Invasive blood pressure recording comparing nursing charts with an electronic monitor: a technical report

Benjamin T Wong, Neil J Glassford, Victoria Bion, Syn Y Chai and Rinaldo Bellomo

Blood pressure management in the early phase of septic shock has been reported to influence renal outcomes.[1] In an observational cohort study, Panwar and colleagues investigated the relationship between the time-weighted average of the mean perfusion pressure deficit and subsequent acute kidney injury in patients with septic shock.[1] Hourly data on mean arterial pressure (MAP) and central venous pressure (CVP) were obtained from nursing charts over a 72-hour period or until cessation of vasopressor support, whichever occurred earlier. A previous observational study has suggested that nursing recording of oxygen saturation may be subject to ascertainment bias. This may also be true for MAP measurement,[2] but the accuracy of such chart-derived values remains untested.

Intra-arterial blood pressure monitoring is the standard of haemodynamic monitoring in patients with shock within the intensive care unit.[3] Continuous beat-to-beat measurements provide near real-time evidence of haemodynamic instability, which is stored on the patient's bedside monitor. Bedside nurses record observations, including blood pressure, hourly. These observations may or may not accurately reflect the average of fluctuations in blood pressure that occur within the hour.[2]

We hypothesised that there would be a significant difference in nursing chart blood pressure values compared with average blood pressure values obtained from the bedside monitor over the corresponding period. Based on previous literature, a difference of ≥ 5 mmHg was deemed to be clinically significant.[4,5]

Methods

Our study was approved by the Austin Health Office for Research as an audit activity (LNR/13/Austin/234). The need for informed consent was waived.

We studied 20 patients with shock requiring vasopressor support and with intra-arterial blood pressure monitoring in a tertiary ICU. Hourly MAP values were obtained from the nursing charts over a 12-hour period. The MAP was calculated from systolic and diastolic values recorded on the chart. Blood pressure data taken every 10 minutes (systolic pressure, diastolic pressure and MAP) were downloaded from patient monitors (IntelliVue MP70, Phillips Medizin Systeme) over the corresponding period (72 measurements

ABSTRACT

Background: Blood pressure management (assessed using nursing charts) in the early phase of septic shock may have an effect on renal outcomes. Assessment of mean arterial pressure (MAP) values as recorded on nursing charts may be inaccurate.

Aim: To determine the difference between hourly blood pressure values as recorded on the nursing charts and hourly average blood pressure values over the corresponding period obtained electronically from the bedside monitor.

Methods: We studied 20 patients with shock requiring vasopressor support and invasive blood pressure monitoring. Hourly blood pressure measurements were recorded on the nursing charts over a 12-hour period. Blood pressure values recorded every 10 minutes were downloaded from electronic patient monitors over the corresponding period. The hourly average of the 10-minute blood pressure values was compared with the measurements recorded on the nursing charts.

Results: We assessed 240 chart readings and 1440 electronic recordings. Average chart MAP was 72.54 mmHg and average electronic monitor MAP was 71.54 mmHg. MAP data from the two sources showed a strong correlation ($\rho = 0.71$, $P < 0.005$). Bland–Altman assessment revealed acceptable agreement, with a mean bias of 1 mmHg and 95% limits of agreement of –11.76 mmHg and 13.76 mmHg. Using average data over 6 hours, 95% limits of agreement narrowed to –6.79 mmHg and 8.79 mmHg.

Conclusion: With multiple measurements over time, mean blood pressure as recorded on nursing charts reasonably approximates mean blood pressure recorded on the monitor.

over a 12-hour period). The hourly mean was obtained for these measurements and compared with the hourly measurements recorded on the nursing charts, using the Spearman rank-order correlation and the Bland–Altman method for comparison analysis.[6,7]

