - Ventilation management
  - Staged surgical repair (Norwood 3–5 years to complete)
  - Cardiac transplant

Acyanotic
Patent Ductus Arteriosus

- Fourth most common cardiac lesion
- 8 of 1,000 premature births, 2 of 1,000 full term births
- Persistent patency of the duct or failure of it to close
- Prostaglandins inhibit the closure of this duct
- Maintains fetal circulation in utero and meant to close after birth


Patent Ductus Arteriosus

- Clinical manifestations
  - Cardiomegaly
  - Bounding peripheral pulses
  - Widening pulse pressure
  - Low diastolic blood pressure
  - Metabolic acidosis
  - Continuous murmur may be auscultated in upper left sternal border
Patent Ductus Arteriosus

- Echocardiograph is the gold standard for diagnosis
- B-type natriuretic peptide levels of 70–100 pg/mL can be used to identify a PDA

Patent Ductus Arteriosus

- Treatment/management
  - Fluid restriction
  - Diuretics
  - Ventilation therapy
  - NSAIDs (indomethacin and ibuprofen)
  - Surgical management (ligation)
**Patent Ductus Arteriosus**

**Arachidonic Acid Pathways**

- Lipooxygenase pathway
- Leukotrienes
- Cyclooxygenase pathway
- Prostaglandins
- Cyclooxygenase inhibitors
- Prostaglandin synthase inhibitors
- Indomethacin (NeoProfen)

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**Atrial Septal Defect**

- 1 per 5,000 births
- More common in females
- Defect in the formation of the septum or patent foramen ovale
- Usually asymptomatic
- Systolic murmur may be detectable
- Failure to thrive
- Recurrent respiratory infections may occur

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**Atrial Septal Defect**

- Defect may close on its own
- Manage CHF if present
- Surgical repair
- Transcatheter closure

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**Ventricular Septal Defect**

- 2 per 1,000 births
- Most common of all defects (about 50%)
- Abnormal opening of the septum between the right and left ventricle

Ventricular Septal Defect

- Clinical manifestations
  - Small VSD
    - Asymptomatic with a murmur
  - Moderate VSD
    - Asymptomatic with a murmur, fatigue, and respiratory infections
  - Large VSD
    - Signs and symptoms of CHF
    - Loud murmur
    - Cardiomegaly on CXR
    - Echocardiograph done to diagnose

Ventricular Septal Defect

- Treatment
  - 50%–75% of small VSD will close spontaneously (muscular)
  - Surgical banding of pulmonary artery
  - Surgical suturing of defect
  - Surgical patching of defect
  - Transcatheter device
- Prognosis is excellent

Atrioventricular Canal

- Also known as endocardial cushion defect
- 1 per 9,000 births
- Common in Down syndrome

Craig B. Heart. 2006;92(12):1879 – 1885.

Clinical manifestations
- Respiratory distress
- Active precordium
- Murmur
- Respiratory infections
- CXR will show cardiomegaly
Atrioventricular Canal

- Treatment
  - Treat CHF with digoxin and diuretics
  - Pulmonary artery banding
  - Primary repair closure

Pulmonic Stenosis

- 1 in every 14,000 live births
- Narrowing in or below the pulmonary valve
- Depending on the degree of stenosis, may be ductal-dependent or ductal-independent
- Murmur
- Hepatomegaly
- CXR will show cardiomegaly
- Echocardiography is used to diagnose

Pulmonic Stenosis

- Treatment:
  - Oxygen, bicarbonate, PGE1
  - Balloon valvuloplasty
  - Surgical valvotomy if valvuloplasty is not effective

Aortic Stenosis

- 1 in 24,000 births
- More likely in males
- Anatomy includes:
  - Valvular (most common)
  - Subvalvular
  - Supravalvular (least common)
- Increased left ventricular pressure
- Excess blood to the lungs

Aortic Stenosis

- Clinical findings
  - Asymptomatic at birth
  - Murmur detected
  - Congestive heart failure symptoms
  - CXR will show cardiomegaly

Aortic Stenosis

- Treatment
  - Acidosis management and fluid restriction
  - If critical, use PGE1
  - Balloon valvuloplasty
  - Valvotomy or valve replacement
  - Ross-Konno procedure
Coarctation of the Aorta

- Accounts for 7% of cardiac lesions
- More common in males
- Most common form is juxtaductal
- Common in Turner syndrome
- Constriction of the aorta

