THE FEASIBILITY AND REPEATABILITY OF PLETHYSMOGRAPHIC TRACES IN THE MONITORING HAEMODYNAMICS DURING TRANSITIONAL CIRCULATION IN LATE PRETERM AND TERM NEONATES

L.Mahoney^{1,2*}, D. Wertheim³, P.Seddon^{2,4}, H. Rojas-Anaya⁴, J.R. Fernandez –Alvarez^{2,4}, N.Aiton⁴, and H. Rabe^{2,4}

¹Department of Paediatrics, Taunton and Somerset NHS Foundation Trust, Taunton, UK; ²Brighton & Sussex Medical School, Brighton, UK;

³Department of Computing and Information Systems, Kingston University, Kingston, UK; ⁴Trevor Mann Baby Unit, Brighton and Sussex University Hospital NHS Trust, Brighton, UK

Background

Techniques exploring the haemodynamic status in neonates are invasive or not in widespread clinical use. Plethysmographic (Pleth) indices are already in clinical use but have not been widely investigated in late preterm and term infants.^{1,2} Modified pleth variability index (mPVI) is a measurement of cardiac preload and pulse transit time (mPTT) is a measurement of systemic vascular resistance that can be derived from oxygen saturation probes and ECG traces. The aim of this study was to investigate the feasibility and repeatability of modified pulse transit time (mPTT) and pleth variability index (mPVI) in monitoring the transitional circulation at birth.

Methods

- Observational cohort study conducted in a single tertiary neonatal unit in the UK
- Infants aged <72 hours of age whose gestational age was greater than 33+0 weeks' gestation admitted on the postnatal ward receiving routine care or admitted to the neonatal unit for "special care".

Research Measurements

- All measurements were performed once a day. Each infant had a maximum of three sets of research measurements taken from them.
- **Pleth traces** were derived from the oxygen saturation probe using a SOMNOscreen™ plus polysomnography system. mPVI (Fig. 1) and mPTT (Fig. 2) were evaluated from the raw traces using software that we developed in MATLAB® (Mathworks, Inc, USA). mPVI is the ratio of the values derived from maximum Pleth peaks divided by the minimum Pleth peaks over the respiratory cycle. mPTT is derived from the time difference between the R wave on the ECG and maximal peak on concurrent raw Pleth trace.

Fig 1: mPVI calculation from raw pleth data. Affected by preload and lung expansion

Fig 2: mPTT calculation from raw pleth data. Affected by vessel tone and cardiac output

Statistics

Paired daily measurements were compared using the Wilcoxon rank tests. The intra- and inter-rater repeatability of mPTT and mPVI calculation was assessed using Bland Altman plots (including repeatability co-efficient and index)^{3,4} and inter-class correlation co-efficient (ICC) with r-values graded as either “excellent” (>0.9), “good” (0.75-0.9), “moderate” (0.5-0.75) or “poor” (<0.5).

Table 1. Participant Demographics

Cohort (N=50)		
Gestation Age (weeks)		35 (34-40)
Birthweight (grams)		2555 (2040-3338)

Table 2. Longitudinal Analysis

	Day 1 (n=30)	Day 2 (n=35)	Day 3 (n=37)	Pairwise Comparisons		
				Day 1 Vs 2 (n=23)	Day 2 Vs 3 (n=23)	Day 1 Vs 3 (n=17)
mPTT (secs)	0.28 (0.27–0.29)	0.28 (0.26–0.31)	0.27 (0.26–0.29)	0.68	0.51	0.10
mPVI (%)	20.6 (15.8–24.6)	15.3 (12.1–17.9)	9.2 (5.8–12.5)	0.0001	0.0001	0.0001 [#]

Median (Interquartile Range), #n=18

Table 3. Repeatability Analysis

	n	Mean bias	SD of bias	95% LOA	ICC	Repeatability Coefficient	Repeatability Index
mPTT (secs)							
Intra-rater repeatability	48	-0.0002	0.003	-0.006, 0.006	0.998 (0.997-0.999)	0.006	2.1%
Inter-rater repeatability	21	-0.0008	0.005	-0.01, 0.009	0.971 (0.931-0.988)	0.01	3.4%
mPVI (%)							
Intra-rater repeatability	58	-0.11	0.69	-1.47, 1.24	0.999 (0.998-0.999)	1.35	6.0%
Inter-rater repeatability	34	0.38	1.68	-2.91, 3.67	0.991 (0.982-0.996)	3.29	15.2%

Median (Interquartile range); LOA = Level of Agreement, ICC = Inter-class correlation coefficient

Figure 3. Bland Altman plots

Discussion

mPVI was observed to significantly decrease over the first three days of life. We hypothesise that this is due to the natural diuresis seen in the first few days of life reducing the overall total body water content and therefore cardiac preload. Trends for decreases in mPTT were seen and may represent increases in systemic vascular resistance in the first few days of life. The measures of repeatability indicate excellent repeatability whether measured by the same or different observer.

Conclusion

mPTT and mPVI provide non-invasive measurements of transitional circulation changes after birth in late preterm infants. Our results prove their feasibility for use in this population in view of the good repeatability when calculated manually. Future studies should focus on their clinical application and potential automation.

References

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