Figure 1. Mean arterial pressure (MAP) recorded on nursing chart and on electronic monitor (mmHg), line of best fit shown
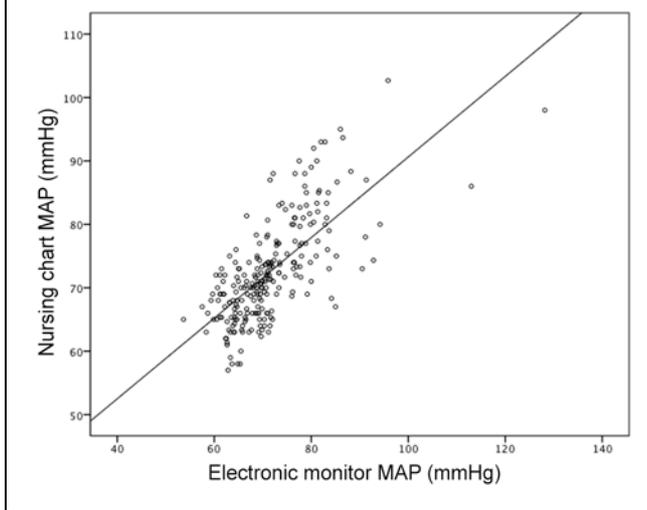
## Figure 2. Mean arterial pressure (MAP) difference v average, between nursing chart and monitor
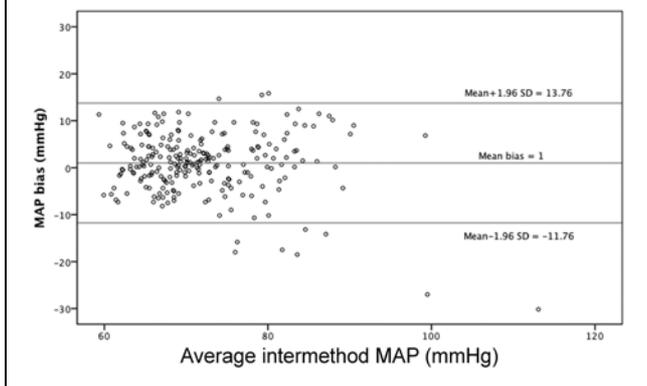
Results

The overall mean for chart measurements was 72.54 mmHg (SD, 7.95 mmHg) and for monitor measurements was 71.54 mmHg (SD, 8.78 mmHg), respectively. The median for chart measurements was 71.33 mmHg (interquartile range [IQR], 65.37–6.46 mmHg) and for monitor measurements was 69.83 mmHg (IQR, 66.75–76.67 mmHg). The Spearman product–moment correlation showed a strong correlation between chart and monitor (ρ=0.71, $P<0.005$) (Figure 1).

Agreement was examined by Bland–Altman analysis (Figure 2). The mean bias was 1 mmHg (standard error of the mean [SEM], 0.42 mmHg), SD was 6.51 mmHg and 95% limits of agreement were −11.76 mmHg and 13.76 mmHg. Sixty-five percent of chart values were within 5 mmHg of

Figure 3. Mean arterial pressure (MAP) difference v average, between nursing chart and monitor over 6 hours
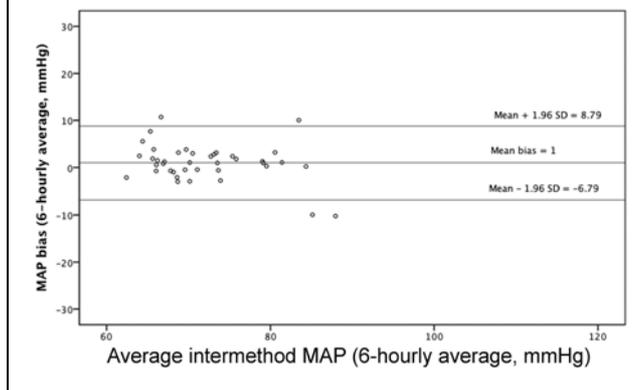
monitor values, and 91% of chart values were within 10 mmHg of monitor values. When 6-hourly average values for chart and monitor were plotted (Figure 3) the mean bias remained at 1 mmHg (SEM, 0.629 mmHg), with an SD of 3.97 mmHg and 95% limits of agreement of −6.79 mmHg and 8.79 mmHg. When the 240 hourly monitor values (not the hourly mean) were compared with chart values, the mean bias was 1.08 mmHg (SEM, 0.44 mmHg), with an SD of 6.80 mmHg and 95% limits of agreement of −12.25 mmHg and 14.41 mmHg.

Discussion

To our knowledge, this is the first study to test the validity of chart-based haemodynamic observations by comparing them with electronically acquired values. We found a strong positive correlation between chart values and monitor values; only a 1 mmHg difference in overall means, a bias of only 1 mmHg, and relatively narrow 95% limits of agreement. Sixty-five percent of values fell within the predetermined, clinically acceptable margin of difference of 5 mmHg. These findings show that, on average, nursing charts reasonably reflect the overall blood pressure values recorded on the monitor over a given 1-hour period.

