Pulse oximetry vs non-invasive blood pressure/oscillometry to record blood pressure in neonates: A prospective observational study

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ABSTRACT

Aim: To assess the usefulness and efficacy of pulse oximetry (disappearance/reappearance of plethysmographic waves) as a method of non-invasive blood pressure monitoring in neonates. Objective: To investigate the reliability of the plethysmographic waveform of the pulse oximeter to measure the systolic blood pressure. Study Setting: A prospective observational study was done to assess usefulness and efficacy of pulse oximetry (disappearance/reappearance of plethysmographic waves) as a method of non-invasive blood pressure monitoring in neonates. Material and Methods: The study was conducted among 500 neonates to investigate the reliability of the plethysmographic waveform of the pulse oximeter to measure the systolic blood pressure as it is a easy way to perform and non invasive. Statistical Analysis Used: The results will compare and analyse statistically by Pearson correlation coefficient. Regression modeling will carried out to explain the relationship of non-invasive blood pressure with mean DP and RP and attempted to predict the non-invasive blood pressure from mean DP/mean RP. Results: The study results revealed that NIBP systolic and diastolic both correlated with DP and RP of pulse oximetry plethysmograph. Conclusion: Study concluded that pulse oximetry is a reliable tool in measuring blood pressure in neonates (appearance and disappearance of plethysmogram).

Keywords: Intra-arterial pressure, measurement location, non-invasive measurement, oscillometric device, pulse oximetry

Introduction

Measuring blood pressure is of pertinent importance in managing of newborn infants with or without comorbidities, congenital disorders, and/or born preterm. Numerous determinants make blood pressure measurement and interpretation a hurdle in this age group of patients such as variable arm size, differences in gestational age and weight, and audibility issues related to Korotkoff sounds.[1,2]

In neonates, additional care has to be taken to interpret blood pressure values. However, the most precise, intra-arterial blood pressure measurement is pricey and not available in all clinical settings. It involves entering an artery, strict asepsis, and costly equipment for recording. Even though the measures are accurate, the complications and efforts are tedious.

When considering the standard non-invasive blood pressure (NIBP), automated oscillometric measurement has been used for decades.[3-5] Finding out arterial blood pressure with the help of pulse oximetry was done by monitoring the disappearance of visual display which takes place on blood pressure cuff inflation, when the reappearance of visual display upon cuff deflation that also is noted, and value is determined by averaging the two ruled out values.[6]
A study was conducted among 46 neonate patients who have undergone cardiac surgery in Seattle to monitor BP using pulse oximeter waveform change. Researchers compared pulse oximeter waveform with an oscillometric measurement and the gold standard, intra-arterial measurement. Simultaneous pressure level measurements were obtained from the blood vessel tubing, the oscillometric device, and therefore the pulse measuring system. Pulse measuring system measurements were obtained with a pressure level cuff proximal to the measuring oximeter probe. They concluded that pulse oximeter waveform change is an accurate and reliable way to measure blood pressure in children non-invasively and is superior to the oscillometric method for small patients.[7]

The technical hurdles of measuring and documenting blood pressure in newborn newborns are significant. Direct measurements from an artery are certainly the most accurate method but have obvious limitations, particularly if repeated observations over a period of hours or days are required. It involves entering an artery, strict asepsis, and expensive equipments for recording. Repeated measurements by indirect means are at best time consuming and tiring for both the baby and observer and at worst upsetting to the baby and, therefore, inaccurate and valueless. Many ingenious methods of indirectly measuring blood pressure have been devised, but all of them have their limitations.[8]

Pulse oximetry is reported as a useful technique to measure systolic blood pressure in newborn infants; oscillometry had the poorest agreement with Doppler findings to detect hypotension.[9] Literature portraying aforementioned findings is scarce in Indian context. In home health monitoring, information on blood arterial oxygen saturation (SpO2) is vital. We also need to figure out what influences the SpO2 measurement. The limits of SpO2 measurement pale in comparison to the benefits of pulse oximeters. Pulse oximeters are widely used and well-known gadgets. They are, however, extremely sensitive to the conditions at the measurement location, as well as other factors and artefacts. As a result, obtaining a high-quality signal is difficult. Family care physicians and primary care physicians are prone to encounter situations to deal with neonatal emergencies. The awareness about alternative measures in obtaining cardinal BP measures of neonates obviously will help them to tackle the emergency to some extent until further reference.[10] Very few studies have been conducted globally in this concern and scarce amount of studies were published within the country, which spearheaded the researcher to conduct this study.

