Applications of Functional Echocardiography in Neonatal Intensive Care Units

Thesis

Submitted for partial fulfillment of M.Sc. Degree in Pediatrics

by

Monica Ashraf Alfons Nashed

(M.B.B.CH.)

Faculty of Medicine, Cairo University

Under supervision of

Prof . Dr. Sonia Ali El-Saiedi

Professor of Pediatrics

Faculty of Medicine, Cairo University

Prof. Dr. Amr Abd El-Rahman Malash

Professor of Pediatrics

Faculty of Medicine, Cairo University

Prof. Dr. Noran Fahmy Hussein

Professor of Pediatrics

Faculty of Medicine, Cairo University

Faculty of Medicine

Cairo University

2016

ACKNOWLEDGMENT

First, grace and foremost thanks are due to **God**, for blessing this work, as a part of His generous help throughout our lives.

It is my pleasure to express my sincere gratitude and respect to **Professor Doctor Sonia Ali El-Saiedi,** Professor of Pediatrics, Cairo University, for her great effort and guidance throughout the entire period of this work and for her kind encouragement and support.

I would like to express my special gratitude and thanks to **Professor Doctor Amr Abd El-Rahman Malash ,** Professor of Pediatrics, Cairo University for his kind encouragement and great help throughout this work.

I also would like to express my deepest thanks and gratitude to **Professor Doctor Noran Fahmy Hussein,** Professor of Pediatrics, Cairo University, for her continuous help and support throughout this work.

Many thanks to **Professor Doctor Aya Fattouh,** Professor of Pediatrics, Cairo University, for her help throughout this work.

Many thanks to **Professor Doctor Nivin Mohamed Mamdouh Habib,** Professor of Pediatrics, Ain Shams University for her help

I also appreciate the kind participation of **Doctor Antoine Abd El Messih,** Assistant lecturer of Pediatrics, Cairo University for his great help and support throughout this work.

I am endebted to every patient included in this study.

I am deeply grateful to my family, friends and colleagues for their continuous support and encouragement.

Lastly, I would like to thank anyone who helped me completing this work.

Table of Contents

List of Tables

- ***Review***

- ***Results***

List of Figures

- ***Review of literature***

- ***Patients and Methods***

- ***Results***

- ***Results (Cont.)***

List of Abbreviations

ANP : Atrial natriuretic peptide
Ao: Aorta
ASD : Atrial septal defect
AV: Aortic valve
BNP : Brain natriuretic peptide
BP : Blood pressure
bpm : Beat per minute
CI: cardiac index
CLD : Chronic lung disease
CO : cardiac output
COX : Cyclo-oxygenase enzyme
CRP : C-reactive protein
CSF : Cerebrospinal fluid
CVP: central venous pressure
CW: continuous wave
ECMO: extracorporeal membrane oxygenation
EF: ejection fraction
ESPAP : Estimated systolic pulmonary artery pressure
ESR : Eythrocyte sedimentation rate
fECHO : Functional echocardiography
FS : Fractional shortening
GA : Gestational age
HSDA : Hemodynamically significant ductus arteriosus
IUGR : Intrauterine growth restriction
IVH : Intraventricular hemorrhage
LA: Left atrium
LPB: Left pulmonary branch
LV : Left ventricle
LVOF : Left Ventricle ouflow

MPA : Main pulmonary artery
MV: mitral valve
NEC : Necrotizing enterocolitis
NICU : Neonatal Intensive Care Unit
NRP: neonatal resuscitation program,
PA: Pulmonary artery
PDA : Patent ductus arteriosus
PEEP : Peek end expiratory pressure
PFO : Patent foramen ovale
PG : Prostaglandins
PGE2 : Prostaglandins E2
PW: pulsed wave
RA: Right atrium
RDS: respiratory distress syndrome,
ROC curve : Receiver-operating characteristic curve
RPB: Right pulmonary branch
RV : Right Ventricle
RVOF : Right Ventricle ouflow
SD : Standard deviation
SV : Stroke volume
SVC : Superior Vena Cava
SVCF : Superior Vena Cava flow
SVR : vasomotor tone
TAPSE : Tricuspid annular plane systolic excursion
Tricuspid e`/a` = Tricuspid annular velocity
VLBW: Very low birth weight
Vti : Velocity time integral

Abstract

The aim of this study was to evaluate the role of functional echocardiography (fECHO) in Neonatal Intensive Care Units (NICU) especially in hemodynamically unstable neonates and to assess response to treatment.

METHODS: 45 neonates were enrolled: thirty hemodynamically unstable neonates admitted to NICU Cairo University hospitals and fifteen healthy neonates as controls. Neonates with complex heart disease were excluded. fECHO was done for all neonates and follow up study to the cases within 48 hours. Each study included assessment of Superior Vena Cava flow (SVCF), Left Ventricle outflow (LVOF), Right Ventricle outflow (RVOF), Patent ductus arteriosus (PDA), Patent foramen ovale (PFO) or Atrial septal defect (ASD) if present, ejection fraction (EF), Fractional shortening (FS) and Estimated systolic pulmonary artery pressure (ESPAP), determination of Tricuspid valve annular velocity by tissue Doppler and detection of pericardial effusion or intracardiac masses.

