Neonatal Cardiac Care: A Neonatologist's Perspective

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Presenter Disclosure

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No relationships to Disclose
Scope of the Problem

• Structural heart disease occurs in 8 out of every 1000 live births

• Nearly 40,000 infants in the United States are born with congenital heart defects each year

• Of these, nearly 1/4-1/3 have critical lesions requiring intervention in the first month of life
Congenital Heart Surgery in the United States (2007-2010)

Number of patients

- Neonates (0-30 days)
- Infants (31 days to 1 year)
- Children (>1 year - <18 years)
- Adults (18 years +)
Congenital Heart Surgery in the United States: Mortality (2007-2010)

Discharge Mortality Rate

- Neonates (0-30 days): 10%
- Infants (31 days to 1 year): 4%
- Children (>1 year <18 years): 2%
- Adults (18 years +): 2%
Neonatal Discharge Mortality by STS-EACTS Category (2007-2010)

STS-EACTS Category

0% 2% 4% 6% 8% 10% 12%

1 2 3 4 5
Birth Before 39 Weeks' Gestation Is Associated With Worse Outcomes in Neonates With Heart Disease

Mortality rate by gestational age

- <34 weeks: 35%
- 34-36 weeks: 20%
- 37-38 weeks: 10%
- 39-40 weeks: 5%
- >41 weeks: 0%

Costello, 2010
Neonates ≠ Small children
Increased neonatal mortality:
Several Causes

• Technical issues related to structure, cannulation and CPB

• Immature organ systems

• Limited reserve
Objectives

• Why/how neonates are different

• Specific problems in premature and low birth infants

• How can neonatologists help?
Fetal Environment

- Demands are few
- Partial separation of the oxygen uptake and delivery systems
- Dependence on uteroplacental unit
Transition to Extrauterine environment

- Demand increases

- Complete separation of oxygen uptake and delivery systems

- Separation from the utero-placental unit
Fetal circulation

Decrease in PVR

Rudolph, Congenital Diseases of the Heart
Artman, Neonatal Cardiology
Transition to Extrauterine Environment
• Sympathetic innervation increases
• Increased concentration of Beta adrenergic receptors in later gestation
• High adrenergic tone in later gestation
• Role of thyroid gland
• Catecholamine surge during labor
• Doubling of cardiac output at birth
Myocardial Performance and Age

• Cardiac output doubles/triples to meet increased demands of extrauterine life.

• Performance at high level (high adrenergic tone) with limited reserve.
Myocardial Structure

- Structural and ultrastructural immaturity
- Limitations in intracellular calcium handling
Recruitment of Frank-Starling relationship is limited.

Graph showing the recruitment of Frank-Starling relationship for different stages:
- **Fetus**: The earliest stage, showing the least recruitment.
- **Neonate**: With a slight increase in recruitment.
- **Older child/adult**: Demonstrating the highest recruitment.

The graph plots SV (stated in blue) against RAP (stated in red), illustrating how recruitment changes across different stages.
Neonatal Heart is Afterload sensitive
Implications:
Postoperative management

• Transient LCOS state 9-12 hours after cardiac surgery is not uncommon in neonates.

• Pharmacological optimization of contractility.

• Dearth of compelling evidence favoring one inotrope/pressor vs another.

• Variation in practice.
Hemodynamic optimization in neonates

• Thresholds for treatment are unclear.

• **Optimization of tissue perfusion should be the goal.**

• Restoration of intravascular volume and effects of volume loading in neonates.

• Maintenance of optimal circulating filling pressure (Role of Steroids, VP).
Cardiopulmonary Bypass - considerations in the neonate

- Most neonatal cardiac surgeries are performed on CPB.
- CPB times are often longer.
- Greater exposure to Hypothermia.
- Smaller patient size vs surface area of bypass circuit: hemodilution.
- Greater activation of the inflammatory cascade.
Transcapillary Fluid Movement
Importance of lymphatic drainage

Respiratory function

- Lung development is incomplete at birth
- Surfactant production
- Lung mechanics: Poorly compliant lungs, highly compliant chest wall
- Easy respiratory muscle fatigue
- Low respiratory reserve
Neonatal Chest Wall Mechanics

Figure 2

Newborn

Adult

Neonatal Respiration and Respiratory Care Image
Implications in Post-operative care

- Acute lung injury after CPB, severity related to length of exposure
- Surfactant inactivation, increased lung water
- Decreased lymphatic flow if respiratory activity is suppressed
- Effect of sternotomy and lateral thoracotomy on chest wall mechanics
- Importance of Extubation to CPAP
- Apnea and opioids
Immaturity of other organ systems

• Hematologic-Platelet dysfunction, decreased coagulation factors

• Greater risk for infection

• Immature renal function
Nutrition is important but often ignored

- Enteral nutrition is best
- Many neonates are not enterally fed until after surgery
- Catabolic state
- Total parenteral nutrition should be provided as soon as possible after birth until optimal enteral nutrition is provided
Necrotizing Enterocolitis

• CHD is a risk factor for NEC
• Some lesions are at a greater risk than others
• Prematurity is an independent risk factor
• High mortality and morbidity
Intraventricular Hemorrhage

- IVH usually occurs in preterm infants
- Lower the gestational age, the greater the risk
- Usually occurs by 5 days of age
- High grade bleeds have poor prognosis
- Risk of CP, hydrocephalus
Neonatologists..

•... are a grossly underutilized resource

•Misconception that Neonatologists are just doctors for preterm babies

•Neonatologists well versed in cardiovascular physiology could play a vital role
Alternative model

• Team based approach with all members of team-nurses, practitioners both nurse and medical well versed in NEONATAL CARDIAC CARE

• Cohorting based on age rather than disease process
Mortality Rates (%) by Year
NYPH-Columbia & STS*: 2007-2010
Summary

• Neonates are different from older children
• Treat them differently, their structure and physiology require/demand it
• Neonates with CHD should be cohorted with other neonates with CHD and are best served by a team well versed in neonatal cardiac care