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

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Abstract. The accuracy of indirect oscillometric blood pressure measurements has been evaluated in 32 infants up to 11 months of age undergoing heart surgery. In a number of 1029 simultaneous measurements the indirect blood pressure was compared with the direct value obtained from a radial artery catheter. Cuffs of different sizes were applied. The main results were as follows: (1) Regarding the ratio of cuff width to arm circumference, the best correlation between oscillometric and direct blood pressure measurements was obtained with a ratio of 0.38-0.41. (2) The value of indirect blood pressure measurements depends on the absolute height of the blood pressure. In low blood pressure there is a tendency to underestimate and in high blood pressure there is a tendency to overestimate by the oscillometric blood pressure measurement.

By applying an appropriate cuff size and by using our diagrams it should be possible to derive a direct value for the blood pressure on the basis of indirect oscillometric blood pressure measurements.

Key words: Arterial blood pressure – Oscillometric method – Cuff size – Infant – Congenital heart defect

Introduction

The non-invasive determination of BP in infants is difficult [1, 19]: Many different methods for non-invasive blood pressure measurement (BPM) have been proposed [4, 10, 12, 18, 20, 27], but direct BPM is still the method of choice in most intensive care units, especially after heart surgery [4, 9, 17, 18, 25, 26]. Recently the Dinamap TM, based on the oscillometric principle was introduced into neonatal intensive care and has also been used for BP monitoring during anaesthesia [5, 9, 18, 19, 21, 25, 28]. Some investigators found a good correlation between Dinamap and direct BPM [2, 3, 5, 8, 9, 11, 15, 16, 28], but most of these studies were performed on anaesthetised patients [2, 28], in infants during heart catheterisation [3, 4], or in groups of neonates and low birth weight infants [5, 9, 16]. There have been relatively few investigations involving the use of Dinamap for post-operative BPM in infants after heart surgery [19, 25]. The purpose of this paper is to evaluate the accuracy of oscillometric BPM for non-invasive, post-operative monitoring of BP. In addition the role of the cuff width and heart rate in relation to the accuracy of non-invasive BPM were evaluated. A detailed description of the oscillometric method has been reported previously [17, 19].

Patients

Our study was of 32 neonates and infants with congenital heart defects who had undergone heart surgery. The patients were 7 days to 11 months old (mean 4.8 months). They weighed 2700 g–6900 g (mean 4660 g). Their length was 50–70 cm (mean 59.3 cm).

Blood pressure measurements. For non-invasive BPM Dinamap¹ was used in 26 infants and Omega² in 6 infants. Both monitors using the oscillometric technique are capable of monitoring systolic, mean and diastolic BP and heart rate. After analysing the amplitude of cuff pressure oscillations during each step of the incriminal deflation sequence, a microcomputer displays the results. The SAP corresponds to the point at which the oscillations begin to increase. MAP and DAP correspond respectively to the points at which the oscillations peak and where they stop decreasing [17, 19]. In all patients original cuffs (Critikon type 2, 3, 4) were used, and were placed on the arm that did not have an arterial catheter. The cuff size was chosen according to the arm circumference, using a ratio of cuff width to arm circumference (CW/ArmC) of 0.25–0.5. In 16 infants cuffs with different sizes were used. In eight infants the measurements were made with a ratio of more than 0.45 or less than 0.33. Preliminary analysis showed

Abbreviations: BP = blood pressure; BPM = blood pressure measurements; CW/ArmC = cuff width to arm circumference ratio; DAP = diastolic arterial pressure; MAP = mean arterial pressure; SAP = systolic arterial pressure; ME = mean error; SD = standard deviation

¹ Dinamap TM 847 XT neonatal signs monitor “Critikon” Inc
² Omega 1100TM neonatal blood pressure monitor “Invivo Research Laboratories”
an unacceptable deviation of indirect BPM from direct BPM in these cases, and measurements with such ratios were discontinued.

During the period of BPM all patients were mechanically ventilated. All patients required an indwelling radial arterial catheter (22.24 gauge teflon catheter) except one who required a femoral arterial catheter. The arterial catheter was liquid-coupled via non-compliant tubing to a pressure transducer (Gould Statham P23Db), located at heart level and coupled to a Siemens monitor (Sirecust 310-NF4). Blood pressure waveform and heart rate were displayed continuously during the measurements. Multiple simultaneous readings were obtained in each patient with a range of 9-46 per study. The mean number of measurements per study was 20 and the total number 1029. The intra-arterial BP reading was obtained by one of us immediately after completion of the indirect measurement. Most of the readings were obtained at roughly 2-5 min intervals, but occasionally it was necessary to suspend the study temporarily while the clinical staff manipulated the patient or when the infant was too active.

Statistics

The paired values were subjected to linear regression analysis and to calculation of correlation coefficients for the different groups of CW/ArmC ratio. For all measurements the mean error (ME) and the standard deviation (SD) in different areas of SAP, MAP and DAP were calculated. In addition, for each series of measurements ME and SD were calculated. The error was defined as the indirect minus the direct BP value. To determine whether or not heart rate influenced the accuracy of oscillometric measurements, a coefficient of correlation for heart rate versus the error of measurement was calculated.

Results

The ratio of cuff width to arm circumference

Our data were divided into six subgroups according to their CW/ArmC ratio. The lowest ratio was less than 0.33 and the highest ratio was between 0.45 and 0.50. It turned out that the accuracy of indirect BPM was very poor when the ratio was too low (<0.33) or too high (0.45-0.50). In these subgroups the correlation coefficient between direct and indirect BPM was less than 0.7. When the ratio CW/ArmC was between 0.33 and 0.45 the correlation between direct and oscillometric BPM seemed sufficient for clinical requirements (r = 0.79–0.88). The following results are derived from 903 simultaneous measurements with a cuff ratio between 0.33 and 0.45.

Correlation between direct and oscillometric BPM for SAP, MAP and DAP

In Fig.1a–c the results of regression analysis for the whole group of 903 simultaneous BPM are presented. The corre-