RESULTS: In controls, mean value of SVCF, LVOF and RVOF were 85.3± 7.3 , 144.1 ± 12.3 and 110.9 ±9.4 ml/kg/min respectively. Our cases were subdivided into: PDA group (33.3 %) and Sepsis group (66.7 %). In sepsis group, SVCF was lower than in controls and increased after treatment (Intensive fluid therapy, Inotropes and antibiotics). Cut-off criterion for SVCF was ≤66.9 ml/kg/min . LVOF in PDA group was higher than in controls and decreased after fluid restriction and Ibuprofen. RVOF in cases and controls were initially comparable; however it increased in cases following treatment. There was no difference in EF between cases and controls with no correlation with LVOF. Four cases died (13.3%) but no correlation between fECHO parameters and survival was established.

CONCLUSIONS: SVCF is decreased in sepsis and increases after treatment. In PDA, LVOF is increased and it decreases after treatment. There is no correlation between EF and LVOF.

KEY WORDS: Echocardiography, Neonates, Hemodynamically unstable, NICU

Introduction

Neonatology is the branch of medicine concerned with dealing with newborn infants. There are major challenges that face the neonatologist to deal with this special population. These challenges include the heterogeneity of the neonatal population due to differences in gestational age (GA) and postnatal age, variations in maturity for a given GA, existing comorbidities (particularly lung disease and infection), complex and multifactorial interactions between systemic and regional perfusion. So the care of the critically ill neonates with cardiovascular compromise may be challenging as severe cases are associated with increased morbidity and mortality (Azhibekov et al., 2015)

Dealing with a hemodynamically unstable neonate is quite problematic because using clinical judgment alone to define the nature of the problem or the disease process can lead to incorrect assumptions or incorrect therapeutic interventions. (Sehgal et al., 2008)

Hence the need for a reliable non invasive tool. The term Functional Echocardiography was introduced to describe this new tool. Functional echocardiography provides information about the underlying hemodynamic function in real time and the changes in the cardiovascular status in response to treatment. (Kluckow et al., 2007)

Several publications highlight the usefulness of functional echocardiography in neonatal intensive care. It can help in assessment of ductus arteriosus, assessment Left ventricular systolic function, assessment of overall myocardial function, assessment of pulmonary hypertension, assessment of atrial level shunting, assessment of Left ventricle and Right ventricle cardiac indices, assessment of Superior Vena Cava (SVC) flow as a measure of systemic blood flow, assessment of right ventricular function and detection of pericardial effusion. (Corredera et al., 2014), (Mertens et al., 2011)

Aim of the work

The aim of this study is

- To evaluate the role of functional echocardiography in Neonatal Intensive Care Units especially in hemodynamically unstable neonates.
- To assess response to treatment given
- To highlight changes occurring in different echo parameters in different clinical situations

Review of Literature

Chapter 1

Neonatal Sepsis and Septic shock

INTRODUCTION:

In 1960, the terms "neonatology" and "neonatologist" were introduced. Also in the early 1960s, an important distinction was made between small infants who were born preterm and term infants who were small because of intrauterine growth restriction (IUGR). Previously, any infant whose birth weight was <2500 g was deemed to be premature. Since then, many efforts were done to improve care provided to newborns (especially preterm neonates), and in turn to improve outcome. These efforts were not in vain: a 1-kg infant who was born in 1960 had a mortality risk of 95% but had a 95% probability of survival by 2000. The advances included the miniaturization of blood samples needed for biochemical measurements, the ability to provide nutrition intravenously and the maintenance of normal body temperature. Also the management of respiratory distress syndrome improved with advancement in mechanical ventilation, antenatal corticosteroid administration, and the introduction of exogenous surfactant. Pharmacologic manipulation of the ductus arteriosus, support of blood pressure, echocardiography, and changes in the management of persistent pulmonary hypertension, including the use of nitric oxide and extracorporeal membrane oxygenation, all have influenced the cardiopulmonary management of the neonate. (Philip, 2005)

CARDIOVASCULAR COMPROMISE IN NEONATES

Maintenance of normal cardiovascular function is a complex process regulated by the autonomic central and peripheral nervous system, endocrine and paracrine regulatory mechanisms, the cardiovascular system and renal function. (Soleymani et al., 2010)

The newborn may have a variety of hemodynamic problems with a variable and complex pathophysiology, that at times have limited clinical manifestations. This cardiovascular vulnerability comes from particular features of the newborn, such as incomplete myocardial development, the presence of fetal shunts, changes in systemic and pulmonary vascular resistance, and more generally the complex hemodynamic changes that take place during transition to extrauterine life. (Corredera et al., 2014)