In studies investigating the effect of MAP on a given outcome measure, MAP is measured and recorded on a frequent basis over a significant period of time, with the average or time-weighted average of blood pressure often used in data analysis.[1,8-12] The Bland–Altman plot shows acceptable agreement between the two methods, with a clinically insignificant positive bias (1 mmHg) toward nursing chart MAP data. The 95% limits of agreement appear of limited consequence, given the reduction in dispersion with repeated sampling over time

and the use of average MAP control over periods greater than 1 hour. This is shown by the narrowing of the limits of agreement when 6-hourly average values were used instead of hourly values. The use of nursing chart blood pressure in data collection can therefore be justified for research purposes, as it is logistically more straightforward to obtain than continuous electronic monitor records.

This was a single-centre study with a limited population. The results may have limited generalisability, but our hospital has all the typical features of an academic ICU in a developed country, suggesting a degree of external validity. We did not account for nursing experience or for the potential effects of diurnal variation. However, the use of >200 nursing chart observations and >1400 electronic data points suggest that our findings have a reasonable degree of robustness.

Conclusion

With multiple measurements over time, mean blood pressure as recorded on nursing charts reasonably approximates mean blood pressure as recorded by the electronic monitor. These observations support the validity of using nursing charts in studies investigating the effect of blood pressure management on various outcome measures.

Competing interests

None declared.

Author details

Benjamin T Wong, Research Fellow[1]
Neil J Glassford, PhD Fellow[1,2]
Victoria Bion, Medical Student[1]
Syn Y Chai, Hospital Medical Officer[1]
Rinaldo Bellomo, Director of Research (Austin),[1] and Co-Director[2]

1 Department of Intensive Care, Austin Hospital, Melbourne, VIC, Australia.

2 Australian and New Zealand Intensive Care Research Centre and Department of Epidemiology and Preventive Medicine, Monash University, Melbourne, VIC, Australia.

Correspondence: rinaldo.bellomo@austin.org.au

References

1 Panwar R, Lanyon N, Davies AR, et al. Mean perfusion pressure deficit during the initial management of shock -- an observational cohort study. *J Crit Care* 2013; 28: 816-24.

2 Eastwood GM, O'Connell B, Considine J. Low-flow oxygen therapy in intensive care: an observational study. *Aust Crit Care* 2011; 24: 269-78.

3 Horowitz D, Amoateng-Adjepong Y, Zarich S, et al. Arterial line or cuff BP? *Chest* 2013; 143: 270-1.

4 Pickering TG, Hall JE, Appel LJ, et al. Recommendations for blood pressure measurement in humans and experimental animals: part 1: blood pressure measurement in humans: a statement for professionals from the Subcommittee of Professional and Public Education of the American Heart Association Council on High Blood Pressure Research. *Circulation* 2005; 111: 697-716.

5 O'Brien E, Atkins N, Stergiou G, et al. European Society of Hypertension International Protocol revision 2010 for the validation of blood pressure measuring devices in adults. *Blood Press Monit* 2010; 15: 23-38.

6 Bland JM, Altman DG. Statistical methods for assessing agreement between two methods of clinical measurement. *Lancet* 1986; 1: 307-10.

7 Taylor R. Interpretation of the correlation coefficient: a basic review. *J Diagn Med Sonog* 1990; 6: 35-9. doi: 10.1177/875647939000600106.

8 Octavio JA, Contreras J, Amair P, et al. Time-weighted vs. conventional quantification of 24-h average systolic and diastolic ambulatory blood pressures. *J Hypertens* 2010; 28: 459-64.

9 Verdecchia P, Porcellati C, Schillaci G, et al. Ambulatory blood pressure. An independent predictor of prognosis in essential hypertension. *Hypertension* 1994; 24: 793-801.

10 Staessen J, Thijs L, Fagard R, et al. Predicting cardiovascular risk using conventional vs ambulatory blood pressure in older patients with systolic hypertension. Systolic Hypertension in Europe Trial Investigators. *JAMA* 1999; 282: 539-46.

11 Kario K, Pickering TG, Matsuo T, et al. Stroke prognosis and abnormal nocturnal blood pressure falls in older hypertensives. *Hypertension* 2001; 38: 852-7.

12 Verdecchia P. Prognostic value of ambulatory blood pressure: current evidence and clinical implications. *Hypertension* 2000; 35: 844-51. ❏

Publisher of

- Critical Care and Resuscitation
- The Medical Journal of Australia
- MJA InSight
- The Medical Directory of Australia

For more information about AMPCo see
http://www.ampco.com.au