### Materials and Methods

This study adopted a quantitative approach using a prospective observational study design. Study subjects were 500 neonates admitted over 1 year and were recruited to the study, using a non-probability sampling technique. Neonates, both inborn and out born, was included for the study. Consent was obtained from the parents of study subjects, IEC approval, and setting permission was also availed prior to the study. Sphygmomanometer used to compare with values of waveform measures are calibrated according to the norms.

#### Brief procedure

A blood pressure cuff of appropriate size (connected to sphygmomanometer) will be tied around the limb. Pulse oximetry probe (NELLCOR) will be applied to the finger/toe of the same limb. No preference for any specific limb to measure the BP will be shown. The pulse oximeter mode will be set to display continuous plethysmographic wave pattern. When a stable plethysmographic wave is obtained, the BP cuff will be inflated slowly by 2 mm Hg increments. The point of disappearance of the plethysmogram wave form will be noted (DP). Pressure will be further raised by 2 mm Hg increments. The point of reappearance of plethysmogram wave form

| Table 1: Descriptive statistics |
|--------------------------------|
| **n** | **Minimum** | **Maximum** | **Mean** | **Std. deviation** |
| Mean DP | 500 | 42.00 | 106.67 | 76.60 | 11.78 |
| Mean RP | 500 | 30.00 | 97.33 | 54.64 | 12.39 |
| NIBP Systolic | 500 | 31.00 | 114.00 | 74.30 | 13.16 |
| NIBP Diastolic | 500 | 16.00 | 74.00 | 43.07 | 9.40 |
| NIBP mean arterial pressure | 500 | 21.00 | 97.00 | 53.63 | 12.40 |

| Table 2: Correlation between Mean DP vs NIBP systolic BP |
|--------------------------------|
| Correlations (Pearson Correlation) |
| NIBP systolic | NIBP diastolic | NIBP mean arterial pressure |
| Mean DP | 0.317 (**) | 0.255 (**) | 0.252 (**) |
| Mean RP | 0.282 (**) | 0.259 (**) | 0.274 (**) |

**Correlation is significant at the 0.01 level (2-tailed).**

| Table 3: Regression model summary (a) |
|--------------------------------|
| **Model** | **R** | **R²** | **Adjusted R²** | **Std. error of the estimate** |
| 1 | 0.317 (a) | 0.101 | 0.099 | 12.492 |

Predictor: (Constant), Mean DP *Dependent Variable: NIBP Systolic

| Table 4: Regression analysis (Coefficients (a)) |
|--------------------------------|
| **Coefficients (a)** |
| **Model** | **Unstandardized coefficients** | **Standardized coefficients** | **t** | **Sig.** | **95% Confidence interval for B** |
| | **B** | **Std. error** | **Beta** | **Lower bound** | **Upper bound** |
| 1 | (Constant) | 47.171 | 3.679 | 12.823 | 0.000 | 39.943 | 54.399 |
| Mean DP | 0.354 | 0.047 | 0.317 | 7.461 | 0.000 | 0.261 | 0.447 |

*Dependent Variable: NIBP Systolic
will be noted (RP). Three readings will be repeated. Mean of DP and RP will be calculated. Simultaneously, BP will taken by NIBP method. The results will be compared and analyzed statistically by Pearson correlation coefficient. Regression modeling will be carried out to explain the relationship of NIBP with mean DP and RP and attempted to predict the NIBP from mean DP/mean RP.

Results

Sociodemographic variables

All study subjects were full term normal or CS delivered. Preterm babies and babies with any kind of genetically affected disorders or other comorbidities were excluded from this study. Regarding gender distribution, subjects were more or less belonging to both genders in same proportion. Table 1 depicts Mean DP, RP, NIMP MAP, and Blood Pressure observed.