Coarctation of the Aorta

- Congestive heart failure due to high afterload
- Pulses decreased or absent in the lower extremities
- Blood pressure higher in upper extremities
- CXR will show enlarged heart and pulmonary vascular markings
- Echocardiogram is the standard tool to detect, but cannot rule out coarctation in patients with PDA
- MRI can determine location of coarctation
Coarctation of the Aorta

- Treatment
  - CHF management
  - PGE1
  - Palliative balloon angioplasty to open narrowing
  - Stent placement
  - Surgical correction (resection, reanastomosis, or patch)

Vascular Rings and Slings

- Occur secondary to abnormal development of aortic arch
- Can cause compression to the trachea and esophagus
- Symptoms include respiratory distress and stridor
Management After Cardiac Surgery

- Noninvasive monitoring
  - ECG
  - Blood pressure
  - Continuous pulse oximetry
  - Urine output
  - Cerebral near-infrared spectroscopy

- Invasive monitoring
  - Arterial pressures
  - Right-sided cardiac pressures
  - Pulmonary artery pressure
  - Left-sided cardiac pressure
  - Epicardial pacing
- Hemodynamic monitoring
Review Questions

Question 1

What is the most common neonatal dysrhythmia?

A. SVT  
B. Complete heart block  
C. Junctional ectopic tachycardia  
D. Hyperkalemia
Question 1—Rationale

What is the most common neonatal dysrhythmia?

A. SVT—This is the most common neonatal dysrhythmia
   - Complete heart block—Typically associated with lupus, which isn’t very common
   - Junctional ectopic tachycardia—Typically occurs in neonates after cardiac repair, not the most common
   - Hyperkalemia—Usually found in premature babies who are critically ill and acidotic. This is a unique situation

Question 2

The most common cause of bradycardia in the newborn population is:

A. Hypoxia
B. Pain
C. Fever
D. NICU admission
Question 2—Rationale

The most common cause of bradycardia in the newborn population is:

A. Hypoxia—The most common cause of bradycardia in a newborn. Most infants have bradycardia for the same reasons they have apnea; often, bradycardia results from the baby having apnea. Apnea is defined as a pause $>15–20$ seconds in a baby’s regular breathing

- Pain—A sympathetic response which causes heart rate acceleration
- Fever—A sympathetic response which causes heart rate acceleration
- Hypercapnia—May be responsible for tachypnea but not bradycardia

Question 3

The organ responsible for gas exchange in utero is the:

A. Placenta
B. Heart
C. Lung
D. Kidney
Question 3—Rationale

The organ responsible for gas exchange in utero is the:

A. Placenta—The placenta is responsible for all gas exchange in utero
   - Heart—Not responsible for gas exchange; responsible for pumping blood around in utero
   - Lung—Once baby is born, the lung is responsible; only function in utero is to practice breathing and to grow
   - Kidney—Function of the kidney in utero is to produce amniotic fluid

Question 4

The fetal vessel connecting the pulmonary artery to the descending aorta is:

A. Ductus arteriosus
B. Foramen ovale
C. Ductus venosus
D. VSD
Question 4—Rationale

The fetal vessel connecting the pulmonary artery to the descending aorta is:

A. Ductus arteriosus—A short vessel that shunts blood from the pulmonary artery directly to the ascending aorta, bypassing the lungs, before birth
   - Foramen ovale—The connection at the atrial septum opening; it connects the left atria to the right atria
   - Ductus venosus—The fetal vein that passes through the liver to the inferior vena cava
   - VSD—Early opening in the embryologic heart. The VSD is a hole in the wall separating the two lower chambers of the heart

Question 5

Your patient in the NICU has cyanotic heart disease and was started on PGE. The most important thing for the nurse to have available at the bedside is:

A. Resuscitation equipment
B. Cooling mattress
C. Inotropes
D. Chest tube
Question 5—Rationale

Your patient in the NICU has cyanotic heart disease and was started on PGE. The most important thing for the nurse to have available at the bedside is:

A. Resuscitation equipment—bag valve mask. The nurse should be prepared to treat the apnea that may occur as a side effect of administering PGE
   - Cooling mattress—An infant may become flush and have a fever from administration of PGE, but placing a cooling mattress is not the treatment of choice for this symptom and is not the most important intervention
   - Inotropes—PGE administration does not cause hypotension
   - Chest tube—PGE is not known to cause air leaks

References

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References