Cardiovascular assessment, monitoring and care are reliant on continuous monitoring of blood pressure (BP) or poorly validated clinical signs such as capillary refill time, heart rate (Sehgal et al., 2008), diuresis, central venous pressure (if a central venous catheter was placed) and oxygen saturation measurement in the upper and lower extremities. (Di Nardo et al., 2010)

Other non-invasive or invasive technologies (for example, continuous impedance cardiography, transesophageal Doppler and continuous pulse contour methods) are , in fact, quite problematic in neonates in whom relevant hemodynamic changes are common during the transition to postnatal life.
(Di Nardo et al., 2010)

Unfortunately, these parameters are only surrogate markers of the adequacy of tissue oxygenation and may lead to incorrect clinical assumptions and therapeutic lines and may even cause harm. Some publications have highlighted the current uncertainty in deciding the optimal management of hypotension and patent ductus arteriosus (PDA) in newborns (Evans, 2006), (Laughon et al., 2004)

The lack of consensus on ‘normal BP’ increases the degree of medical uncertainty. These challenges are potentially greatest in the immediate postnatal period when complex hemodynamic changes are occurring in response to transition from in utero to ex utero life. (Sehgal et al., 2008) Many publications have demonstrated that the correlation between BP and cardiac output is weak. (Osborn et al., 2004), (Victor et al., 2006)

Accordingly, blood pressure may remain within the “normal range”, even though cardiac output may be decreased but compensated for an increased vasomotor tone. Similarly, blood pressure may be “normal” when vasomotor tone is low but it is compensated for an increase in cardiac output (Figure 1). (Wu et al., 2014)

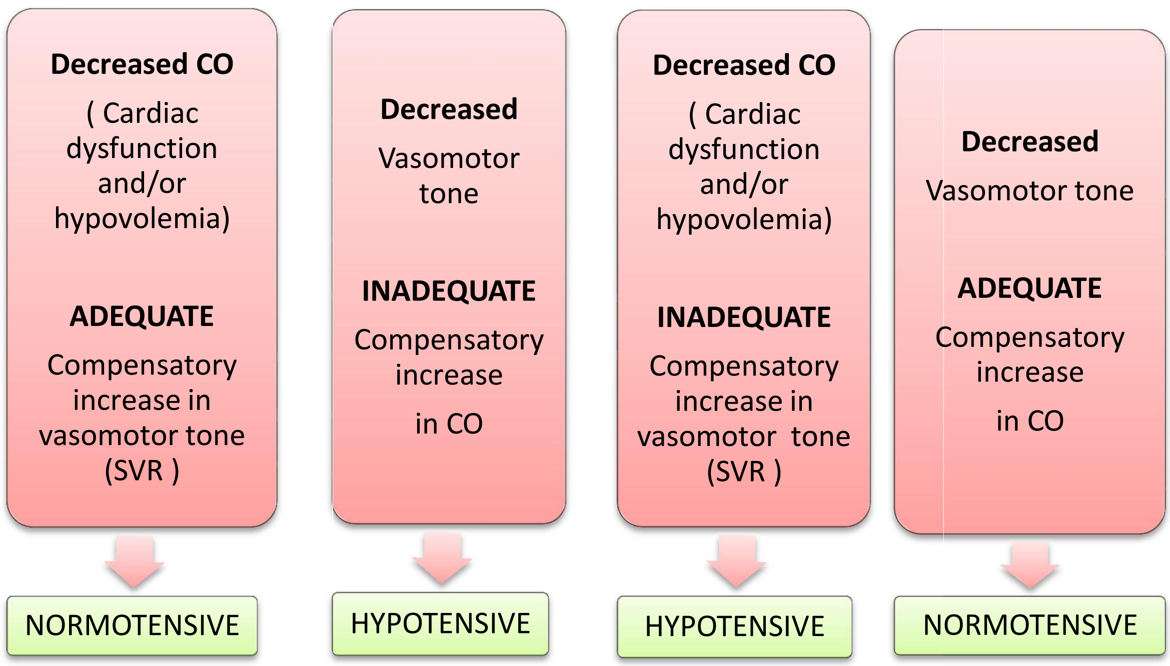

Figure 1: Significance of blood pressure in neonates
CO = cardiac output; SVR = vasomotor tone
Infants who are normotensive may still have underlying abnormalities in CO or SVR
For those who are hypotensive, the compensatory mechanisms become inadequate.
From “Workbook in practical neonatology” by Wu T-W, Noori S, Seri I, 2014. Copyright 2014, Elsevier/Saunders Co; Philadelphia, PA

Despite a “normal blood pressure”, end organ perfusion may still be compromised, as the compensated phase of shock is about to give way to the uncompensated phase. Two infants of similar gestational age may have similar “normal” blood pressure values, but the underlying state of their organ blood flow may be potentially different from each other, depending on their capacity to compensate by adjusting their cardiac output and/or local end organ vascular resistance (Wu et al., 2014).