Table 2 showing the correlation between Mean DP vs NIBP systolic BP, that is, \( r = 0.317, P < 0.001 \); Mean DP vs NIBP diastolic BP, that is, \( r = 0.255, P < 0.001 \). Similarly, it is showing correlation between Mean RP vs NIBP systolic, that is, \( r = 0.282, P < 0.001 \); Mean RP vs NIBP diastolic BP, that is, \( r = 0.259, P < 0.001 \).

Tables 3 and 4 showing significant linear relationship of NIBP systolic BP on Mean DP, \( y = 47.17 + 0.354 \times \text{mean DP} \), where \( y = \text{mean systolic BP} \). \( F = 55.66, P < 0.001 \).

Tables 5 and 6 showing significant linear relationship of NIBP systolic BP on Mean RP, \( y = 57.91 + 0.300 \times \text{mean RP} \), where \( y = \text{mean systolic BP} \). \( F = 43.10, P < 0.001 \).

Tables 7 and 8 showing significant linear relationship of NIBP diastolic BP on Mean DP, \( y = 27.47 + 0.20 \times \text{mean DP} \), where \( y = \text{mean diastolic BP} \). \( F = 34.695, P < 0.001 \).

Tables 9 and 10 showing significant linear relationship of NIBP diastolic BP on Mean RP, \( y = 32.32 + 0.197 \times \text{mean RP} \), where \( y = \text{mean diastolic BP} \). \( F = 35.88, P < 0.001 \).

Tables 11 and 12 showing significant linear relationship of NIBP mean arterial pressure on Mean DP, \( y = 33.30 + 0.27 \times \text{mean AP} \), where \( y = \text{mean MAP} \). \( F = 33.84, P < 0.001 \).

Discussion

Accurate BP measurement is critical in neonates, most common cause for blood pressure fluctuations are physiological variation, anatomical variation, as well as cuff compression variation. The requirements of successful blood pressure monitoring are that the method should be easy to set up, reliable, and give continuous information or enable measurements to be made at frequent intervals with minimal disturbance to the baby.

In this study, NIBP systolic had better correlation with DP (\( r = 0.317 \)) \( P < 0.001 \) compared with RP (\( r = 0.282 \)) [Figures 1 and 2, respectively]. This study’s findings are consistent with a study conducted among adults and neonates using the same methodology that uses pulse oximeter signal disappearance and reappearance as an alternative method.[11] Langbaum investigated the precision of the plethysmographic waveform of a pulse oximeter in gauging systolic blood pressure in sick neonates in a study. Pulse oximetry waveform analysis is a simple and accurate method to quantify blood pressure in newborns, and it is much more accurate than the oscillometric method.[12]

Another two studies conducted in Indian setting also reported the significant accuracy of using pulse oximeter in comparison with other NIBP methods.[13,14] Studies reported that blood pressure measurement among Takayasu’s arteritis patients also ruled out that this method is a useful alternative for this clinical situation, for which the oscillometric device did not work.[15]
However, some systematic reviews warrant further research in this area to validate and develop oscillometric methodology with enhanced accuracy.\[16\]

Despite the fact that neonates did not become sick or badly impacted during corona virus induced disease (COVID-19), the necessity for monitoring was critical. One potential way to mitigate the likelihood of complications in patients is to have those diagnosed with COVID-19 but not symptomatic enough to necessitate admission monitor their arterial oxygenation at home using pulse oximetry and present for care if they show signs of hypoxemia. Although pulse oximetry's ease of use and relatively inexpensive make it an enticing prospect for recognizing problems early on, there are key factors with pulse oximetry that patients and providers may not be aware of, which can impede the successful implementation of such monitoring tools. The relevance of basic pulse oximetry use is also highlighted in this study.\[17\]

The main implication of this study is to provide a strategy for clinicians, researchers, and industry to conduct future clinical research studies in a consistent, evidence-based manner to improve the quality, accuracy, and applicability of future studies.
neonatal hemodynamic studies. Study portrays use of pulse oximetry which is a reliable tool in measuring blood pressure in neonates. Studies related to this topic are scarcely published in Indian context in the last two decades, hence it makes a pertinent finding.

