TRINITY
COLLEGE
DUBLIN

Functional Echocardiography in the Preterm infant

Adam James

A thesis submitted to Trinity College Dublin in fulfilment of the requirements for the degree Medical Doctorate (M.D.)

September 2017

Rotunda Hospital

Supervisors: Prof Afif El-Khuffash

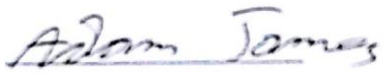
Dr David Corcoran

Dr Orla Franklin

Declaration

I declare that this thesis has not been submitted as an exercise for a degree at this or any other university and it is entirely my own work.

I agree to deposit this thesis in the University's open access institutional repository or allow the library to do so on my behalf, subject to Irish Copyright Legislation and Trinity College Library conditions of use and acknowledgement.

Signed 

Student Number : 97538116

Date _____29th September 2016 _____

Table of Contents

List of Figures

List of Tables

Abbreviations

PDA: Patent Ductus Arteriosus

CLD: Chronic Lung Disease

NEC: Necrotising Enterocolitis

ROP: Retinopathy of Prematurity

RDS: Respiratory Distress Syndrome

PVL: Periventricular Leukomalacia

PFO: Patent Foramen Ovale

VLBW: Very Low Birth Weight

PPHN: Persistent Pulmonary Hypertension of the Newborn

IVH: Intraventricular Haemorrhage

PMA: Post Menstrual Age

BP: Blood Pressure

MAP: Mean Airway Pressure

EF: Ejection Fraction

SF: Shortening Fraction

VCFc: Velocity of Circumferential Fibre Shortening

PAAT: Pulmonary artery acceleration time

RVET: Right ventricular ejection time

LVEDD: LV end diastolic diameter

LVESD: LV end systolic diameter

LVPWD: LV posterior wall diameter in diastole

VTI: Velocity Time Integral

LVO: Left Ventricular Output

RVO: Right Ventricular Output

TDI: Tissue Doppler Imaging

STE: Speckle Tracking Echocardiography

SR: Strain rate

BLS: Basal Longitudinal Strain

TAPSE: tricuspid annular plane systolic excursion

FAC: Fractional Area Change

LVTR: LV twisting rate

LVUTR: LV untwisting rate

MRI: Magnetic Resonance Imaging

NICU: Neonatal Intensive Care Unit

LV: Left Ventricle

RV: Right Ventricle

MV: Mitral valve

TV: Tricuspid Valve

PA: Pulmonary Artery

IVS: Interventricular Septum

PVR: Pulmonary Vascular Resistance

SVR: Systemic Vascular Resistance

RVSp: RV systolic pressure

TR: Tricuspid Regurgitation

FPS: Frames per Second

FR/HR: Frame rate: Heart Rate ratio

SD: Standard Deviation

IQR: Interquartile Range

ROI: Region of Interest

$MgSO_4$: Magnesium Sulphate

Summary

From our research we have shown that myocardial function assessment using tissue Doppler derived strain, strain rate, torsion and fractional area change is both feasible and reliable. We applied these novel echocardiographic markers to assess certain disease states such as assessment of a patent ductus arteriosus, chronic lung disease, treatment with antenatal magnesium sulphate as well as longitudinal follow up over the early neonatal period and found that they may be a useful tool as part of a comprehensive functional myocardial assessment in the preterm population. With the advancement in echocardiography and the continued widespread use for the assessment of the preterm infant these tools may pave the way forward for its clinical use in aiding the diagnosis and management of pathological conditions of preterm infants to improve both morbidity and mortality.

Dedication

I would like to dedicate this thesis to my wife Karen and my three kids Conor, Lily and Ciara

Acknowledgement

I would like to thank my Supervisors, Prof Afif El-Khuffash, Dr David Corcoran and Dr Orla Franklin for their support during my thesis in particular Afif who was a great mentor, friend and support through the whole process and helped me achieve more than I could have ever expected at the start of this journey.

I would like to thank all the premature infants and their parents who always amaze me in their resilience and willingness to help.

My family who remain supportive and caring.

And most importantly to my wife who is the light of my life and is the best support and companion anyone could wish for. To my kids who are always smiling and loving and put everything into perspective. Without all of them this thesis would have been a struggle, but with them it is a blessing.

Research Output from Thesis

2016; **Novel Echocardiography Methods in the Functional Assessment of the Newborn Heart.**
Breatnach CR, Levy PT, **James AT**, Franklin O, El-Khuffash A.
Neonatology. 2016 Jun 10;110(4):248-260.

2016; **Longitudinal Assessment of Left and Right Myocardial Function in Preterm Infants Using Strain and Strain Rate Imaging**
James AT, Corcoran JD, Breatnach CR, Franklin O, Mertens L, El-Khuffash A.
Neonatology. 2016 Jan;109(1):69-75

2016; **Clinical utility of right ventricular fractional area change in preterm infants.**
James AT, Corcoran JD, Franklin O, El-Khuffash AF.
Early Hum Dev. 2016 Jan;92:19-23

2015; **A Patent Ductus Arteriosus Severity Score Predicts Chronic Lung Disease or Death before Discharge.**
El-Khuffash A, **James AT**, Corcoran JD, Dicker P, Franklin O, Elsayed YN, Ting JY, Sehgal A, Malikiwi A, Harabor A, Soraisham AS, McNamara PJ.
J Pediatr. 2015 Dec;167(6):1354-1361

2015; **The effect of antenatal magnesium sulfate on left ventricular afterload and myocardial function measured using deformation and rotational mechanics imaging.**
James AT, Corcoran JD, Hayes B, Franklin O, El-Khuffash A.
J Perinatol. 2015 Nov;35(11):913-8.

2014; **Treatment of Premature Infants with Pulmonary Hypertension and Right Ventricular Dysfunction with Milrinone: A Case Series**.
James AT, Bee C, Corcoran JD, McNamara P, Franklin O, El-Khuffash A.
J Perinatol. 2015 April 35(4): 268-73

2014; **Left Ventricular Rotational mechanics in Preterm Infants Less than 29 Weeks Gestation over the First week after birth**.
James AT, Corcoran JD, Franklin O, Mertens L, El-Khuffash A.
J Am Soc Echocardiogr. 2015 Jul;28(7):808-17.

2014; **The Effect of Milrinone on Right and Left Ventricular Function when used as a Rescue Therapy for Term Infants with Pulmonary Hypertension**.
James AT, Corcoran D, McNamara P, Franklin O, EL-Khuffash A.
Cardiology in the Young 2016 Jan;26(1):90-9

2014; **Assessment of myocardial performance in preterm infants less than 29 weeks gestation during the transitional period**.
James AT, Corcoran D, Jain A, McNamara PJ, Mertens L, Franklin O, EL-Khuffash A.
Early Hum Dev 2014 Oct 29; 90(12):829-835