Cerebral Blood Flow Velocity Variability in Very Low Birthweight Infants

Heather Coughtrey

A thesis submitted in partial fulfilment of the requirements for the degree of Doctor of Medicine, the University of Auckland, 2002.

Acknowledgements

All studies were performed by myself.

I would like to thank the following people for their invaluable assistance and guidance

- Paul Scriven and Hugh Dangerfield of BA^{e}SEMA for writing software within Labview to enable data analysis

- Tim Cole for his extremely useful statistical advice

- Janet Rennie for her very generous assistance and encouragement with design, analysis and writing

- David Evans for his major input regarding physics and instrument support

- The nursing staff of the Special Care Baby Unit, Rosie Maternity Hospital, Cambridge for their tolerance and cooperation throughout the study

- Ruth Morley for assessing the infants at 18 months

LIST of ABBREVIATIONS

ACA	Anterior cerebral artery
AF	Anterior fontanelle
AUTVC	Area under the velocity curve
BWt	Birthweight
BPV	Blood pressure variability
BP	Blood pressure
CBF	Cerebral blood flow
CBFV	Cerebral blood flow velocity
CBFVV	Cerebral blood flow velocity variability
CBV	Cerebral blood volume
CLD	Chronic lung disease
CNS	Central nervous system
CPAP	Continuous positive airway pressure
CSA	Cross-sectional area
CV%	Coefficient of variation expressed as a percentage
CVR	Cerebral vascular resistance
CP	Cerebral palsy
CPP	Cerebral perfusion pressure
CSA	Cross-sectional area
CT	Computerised tomograph
CVP	Central venous pressure
CW	Continuous wave(Doppler)
ECMO	Extracorporeal membrane oxygenation
EDFV	End-diastolic flow velocity
ELBW	Extremely low birthweight

EM	Electromagnetic
FFT	Fast Fourier Transform
GA	Gestational age
HIE	Hypoxic ischaemic encephalopathy
HR	Heart rate
HRV	Heart rate variability
ICH	Intracranial haemorrhage
ICP	Intracranial pressure
IPH	Intraparenchymal haemorrhage
IPPV	Intermittent positive pressure ventilation
IUGR	Intrauterine growth retardation
IVH	Intraventricular haemorrhage
MAP	Mean arterial pressure
MABP	Mean arterial blood pressure
MCA	Middle cerebral artery
MRI	Magnetic resonance imaging
NIRS	Near infra-red spectroscopy
NICU	Neonatal intensive care unit
NMR	Neonatal mortality rate
$PaCO_2$	Arterial partial pressure of carbon dioxide
PaO_2	Arterial partial pressure of oxygen
PCA	Postconceptional age
PDA	Patent ductus arteriosus
PET	Positron emission tomography
PI	Pulsatility index
PNS	Parasympathetic nervous system
PVH	Periventricular haemorrhage

PVHI	Periventricular haemorrhagic infarction
PVL	Periventricular leucomalacia
PW	Pulse wave(Doppler)
rCBF	Regional cerebral blood flow
RD	Respiratory distress
RI	Resistance index
RDS	Respiratory distress syndrome
RSA	Respiratory sinus arrhythmia
SD	Standard deviation
sec	seconds
SEH	Subependymal haemorrhage
SNS	Sympathetic nervous system
SPONT RESP	Spontaneous respiration
SPSS	Statistical Package for the Social Sciences
TCD	Transcranial Doppler
VENT	Ventilation
VLBW	Very low birthweight
VMS	Ventrolateral medullary surface
WMD	White matter damage
^{133}Xe	^{133}Xenon

Abstract

Short-term variability in cerebral blood flow velocity(CBFV) in the VLBW infant largely relates to respiratory influence. Extreme variability may be a poor prognostic indicator. Few have studied cohorts of babies in this regard.

I sequentially studied a consecutive cohort of unselected VLBW infants, to determine the frequency of respiratory influence on CBFVV and to identify factors associated with its occurrence. Doppler CBFV, arterial BP and respiratory signals were recorded simultaneously and spectral analysis was applied to identify a respiratory signal in BP and CBFV traces.

Respiratory associated variability was present in the cerebral circulation at some time in more than half of the infants studied and was most likely in those of lowest gestational age who were hypotensive. Mortality, and cerebral morbidity as assessed by cerebral ultrasound were more common in those demonstrating a respiratory influence in CBFV.

There was a strong correlation between the coefficient of variation(CV%) of BP and that of CBFV. Babies demonstrating hypotension had higher CV%s in CBFV; those who did not survive showed higher variability than survivors, but there was a wide spread of values in both groups. Where the variability in CBFV was high, correlation between CBFV and BP was greater. However, no significant association was found between CV% of CBFV and brain injury, ductal patency, or sedation. Although exaggerated beat-to-beat variability in CBFV was an adverse prognostic indicator, absence of variability carried the worst prognosis.

Slow variations of cerebral blood flow velocity at a frequency of 1-5 cycles per minute, previously described as a normal phenomenon, were also examined. Evolution of this variability was studied amongst those present for a month or more. Slow variations diminished with both increasing postnatal and postconceptional age, perhaps representing maturation of the balance between the two components of the autonomic nervous system. The cycle length of the slow variations was variable suggesting the presence of several low frequency components; longer recordings would be needed to resolve these.

Addition of serial Doppler measurements of CBFV performed in the first week of life, did not improve prediction of an 18-month outcome obtained from ultrasound imaging alone.

Table of Contents

LIST OF TABLES

LIST OF FIGURES