**Key message**

- In neonates, information on blood arterial oxygen saturation (SpO2) is critical.
- Pulse oximetry is a pertinent technique to measure systolic blood pressure in newborn infants.
- Pulse oximetry is a reliable tool in measuring blood pressure in neonates.
- Family physicians need to be aware about this simple and straight forward measure of blood pressure of neonates.

**Declaration of patient consent**

The authors certify that they have obtained all appropriate patient consent forms. In the form the patient(s) has/have given his/her/their consent for his/her/their images and other clinical information to be reported in the journal. The patients understand that their names and initials will not be published and due efforts will be made to conceal their identity, but anonymity cannot be guaranteed.

**Financial support and sponsorship**

Nil.

**Conflicts of interest**

There are no conflicts of interest.

**References**

1. Report of the Second Task Force on Blood Pressure Control in Children -1987. Task Force on Blood Pressure Control in Children. National Heart, Lung, and Blood Institute, Bethesda, Maryland. Paediatrics1987;79:1-25.
2. Matsuoka OT, Pinheiro AC, PascuasDZ, Leone CR. Evolution of systemic arterial blood pressure during neonatal period in term newborns adequate for gestacional age. J Pediatr (Rio J) 1996;72:155-8.
3. Pilossof V, Schöber JG, Peters D, Bühlmeyer K. Non-invasive oscillometric measurement of systolic, mean and diastolic blood pressure in infants with congenital heart defects after operation. A comparison with direct blood pressure measurements. Eur J Pediatr 1985;144:324-30.
4. Lui K, Doyle PE, Buchanan N. Oscillometric and intra-arterial blood pressure measurements in the neonate: A comparison of methods. JPediatrChild Health 1982;18:32-4.
5. Pilossof V, Schöber JG, Peters D, Bühlmeyer K. Non-invasive oscillometric measurement of systolic, mean and diastolic blood pressure in infants with congenital heart defects after operation. A comparison with direct blood pressure measurements. Eur J Pediatr 1985;144:324-30.
6. Chawla R, Kumaravel V, Girdhar KK, Sethi AK, Indrayan A, Bhattacharya A. Can pulse oximetry be used to measure systolic blood pressure? AnaesthAnalg 1992;74:196-200.
7. MoviusAJ, BrattonSL, SorensenGK. Use of pulse oximetry for blood pressure measurement after cardiac surgery. Arch Dis Child1998;78:457-60.
8. Gupta JM, Scopes JW. Observations on blood pressure in newborn infants. Arch Dis Child 1965;40:637-44.
9. Ribeiro MA, Fiori HH, Luz JH, Piva JP, Ribeiro NM, Fiori RM. Comparison of noninvasive techniques to measure blood pressure in newborns. J Pediatr (Rio J) 2011;87:57-62.
10. Sondej T, Zawadzka S. Influence of cuff pressures of automatic sphygmomanometers on pulse oximetry measurements. Measurement (Lond) 2022;187:110329.
11. Wallace CT, Baker JD 3rd, Alpert CC, Tankersley SJ, Conroy JM, Korns RE. Comparison of blood pressure measurement by Doppler and by pulse oximetry techniques. AnesthAnalg 1987;66:1018-9.
12. Langbaum M, Eyal FG. A practical and reliable method of measuring blood pressure in the neonate by pulse oximetry. J Pediatr 1994;125:591-5.
13. Chawla R, Kumaravel V, Girdhar KK, Sethi AK, Indrayan A, Bhattacharya A. Can pulse oximetry be used to measure systolic blood pressure? AnaesthAnalg 1992;74:196-200.
14. Talke P, Nichols RJ Jr, Traber DL. Does measurement of systolic blood pressure with a pulse oximeter correlate with conventional methods? J ClinMonit 1990;6:5-9.
15. Manfrini O, Bugiardini R. Takayasus’s arteritis: A case report and a brief review of the literature. Heart Int 2006;2:66.
16. Dionne JM, Bremner SA, Baygani SK, Batton B, Ergenekon E, Bhatt-Mehta V, et al. Method of blood pressure measurement in neonates and infants: A systematic review and analysis. J Pediatr 2020;221:23-31.e5.
17. Luks AM, Swenson ER. Pulse oximetry for monitoring patients with COVID-19 at home. Potential pitfalls and practical guidance. Ann Am Thorac Soc 2020;17:1040-6.